

A photograph of a koala climbing a tree trunk, positioned on the left side of the cover. The koala is grey with a white chest and is reaching up with its claws. The tree bark is rough and textured.

Travers

bushfire & ecology

Watercourse Constraints Assessment Report

Proposed River Gardens
Cemetery,

Lot 1 DP 776645
1290 Greendale Road,
Wallacia, NSW

November 2020



Watercourse Assessment Report

**Proposed River Gardens Cemetery
Lot 1 DP 776645
1290 Greendale Road, Wallacia**

Report authors:	Michael Sheather-Reid – B Nat Res Hons Bronte Talbot B. Env. Sc. Mgmt.
Plans prepared:	Bronte Talbot B. Env. Sc. Mgmt.
Approved by:	Michael Sheather-Reid – B Nat Res Hons – Managing Director
Date:	25/11/2020
File:	20MKD03RIP

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The mapping is indicative of available space and location of features which may prove critical in assessing the viability of the proposed works. Mapping has been produced on a map base with an inherent level of inaccuracy, the location of all mapped features are to be confirmed by a registered surveyor.

TBE Environmental Pty Ltd
ABN 85 624 419 870
PO Box 7138
Kariang NSW 2250

38A The Avenue
Mt Penang Parklands
Central Coast Highway
Kariang NSW 2250

t: 02 4340 5331
e: info@traverseecology.com.au
www.traverseecology.com.au

Executive Summary

Travers bushfire & ecology has been engaged to undertake a Watercourse Assessment Report for the proposed construction of a cemetery within Lot 1 DP 776645, No. 1290 Greendale Road, Wallacia. This lot will hereafter be referred to as the 'study area'.

This watercourse constraints assessment report has been prepared by *Travers bushfire & ecology* to verify the existing watercourses on site and to identify the riparian vegetated riparian zone (VRZ) constraints in accordance with the *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018).

This assessment identifies that the riparian lands are mostly associated with the Nepean River and Duncans Creek. The Nepean River is classified as a fifth order stream sets the western boundary of the site. Any river greater than a fourth order has an applied 40m buffer in accordance with the with *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018) requirements. Duncans Creek is a fourth order stream once again a 40m riparian buffer has been applied.

All works within the riparian protection zone and ongoing management will be in accordance with *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018) and the issued General Terms of Approval for future development applications.

Alternative solutions and riparian offsets are appropriate within this site for highly degraded riparian corridors and are approvable under a Controlled Activity Approval in accordance with the requirements of the *WM Act*. This project encroaches the outer 50% of the riparian zone of Duncans Creek and a riparian offset of equivalent area has been provided. Controlled Activity Approval will be required for all works within waterfront land as defined under the *WM Act* and its Regulations.

A vegetation management plan (VMP) has been prepared to specify the outcomes of all riparian management works in terms of areas to be protected, revegetation inclusive of planting densities and plant species to be used.

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List of abbreviations

APZ	asset protection zone
BAM	Biodiversity Assessment Method
BAR	Biodiversity Assessment Report
<i>BC Act</i>	<i>Biodiversity Conservation Act (2016)</i>
<i>BC Reg</i>	<i>Biodiversity Conservation Regulation (2017)</i>
BCAR	Biodiversity Certification Assessment Report
BDAR	Biodiversity Development Assessment Report
BOS	Biodiversity Offset Scheme
BPA	bushfire protection assessment
BSSAR	Biodiversity Stewardship Site Assessment Report
CEEC	Critically endangered ecological community
<i>CM Act</i>	<i>Coastal Management Act 2016</i>
DCP	development control plan
DEC	NSW Department of Environment and Conservation (superseded by DECC from April 2007)
DECC	NSW Department of Environment and Climate Change (superseded by DECCW from October 2009)
DECCW	NSW Department of Environment, Climate Change and Water (superseded by OEHS from April 2011)
DEWHA	Commonwealth Department of Environment, Water, Heritage & the Arts (superseded by SEWPAC)
DOEE	Commonwealth Department of Environment & Energy
EEC	endangered ecological community
EPA	Environmental Protection Agency
<i>EP&A Act</i>	<i>Environmental Planning and Assessment Act (1979)</i>
<i>EPBC Act</i>	<i>Environment Protection and Biodiversity Conservation Act (1999)</i>
<i>FM Act</i>	<i>Fisheries Management Act</i>
IBRA	Interim Biogeographic Regionalisation for Australia
LEP	local environmental plan
LGA	local government area
<i>LLS Act</i>	<i>Local Land Services Act (2013)</i>
NRAR	Natural Resource Access Regulator
NES	national environmental significance
<i>NPW Act</i>	<i>National Parks and Wildlife Act (1974)</i>
NSW DPI	NSW Department of Industry and Investment
OEHS	Office of Environment and Heritage
PCT	plant community type
PFC	projected foliage cover
RFS	NSW Rural Fire Service
ROTAP	rare or threatened Australian plants
SAII	Serious And Irreversible Impacts
SEPP	State Environmental Planning Policy
SEWPAC	Commonwealth Dept. of Sustainability, Environment, Water, Population & Communities (superseded by DOEE)
SIS	species impact statement
SRZ	Structural root zone
SULE	safe useful life expectancy
TEC	threatened ecological community
TPZ	tree preservation zone
<i>TSC Act</i>	<i>Threatened Species Conservation Act (1995) – Superseded by the Biodiversity Conservation Act (2016)</i>
VMP	vegetation management plan



Introduction

1

Travers bushfire & ecology has been engaged to prepare a Watercourse Assessment Report for construction of a cemetery within Lot 1 DP 776645, No. 1290 Greendale Road, Wallacia. This lot will hereafter be referred to as the 'study area'.

The identification of watercourses and vegetated riparian zones (VRZs) are required pursuant to the *WM Act* which controls activities within 40m of a designated watercourse. Any controlled activities being undertaken within 40m of a designated watercourse require a permit from the administering authority, Infrastructure NSW.

This watercourse assessment report has been prepared by *Travers bushfire & ecology* to verify the existing watercourses on site and to identify the riparian buffer (VRZ) constraints in accordance with the *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018).

This advice identifies whether the site is affected by a watercourse as defined under the *WM Act*, assesses the existence and condition of the mapped watercourses, presence of any sensitive riparian or wetland habitat, confirms the extent of watercourses, their classification and assesses the level of riparian corridor protection required in accordance with the Controlled Activity Guidelines for watercourses as issued by the *NSW Department of Industry*.



Figure 1 – Study area
(Source: SIX Maps)

Where warranted, recommendations are also made for poor condition riparian corridors that can be replaced with designed embankments, vegetated banks, offline stormwater quality and quantity control devices that will mitigate the potential impacts, protect the catchment and riparian functions and habitat.

1.1 Proposed Cemetery

The proposed river garden cemetery to be developed within Lot 1 DP 776645 comprises of multiple structures and associated gardens.

Approval is sought for the development and associated works as follows:

- Cemetery;
- Crematoria;
- Community facilities;
- Administration buildings;
- Halls;
- Chapels;
- Other buildings and structures;
- Garden;
- Parkland and landscaping; and
- Internal roads, lakes and ponds.

Access

Access to the proposed development will be provided via two proposed access points along Greendale Road. An internal road network will be constructed to provide vehicular access across the entire development. There will also be pedestrian footpaths, for pedestrian access across the entire development.

Figure 2 demonstrates the proposed site plan for the river gardens cemetery.



Figure 2 – Masterplan Layout of proposed cemetery
 (Source: MKDarchitects – drawing number B4.01 – November 2020)

The following sections provide a brief description of the site.

1.2 Site description

Table 1 provides a summary of the planning, cadastral, topographical, and disturbance details of the subject site.

Table 1 – Site features

Location	Lot 1, DP776645, 1290 Greendale Road, Wallacia
Size	73.46ha
Grid reference	282571.47E 6246772.24S
Elevation	Approximately 33 – 75m AHD
Topography	Situated in a low to very steep slope with a westerly aspect
Geology and soils	Geology: Q _a Clastic sediment and Twib Shale Soils: Mottled Natric Red Kurosol (ASC), Red Podzolic Soil (GSG). Soil moderately permeable and imperfectly drained. Three soil horizons are present within this soil profile, which contain clay loam, medium clay and high medium clay.
Catchment and drainage	Hawkesbury-Nepean Catchment, with four watercourses and drainage lines on site. These watercourses, drainage lines and overland flow enters Duncans Creek and the Nepean River
Vegetation	Approximately 65.58 ha of land within the study area is cleared
Existing land use	Zoned RU1 – Primary Production under Liverpool LEP 2008.
Clearing	>80% of the original vegetation has been cleared.

1.3 Vegetation descriptions

Vegetation communities observed within the study site include:

- PCT 835 – Forest Red Gm – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 849 – Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- PCT 850 – Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- PCT 1108 – River Peppermint – Rough-barked Apple – River Oak herb/grass riparian forest of coastal lowlands, southern Sydney Basin Bioregion and South East Corner Bioregion.
- Planted Native Vegetation

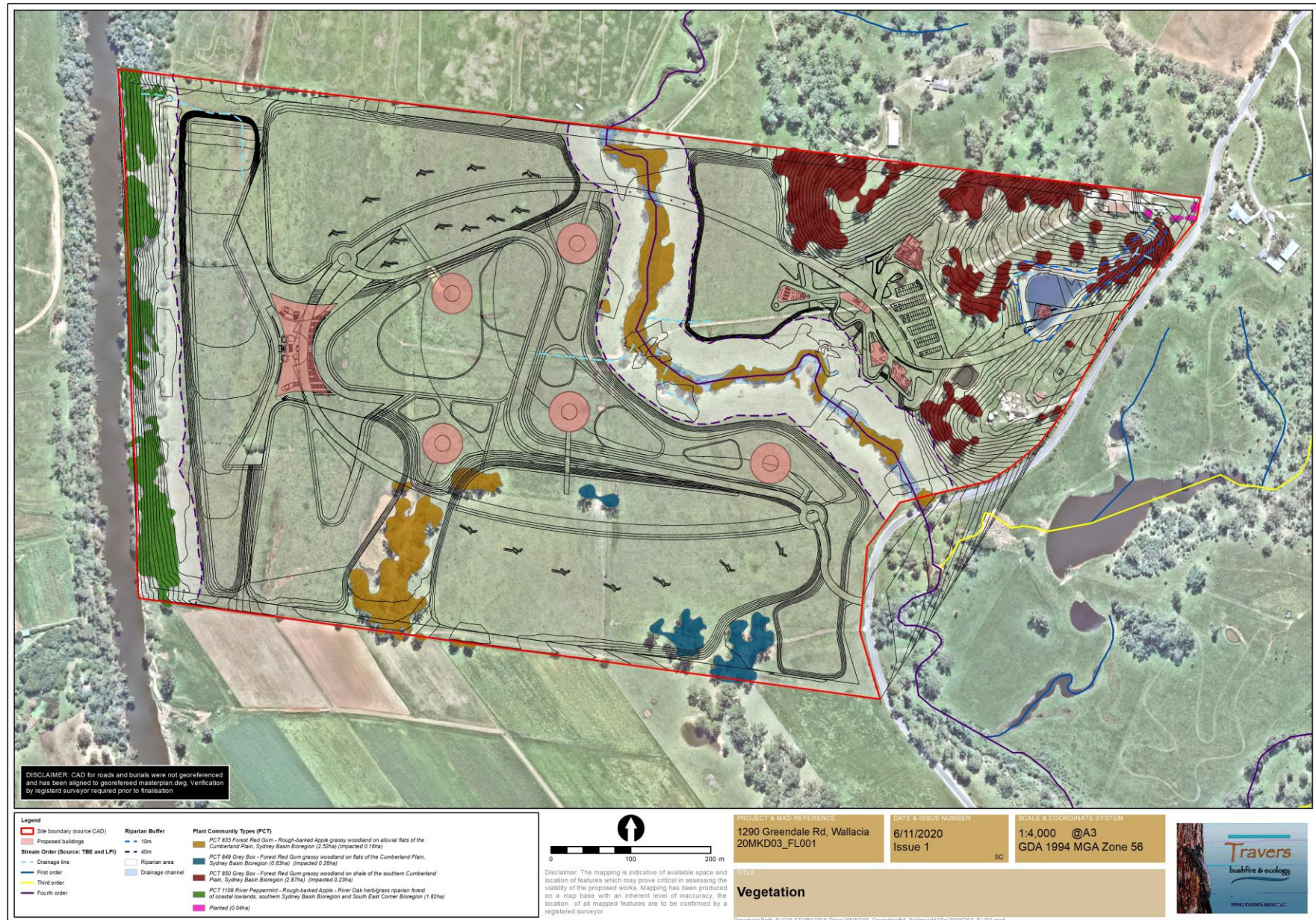


Figure 3 – Vegetation Mapping overlay with the Masterplan layout

PCT 1108 – River Peppermint - Rough-barked Apple - River Oak herb/grass riparian forest of coastal lowlands, southern Sydney Basin Bioregion and South East Corner Bioregion (Zone 1) TEC RFEF

Canopy – 18 to 25 m high providing 20–50% projected foliage cover (PFC). Species include *Casuarina cunninghamiana*, *Eucalyptus elata* and *Eucalyptus benthamii*.

Mid - storey – Native *Backhousia myrtifolia*, *Melia azedarach*, *Bursaria spinosa*, *Acacia binervia*, *Maytenus sylvestris* provide 3–10% PFC. Naturalised exotics such as *Robinia pseudoacacia*, *Ligustrum sinense*, *Cardiospermum grandiflorum* and *Lantana camara* provide 20–40% PFC.

Groundcovers – Native *Microlaena stipoides*, *Cynodon dactylon*, *Austrostipa ramosissima*, *Themeda triandra*, *Rumex brownii*, *Oplismenus aemulus*, *Dichondra repens*, *Lobelia purpurascens*, *Cheilanthes sieberi*, *Sigesbeckia orientalis*, *Solanum americanum*, *Juncus usitatus*, *Oxalis perennans* and *Hydrocotyle tripartita* provide 5–14% PFC. Exotic species include *Setaria parviflora*, *Conyza* spp., *Poa annua*, *Ageratina adenophora*, *Senecio madagascariensis*, *Bidens pilosa* and *Tradescantia flumensis*, and provide 5–15% PFC.

PCT 835 – Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (Zone 2) TEC RFEF

This vegetation community occurs in the floodplain areas in the south-west of the study area, and within the riparian areas adjacent to Duncans Creek. This community is highly disturbed, with few understorey species and an abundance of naturalised exotics.

Canopy – The canopy of the south-western patch is entirely comprised of *Eucalyptus tereticornis*. Along Duncans Creek there are additional species including *Casuarina cunninghamiana*, *Angophora subvelutina*, *E. amplifolia* and *E. baueriana*. Trees are 18–23 m tall and provide 40–65% PFC.

Mid-storey – The native mid-storey is largely absent, with occasional occurrences of *Bursaria spinosa*, *Acacia parramattensis*, *Callistemon salignus*, *Melaleuca linearifolia* and *Melaleuca styphelioides* providing < 3% PFC. Naturalised exotics such as *Ligustrum sinense*, *Robinia pseudoacacia* and *Olea europea* are common in the riparian area and provide up to 27% PFC.

Groundcovers – Native groundcovers include *Microlaena stipoides*, *Oplismenus aemulus*, *Rumex brownii*, *Solanum americanum*, *Sigesbeckia orientalis*, *Urtica incisa*, *Oxalis perennans*, *Juncus usitatus*, *Marsilea hirsuta*, *Einadia trigonos* and *Geranium homeanum*, providing 2–17 PFC. Naturalised exotics are abundant and include *Tradescantia flumensis*, *Ehrharta erecta*, *Sida rhombifolia*, *Euphorbia peplus*, *Trifolium repens*, *Silybum marianum*, *Chenopodium albens*, *Eragrostis curvula*, *Digitaria sanguinalis*, *Sonchus oleraceus*, *Capsella bursa-pastoris*, *Bidens pilosa*, *Cirsium vulgare*, *Modiola caroliniana* and *Veronica persica* providing 4–30% PFC.

PCT 849 – Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (Zone 3) TEC CPW

This vegetation occurs in the south-east of the study area and is comprised of canopy trees with a very disturbed understorey with no shrubs and very few native groundcovers.

Canopy – *E. moluccana* and *E. tereticornis* 18–25 m tall and providing 25% PFC.

Mid-storey – absent.

Groundcovers – Dominated by exotic grasses and groundcovers, including *Lolium perenne*, *Plantago lanceolata*, *Senecio madagascariensis*, *Sida rhombifolia*, *Sonchus oleraceus*, *Lepidium bonariense*, *Ehrharta erecta*, *Cenchrus clandestinus* and *Malva parviflora*, providing 55% PFC. Native species provide 7% PFC and include *Oxalis perennans*, *Wahlenbergia gracilis*, *Cotula australis* and *Desmodium varians*.

PCT 850 – Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (Zone 4) TEC CPW

This community occurs in the north-eastern portion of the study area on the gentle slopes and hills. As with the other communities onsite, the vegetation is highly disturbed from past and ongoing land use practices.

Canopy – *E. moluccana* and *E. tereticornis* 18–25 m tall and providing 23–31% PFC.

Mid-storey – Native shrubs are largely absent. Exotic species provide 1–22% PFC and include *Olea europaea*, *Lycium ferocissimum* and *Lantana camara*.

Groundcovers – Native species include *Microlaena stipoides*, *Solanum prinophyllum*, *Einadia polygonoides*, *Oxalis perennans*, *Rumex brownii*, *Dichondra repens*, *Cyperus gracilis*, *Oplismenus aemulus*, *Cotula australis* and *Desmodium varians* providing 10–60% PFC. Exotic grasses and groundcovers include *Cirsium vulgare*, *Conyza sumatrensis*, *Plantago lanceolata*, *Solanum nigrum*, *Alternanthera pungens*, *Solanum linnaeanum*, *Paspalum dilatatum*, *Hypochaeris radicata*, *Senecio madagascariensis*, *Sida rhombifolia*, *Sonchus oleraceus*, *Lepidium bonariense*, *Ehrharta erecta*, *Cenchrus clandestinus* and *Malva parviflora*, providing 5–15% PFC.

1.4 Riparian features

Aerial photography and mapping obtained from the NSW Land and Property Management Authority's (LPMA) *Spatial Information Exchange (SIX Viewer)*, *Google Earth Pro* and topographic mapping indicates that there are watercourses in close proximity of the site (refer Figure 5).

Where required, measures need to be taken to provide appropriate riparian protection for any future development to maintain water quality and to conserve riparian vegetation and associated faunal habitat.

HYDROLINE mapped watercourses are 1st, 2nd and 4th order streams are shown. Duncans Creek is the 4th order creek that runs from the south eastern corner of the site through to the north western boundary. The Nepean River runs parallel to the western boundary and is classified greater than a 5th order river. A 10m, 20m and 40m riparian buffer has been applied from the top of bank (TOB) has been applied to the 1st, 2nd and 4th order watercourses on site. A 40m buffer from the TOB has been applied to the Nepean River, which extends into the study area and is to be revegetated as specified in the VMP.

The Nepean River is located to the west of the property boundary. Being a river that is classified using the Strahler classification system as being greater than a fourth order river a 40m riparian buffer has been applied from the top of bank.

The Liverpool Local Environmental Plan (LEP), 2008, identifies that Lot 1 DP 776645 is flood prone land and also sections of the lot is classified as environmentally significant land.

The required riparian setbacks can be achieved and appropriate offsets provided for those encroachments, this assessment concludes that the proposed development can be implemented in accordance with the *NSW Natural Resources Access Regulator - Guidelines*

for controlled activities on waterfront land - Riparian corridors (2018). Impacts on riparian land can be mitigated as recommended within this assessment.

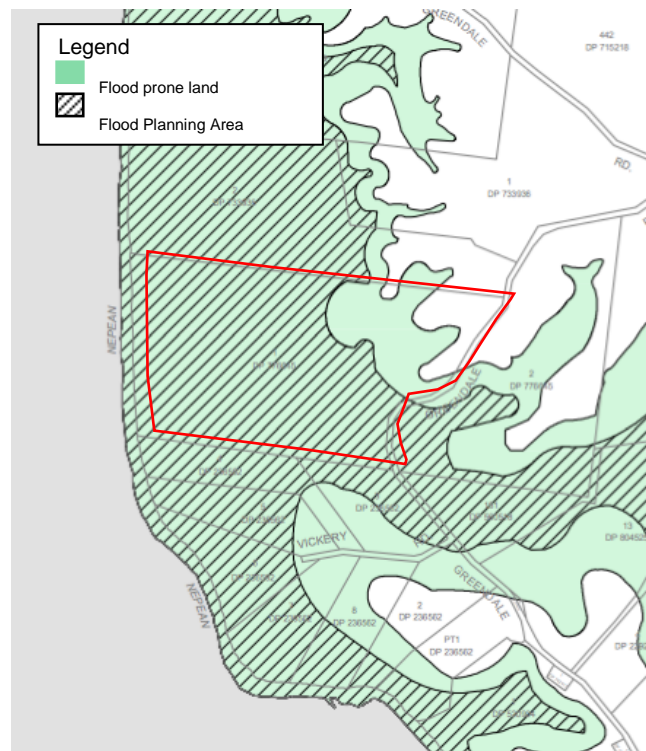


Figure 4 – Flood Planning Area Map
(Liverpool Local Environmental Plan, 2008)

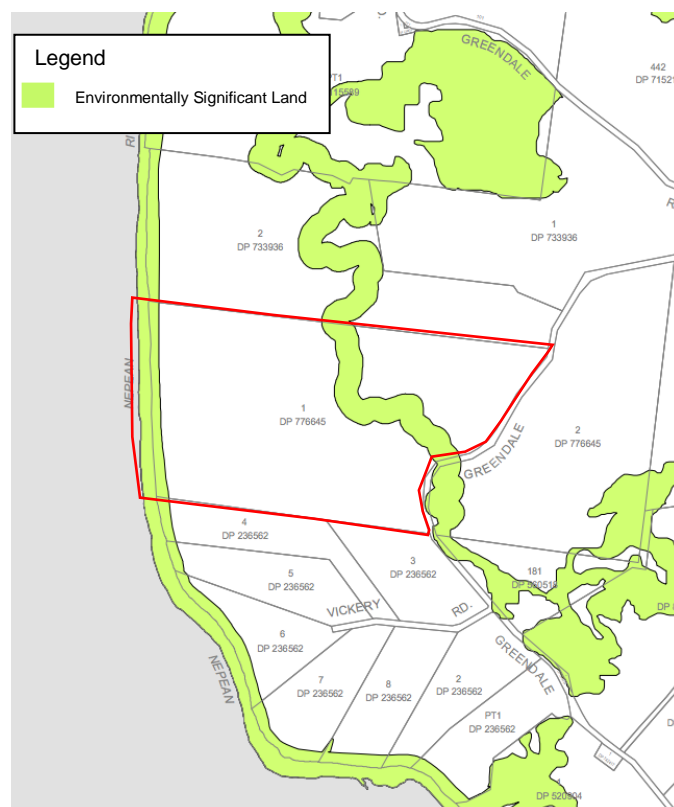


Figure 5 – Environmentally Significant Lands
(Liverpool Local Environmental Plan, 2008)

1.5 Watercourse Validation

The Water Management Act (WMA), 2000 – NSW under Dictionary defines ‘rivers’ and also states what other connecting systems should be included in any such definition. A river includes:

1. any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved;
2. any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (1) flows; and
3. anything declared by the regulations to be a river, whether or not it also forms part of a lake or estuary but does not include anything declared by the regulations not to be a river.

Nine Part test based on Taylor and Stokes (2005 a,b) to assess the presence/absence of fluvial features that are usually present in a bona fide stream or river.

1. Are there definable channel banks and a channel bed?
2. Are there fluvial bedforms e.g. pools, riffles, sediment point bars etc and if so what are they?
3. Is there any evidence for substantial erosion from water flow within the drainage feature?
4. Are there any spring lines that may indicate seasonally intermittent or perennial flow?
5. Is the catchment large enough to sustain perennial or intermittent groundwater flow?
6. Are there any indicators of prolonged wetness within the drainage feature?
7. If surface flow is present, is it continuous and how extensive across the base of the drainage feature is it?
8. Are there any visible aquatic habitats that might sustain aquatic fauna?
9. Are there any aquatic flora present that would require periods of uninterrupted moisture?

Is an artificial drainage a watercourse?

1. Is the subject watercourse natural or artificial? If natural then it is a watercourse and should exhibit the above characteristics. If artificial move to the next question
2. If artificial is it in alignment with a former natural alignment based on contours? If yes then it is a watercourse that has been artificially modified but is still a watercourse. If no then the drainage line is not a watercourse

Does a certain catchment size determine whether a stream/drainage line is a watercourse?

No but it is likely than a catchment of greater than 20ha will likely carry sufficient water to create a natural watercourse subject to the local rainfall patterns, soil, permeability and catchment topography and rainfall load into the catchment.

The definitions and evidence of a stream or river above demonstrates that the watercourses on site at 1290 Greendale Road, Wallacia, are classified as a ‘river’ as per the WMA. The watercourses have the appearance and functionality (physically and biologically) of a natural watercourse, artificially modified. It has either recently contained and still contains a range of aquatic fauna species. In addition the evidence indicates that riparian vegetation once existed down the watercourse and that given suitable restoration techniques, it can be returned to its bank to provide additional and appropriate natural habitat.



Mapped Watercourses

2

Electronic aerial photography from *Google Earth Pro* and *Spatial Information Exchange* were viewed. Hydroline mapping of watercourses for the site (Figure 6) was also viewed as the key legislative map of watercourse for assessment purposes under the Water Management Act 2000.

Based on desktop assessment, watercourses enter the site to the north east and southern boundaries. Five (5) potential hydroline mapped watercourses were investigated (Figure 6), however, the northern and eastern elevated watercourses have been reclassified as drainage lines.

From the site inspection it was concluded that the primary riparian lands consist of Duncan's Creek and the Nepean River. The site is located within the Hawkesbury Nepean catchment, which drains 21,400 kilometres of land. The Nepean River flood zone dominates the lower parts of the site. Duncan's Creek catchment dominates the upper slopes. Several small sub-catchments exist on site but form part of Duncan's Creek catchment area. Mapped watercourses within the north east portion of the site is within a very small catchment and have been reviewed on site and in consultation with NSW DPI&E

Duncan's Creek is mapped as a fourth order stream, which requires a 40m vegetated riparian zone from top of bank.

The Nepean River is located to the west of the site boundary and drains in a northerly direction. The Nepean River is classified using the Strahler system as being greater than a fifth order river, which requires a 40m vegetated riparian zone.



Figure 6 – Mapped Watercourses
 (Source: Water Management (General) Regulation 2018 Hydro Line spatial data)

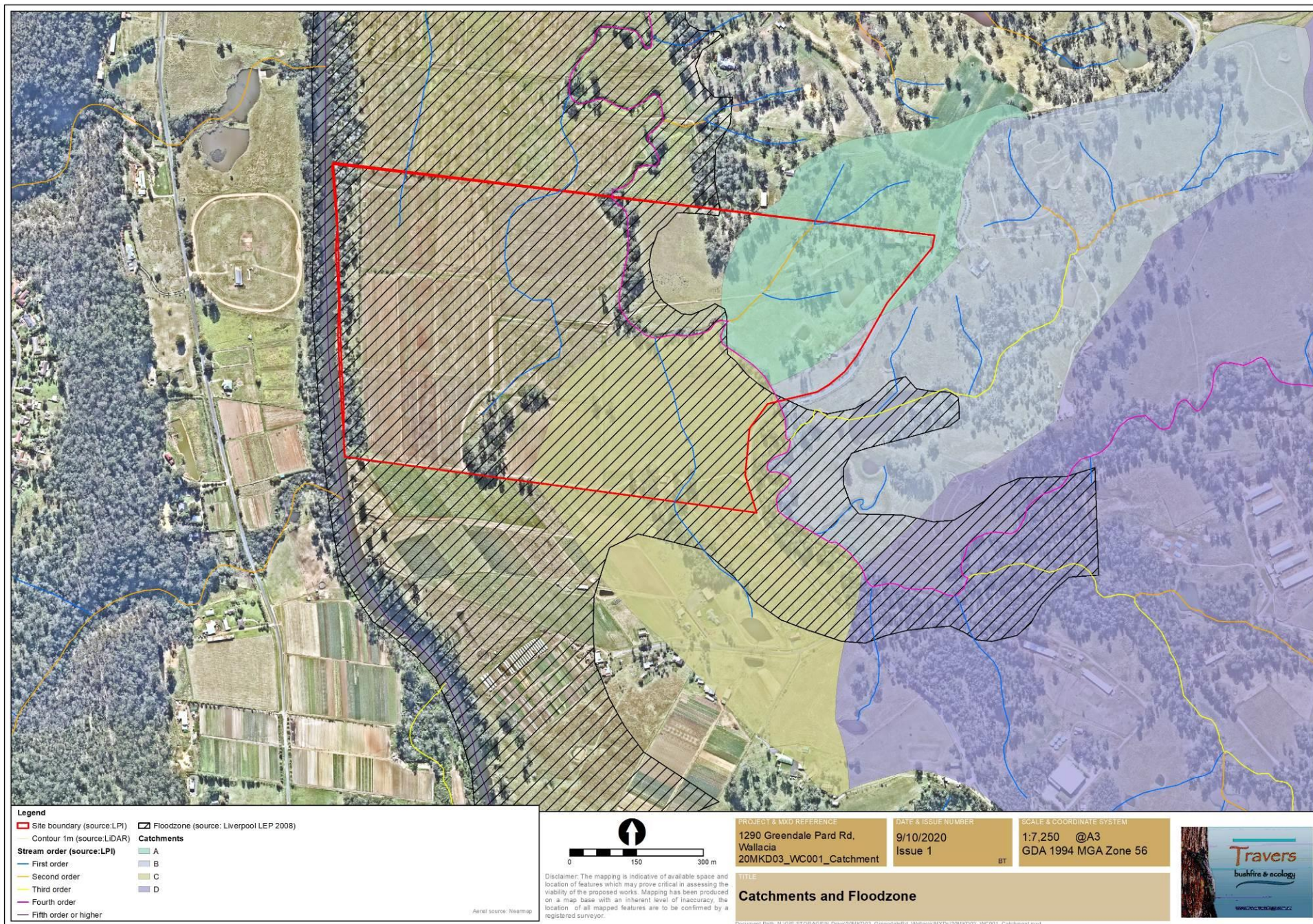


Figure 7 – Catchments and flood zone



Validation of Watercourses

3

An inspection of the site and its watercourses was undertaken on 2nd July 2020 and the 10th July 2020 to identify the presence or absence of watercourse and wetland features and to examine the impacts of the proposed works on riparian zones.

For each potential watercourse present, the following features were assessed:

- the presence of a defined channel (either intermittent or continuous) along the alignment of the watercourse;
- the extent of riparian vegetation;
- the presence of vegetation with environmental value
- the presence of noxious weeds and degree of weed infestation
- the presence of any ponded water; and
- the potential connectivity between any riparian vegetation and upstream or downstream riparian vegetation.

For the purposes of wetland boundary definition, the following features were used to define the extent of the wetland and its boundary:

- any observed endangered protection wetlands
- any observed tidal influences
- any observed estuarine features
- topographic constraints and presence of non-wetland vegetation types
- presence of any groundwater dependent ecosystems that also correspond with a wetland vegetation type.

As identified on Figure 6, the eastern portion of the site drains into Duncans Creek and hence into the Nepean River. The remainder of the lands are floodplain and is subject to back flooding during heavy rainfall events.

Ground truthing confirmed the number and condition of watercourses and drainage lines located on site. Figure 8 identifies the validated watercourses as confirmed from the site visits.

The existing top of bank and wetland boundaries have also been verified by ground truthing to ensure accurate assessment of setbacks and potential riparian impacts, both direct and indirect. All boundaries have been located with a sub 1m accurate differential GPS. The extent of watercourses and top of bank has been mapped by walking the boundary, comparison against regional mapped vegetation and interpolation of contours generated from *LiDAR* data. In this case the *LiDAR* data is considered to be reliable as an indicator of the potential flow path but not fully indicative of the extent of watercourses.

Figure 8 shows the confirmed watercourses and drainage lines onsite.

3.1 Duncans Creek

Duncans Creek is a fourth order stream and runs in a north westerly direction through the site. Along the entire channel there is minimal riparian vegetation due to past land use and management. Duncan's Creek is a flood drainage conveyance.

The inspection identified the following characteristics:

- Intermittent flow, defined channels with highly incised banks;
- Degraded riparian vegetation present on the banks to the south but a restricted canopy present immediately adjacent to the channel;
- Increased riparian vegetation was found along the channel in the north, however, still very sparse;
- Highly eroded banks;
- Sedimentation in the channel;
- Sandstone bridge without any culverts to allow for flow; and
- Debris blocking the channel.

The condition of the watercourse is typical of an operational dairy farm.

3.1.1 Recommended management

Fourth order streams require a 40m VRZ from top of bank. Management options include:

- Protect with a 40m VRZ from top of bank
- Revegetate corridor with Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 835)
- Rehabilitate channel and banks to ensure stabilisation
- Integrate road access that allows for channel flow
- Ensure stable and dissipated runoff from the stormwater outlet through a level spreader to avoid concentrated flows and erosion of intertidal mudflats.
- Ensure proposed works implements scour protection to reduce erosion impacts

The proposal includes a raised creek crossing that fully spans the riparian corridor at a stated 14m in height. The proposed bridge is placed between a gap in the existing treeline and will not involve the removal of any trees or shrubs within the riparian corridor. Given the proposed design of the bridge, it will have negligible impact on the riparian corridor, its vegetation or instream habitat. Revegetation under the crossing will accommodate full ground layer and shrub planting and sub-canopy planting.

3.1.2 Duncans Creek watercourse photos

The following images are typical of the riparian bank and channel along Duncans Creek



Photo 6 – Centre of channel on Duncans Creek at the south eastern portion just inside the lot boundary



*Photo 7 – Duncans Creek channel approximately in the middle of the channel length
– photo taken facing east*

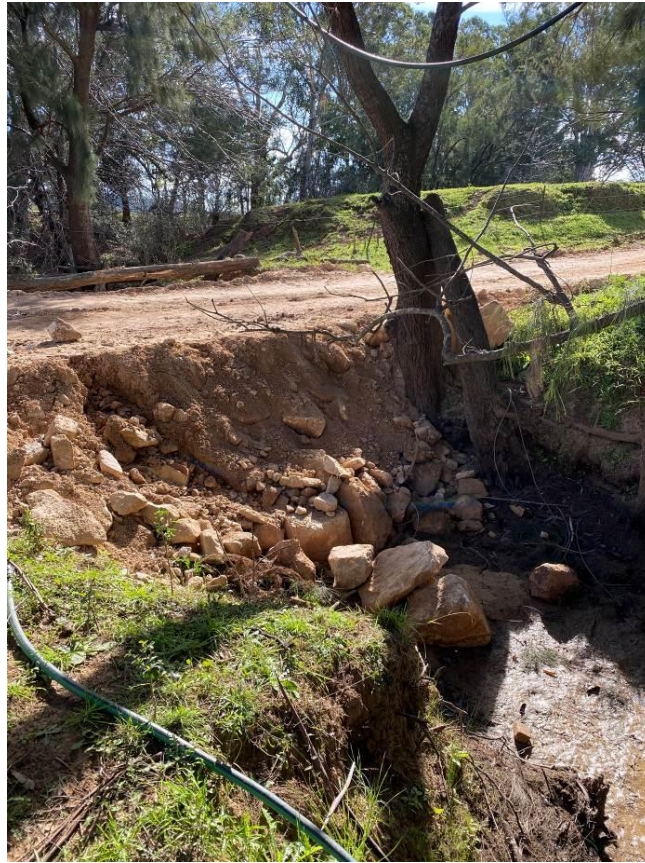


Photo 8 – Duncans Creek existing sandstone road across creek – photo taken facing downstream



Photo 9 – Northern end of Duncans Creek – photo taken facing downstream

3.2 Northern and Eastern Mapped Watercourses

There are four (4) potential hydroline mapped watercourses in the northern and eastern parts of the site as verified during the site visit. These mapped watercourses are classified as a 1st and 2nd order streams using the Strahler method and drain towards Duncan's Creek.

3.2.1 Northern Mapped Watercourses

Based on desktop assessment three (3) watercourses within the northern section of the site are mapped as 1st and 2nd order streams. It is noted that the hydroline watercourse mapping is not the final determination of presence or absence of a watercourse but is subject to site validation and assessment for the presence of any watercourse features

The site inspection identified the following characteristics:

- Partially formed channels with a traceable flow path
- No riparian vegetation
- Incised or eroded flow path on the mapped first order streams only
- Eroded flow path close to Duncans Creek

The above features are not strong determinants of a water course. An approach to Infrastructure NSW, (Case Ref# 00065437) resulted in the northern watercourses being investigated by Infrastructure NSW and advised by email that they were not a watercourse and therefore are not deemed as waterfront land. Further correspondence has not been entered into with infrastructure NSW for an exemption under the Water Management Act 2000.

As a result of this consultation with Infrastructure NSW the northern watercourses were retained as overland flow paths and classed as drainage lines for surface flow management.

3.2.2 Recommended management

The following management is recommended:

- No riparian land constraint applies and is categorised as an overland flow path or drainage line
- Collection and management of runoff from the sub catchment and direct through the proposed stormwater drainage system
- Delivery through stormwater outlet into Duncans Creek

3.2.3 Drainage line photos

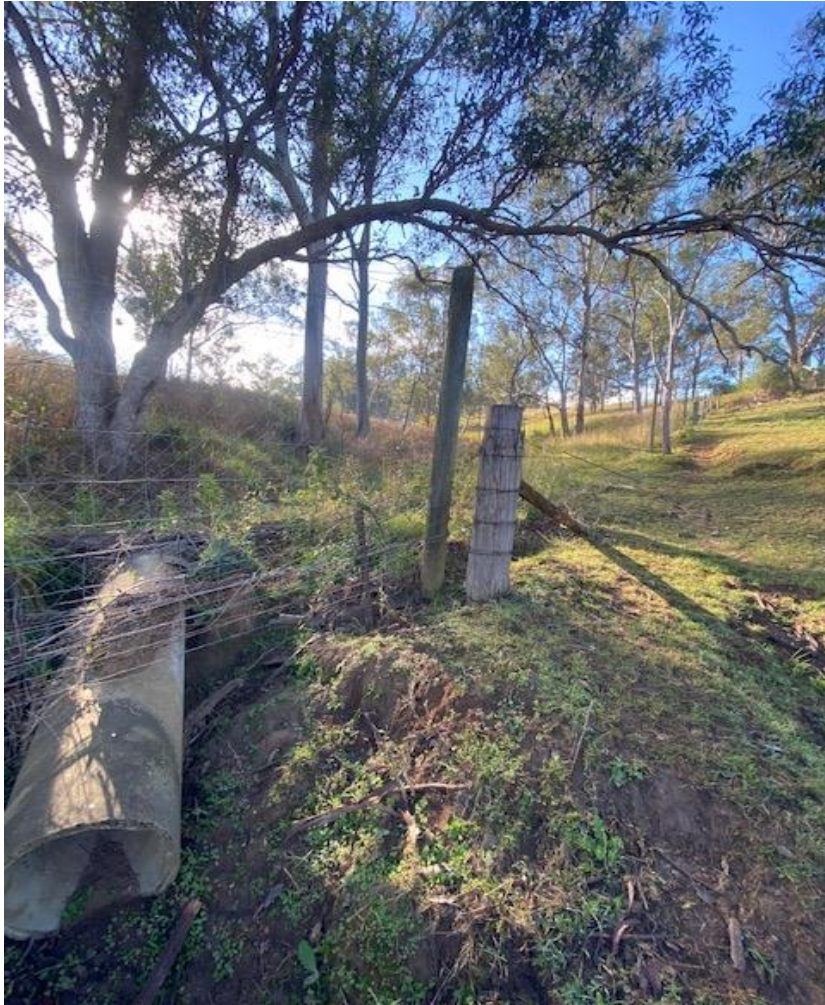


Photo 1 – Split drainage lines entering property along the northern boundary



Photo 2 – Overland flow path below junction of drainage lines looking downhill presenting as an overland flow path



Photo 3 – Lowest reach of the drainage line prior to crossing existing farm access track

3.2.4 Eastern Mapped Watercourse

Desktop assessment using LIDAR contour data, indicated that the eastern Hydroline mapped watercourse runs in a south westerly direction and into a dam. When this dam fills over land flow occurs and eventually drains into Duncans Creek.

The site inspection identified the following characteristics:

- Incised channel above the dam suggestive of a watercourse ;
- Minor occurrence of sedge species
- No demonstrable riparian vegetation
- No channelization below the dam having been managed for dairy pasture over many years.

Given the lack of riparian vegetation and lack of channelisation downstream of the existing dam, the Hydroline mapped watercourse has consequently been reclassified as a drainage line. Consequently we recommend that a riparian constraint does not apply.

3.2.5 Recommended management

The following management is recommended:

- Stabilise drainage line
- Filling of the dam
- Implement scour protection works

3.2.6 Drainage line photos



Photo 4 – Top end of drainage line facing south towards dam with incised drainage line closer to the dam



Photo 5 – Existing Dam proposed to be removed

3.3 Nepean River

The Nepean River is categorised as being greater than a fifth order stream using the Strahler method. The Nepean River runs from south to north, parallel to the property boundary. Riparian vegetation occurs adjacent to the river along the entire length of the boundary. Whilst weed vegetation is present the existing native vegetation is in relatively good condition for its location.

Being greater than a fifth order stream a 40m buffer is applied from the top of bank.

The site inspection identified the following characteristics:

- Permanent flow, defined channels; and
- Moderate riparian vegetation.
- High Order stream (river)

Physical evidence supports the presence of a river classified as being greater than a fifth order watercourse, that is capable of providing a long-term vegetative link not requiring any works for flood mitigation works or bed or bank stabilisation.

3.2.1 Recommended management

Fourth order streams and greater require a 40m VRZ from top of bank. Management options include:

- protect with a 40m VRZ from top of bank
- revegetate corridor with River Peppermint – Rough-barked Apple – River Oak her/grass riparian forest on coastal lowlands, southern Sydney Basin Bioregion and South East Corner Bioregion (PCT 1108);
- ensure stable and dissipated runoff from overland flow

3.2.2 Watercourse photos

The following images are typical of the riparian bank along the Nepean River to the north west of the site.



Photo 10 – Flood plain next to The Nepean River and Riparian Zone – Photo taken facing west



Photo 11 – Drainage line that delivers excess flood flows into The Nepean River, located to the north west of the site

3.4 Combined riparian constraints within the site

The combined riparian constraints within the site is shown on the following figure 8 which is combination of the desktop assessment, site investigations and consultation with

Infrastructure NSW. *Travers bushfire & ecology* considers these constraints to be a balanced riparian lands outcome for the site.

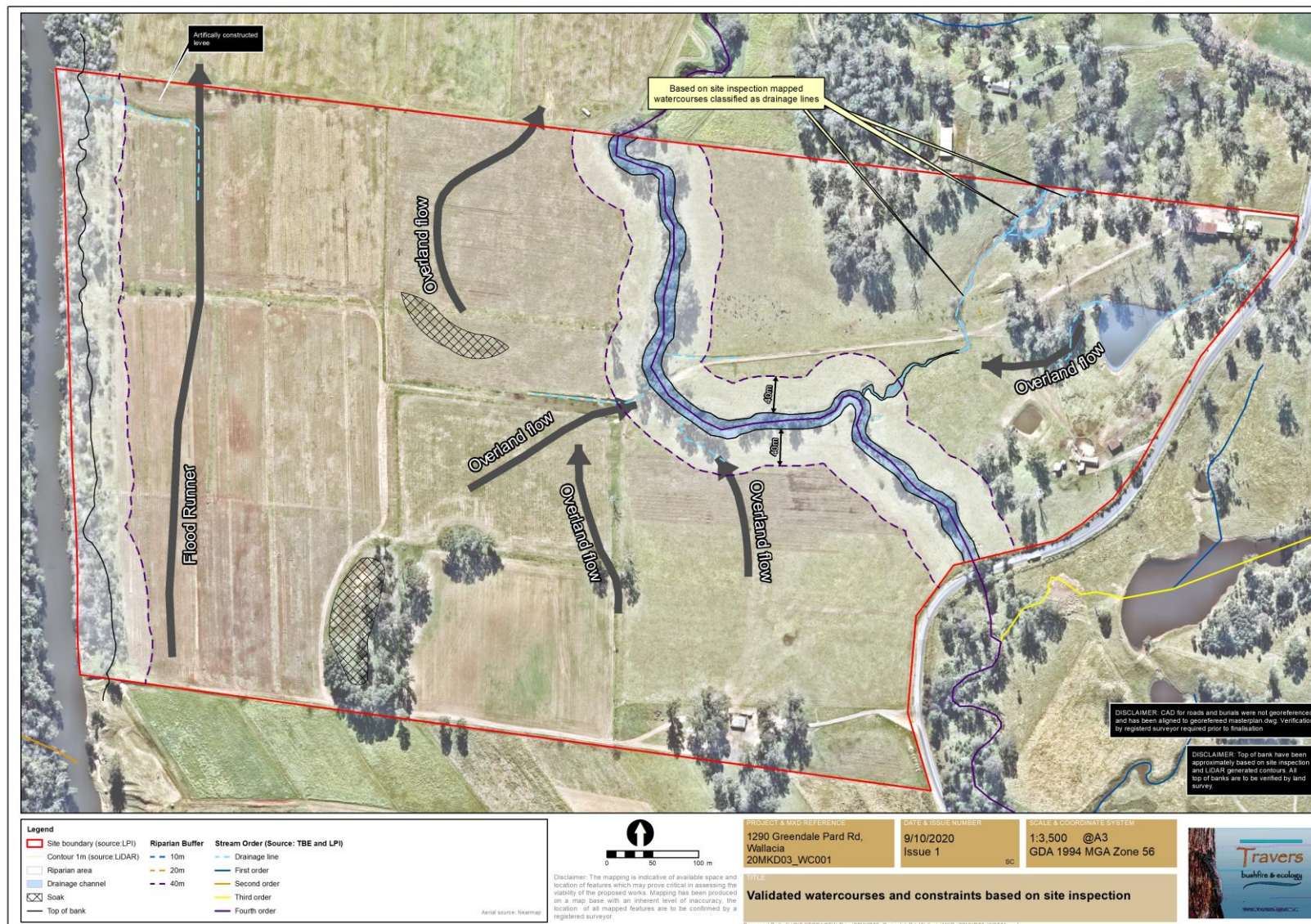


Figure 8 - Validated watercourses and Riparian Constraints based on site inspection



Riparian Controls

4

4.1 Objectives for riparian corridor management

The overarching objective of the controlled activities provisions of the *WM Act* is to establish and preserve the integrity of riparian corridors (*NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018)). Ideally, the environmental functions of riparian corridors should be maintained or rehabilitated by applying the following principles:

- Identify whether or not there is a watercourse present and determine its order in accordance with the Strahler System.
- If a watercourse is present, define the riparian corridor / vegetated riparian zone on a map in accordance with Table 2.
- Seek to maintain or rehabilitate a riparian corridor / vegetated riparian zone with fully structured native vegetation in accordance with Table 2.
- Seek to minimise disturbance and harm to the recommended riparian corridor / VRZ.
- Minimise the number of creek crossings and provide a perimeter road separating development from the riparian corridor / VRZ.
- Locate services and infrastructure outside of the riparian corridor / VRZ. Within the riparian corridor / VRZ, provide multiple service easements and / or utilise road crossings where possible.
- Treat stormwater run-off before discharging into the riparian corridor / VRZ.

A range of works and activities on waterfront land and in riparian corridors are allowed to better meet the needs of the community, providing that they cause minimal harm, as outlined in the riparian corridor matrix below.

4.2 Riparian corridors

Controlled activities are certain types of activities that are carried out on waterfront land and defined as a controlled activity under the *Water Management Act 2000 (WM)*. Controlled activities include works for detention basins, cycle ways and pathways, stormwater outlets, essential services and road crossings. Refer to the Natural Resource Access Regulator (NRAR), *Guidelines for controlled activities on waterfront land for controlled activities* permissible within different stream orders.

The NSW Infrastructure administers the *WM Act* and is required to assess the impact of any proposed controlled activity to ensure that no more than minimal harm will be done to waterfront land as a consequence of carrying out the controlled activity.

Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40m of the highest bank of the river, lake or estuary. This means that a controlled activity approval must be obtained before commencing works within the VRZ. Approval applications can be located on the Water NSW website.

In 2018, new rules commenced regarding controlled activities within riparian corridors. The new rules amend the riparian corridor widths that apply to watercourses, providing more flexibility in how riparian corridors can be used and making it easier for applicants to determine the controlled activity approval requirements. Key aspects of the changes include:

- Provision of greater flexibility in the allowable uses and works permitted within riparian corridors
- The core riparian zone and vegetated buffer have been combined into a single VRZ
- The width of the VRZ within the riparian corridor has been pre-determined and standardised for first, second, third and fourth order and greater watercourses
- Where suitable, applicants may provide an offset for this activity by connecting an equivalent area to the riparian corridor within the development site.
- The riparian corridors matrix enables applicants to determine what activities can be considered in riparian corridors.

As stated in the *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018), a riparian corridor (RC) forms a transition zone between the land, also known as the terrestrial environment, and the river or watercourse or aquatic environment. Riparian corridors perform a range of important environmental functions such as:

- providing bed and bank stability and reducing bank and channel erosion
- protecting water quality by trapping sediment, nutrients and other contaminants
- providing diversity of habitat for terrestrial, riparian and aquatic plants (flora) and animals (fauna)
- providing connectivity between wildlife habitats
- conveying flood flows and controlling the direction of flood flows
- providing an interface or buffer between developments and waterways
- providing passive recreational uses

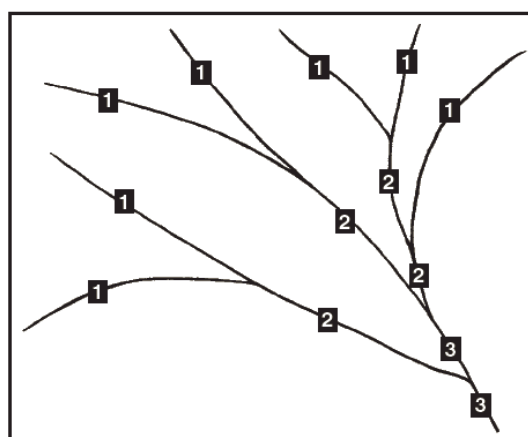
The protection, restoration or rehabilitation of vegetated riparian corridors is important for maintaining or improving the shape, stability (or geomorphic form) and ecological functions of a watercourse (*NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018)).

The proposed management of the riparian corridors can accommodate all these functions without compromising the bushfire safety of the proposed development areas.

4.3 Riparian corridor widths

A VRZ width based on stream order as classified under the Strahler System of ordering watercourses and using current 1:25 000 topographic maps (see Figure 9 and Table 2). The width of the VRZ should be measured from the top of the highest bank on both sides of the watercourse (*NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018))

Table 2 - Recommended riparian corridor widths



Watercourse type	VRZ width (each side of watercourse) (metres)	Total RC width (metres)
First order	10	20 + channel width
second order	20	40 + channel width
third order	30	60 + channel width
fourth order and greater (includes estuaries, wetlands and any parts of rivers influenced by tidal waters)	40	80 + channel width

Figure 9 - The Strahler System

Stream order: The watercourse order as classified under the Strahler System based on 1:25,000, 1:50,000 or 1:100,000 topographic maps, whichever is the smallest scale available. A full list is provided at Part 2, Schedule 2 of the *Water Management (General) Regulation 2011*.

Adherence to the *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018) is subject to the approval and the development consent authority. Consequently, alternative solutions are assessed based on their performance in terms of achieving riparian management objectives. Where a watercourse does not exhibit the features of a defined channel with bed and banks, Infrastructure NSW may determine that the watercourse is not waterfront land for the purposes of the *WM Act*.

The proposed riparian setbacks are consistent with the *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018). Riparian corridors will provide hydraulic and ecological functions and assist in maintaining ecological connectivity upstream and downstream of the site.

To promote ecological as well as hydraulic functions, the riparian corridors can be revegetated over the life of the project which allows for progressive revegetation and regeneration works.

Preparation of a VMP for the riparian corridors is recommended to accurately define the planting densities, spacing and species to be used within each riparian corridor and to integrate with any other vegetation management works or landscaping within the site.

4.4 Permissible works and activities within riparian corridors

The following riparian corridor matrix enables applicants to identify certain works and activities that can occur on waterfront land and in riparian corridors. Applicants should note that the matrix relates to controlled activity approvals under the *WM Act* only. They are still required to comply with other relevant government legislation, such as threatened species, flood planning levels and fisheries guidelines.

Table 3 - Riparian corridor matrix

Stream order	Vegetated Riparian Zone (VRZ)	RC off-setting for non RC uses	Cycleways and paths	Detention basins		Stormwater outlet structures and essential services	Stream realignment	Road crossings		
				Only within 50% outer VRZ	Online			Any	Culvert	Bridge
1 st	10m	•	•	•	•	•	•	•		
2 nd	20m	•	•	•	•	•		•		
3 rd	30m	•	•	•		•			•	•
4 th +	40m	•	•	•		•			•	•

4.4.1 Riparian corridor off-setting for non-riparian corridor uses

In accordance with the *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018), non-riparian uses, such as APZs are allowed within the outer 50% of the vegetated riparian zone, providing that offsets are provided in accordance with the averaging rule.

The riparian corridor offsetting provision can be used to offset the loss of any portions of the riparian corridor impacted by proposed works within the outer 50% of the riparian corridor.

Other proposed activities such as cycleway, paths, detention basins, stormwater outlet structures and essential services and stream realignment are permissible in accordance with the *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018).

In accordance with Figure 9, the proposed development encroaches into the 40m VRZ implemented on Duncans creek. As a result offsetting is required and is to be equivalent or greater to the area being lost. The riparian corridor loss of 0.17ha is estimated and an offset of 0.18ha has been provided.

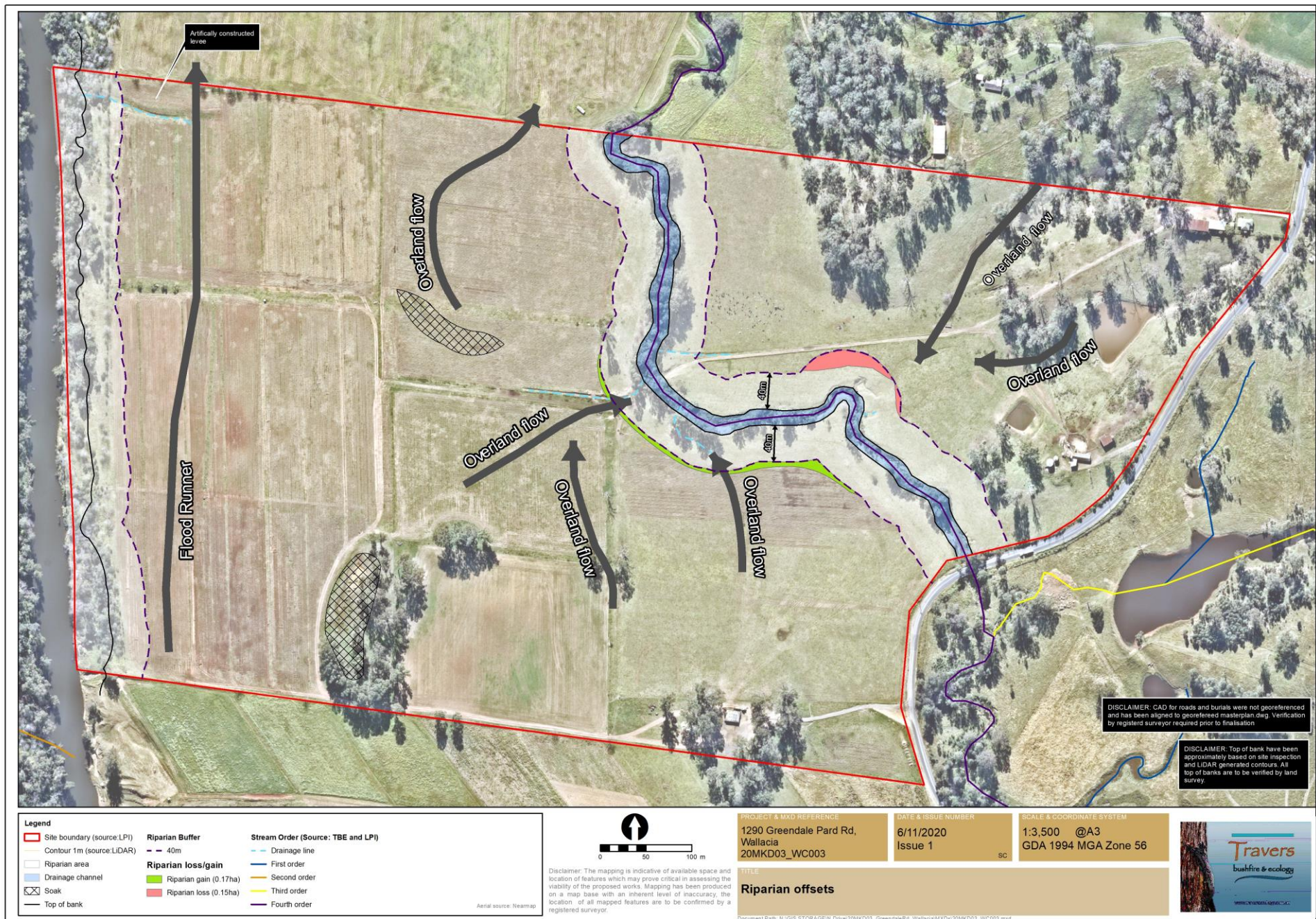


Figure 9 – Riparian Offsets

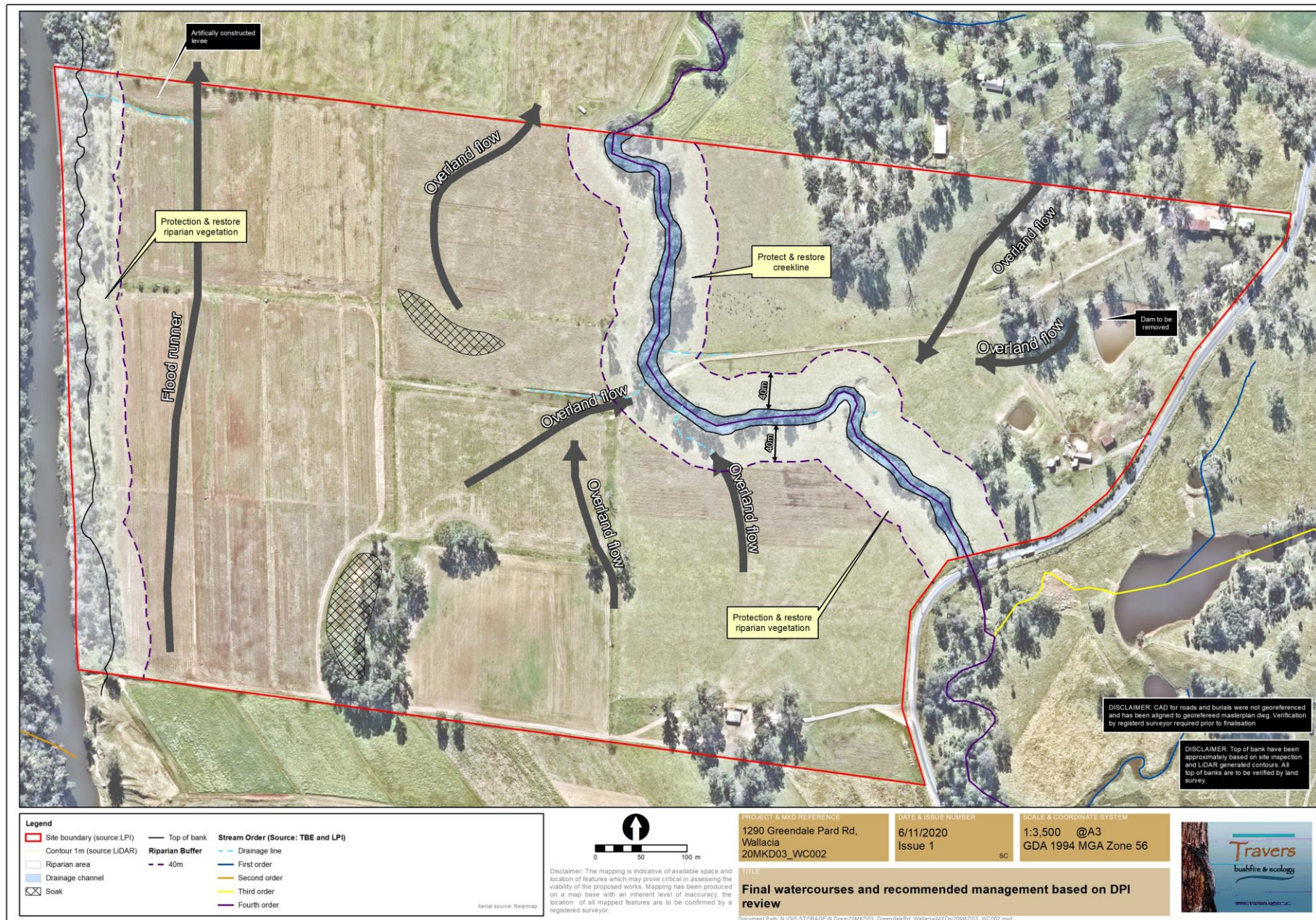


Figure 10 – Final watercourses constraints with recommended management



Conclusions and Recommendations

5

5.1 Conclusions

Based on ground trothing and consultation with Infrastructure NSW, there are two main watercourse located on site consisting of the Nepean River (forming the western boundary) and Duncans Creek. The Hydroline mapped northern mapped watercourses based on site inspection and consultation with Infrastructure NSW (Case Ref# 00065437) has confirmed the existing first and second order streams on the elevated portions of the site are 'not a watercourse'. The eastern most Hydroline mapped watercourse is discontinuous and like the northern water course is not considered to be riparian land due to the lack of riparian vegetation and discontinuous channelization.

Duncans Creek is one of the remaining watercourses on site and is a fourth order stream which runs through the site and requires a 40m VRZ buffer measured from the top of bank. The first order stream located to the north eastern part of the site drains into Duncans Creek via channels and overland flow.

The Nepean River is greater than a fifth order stream and is located to the west of the site. The river runs south to north, parallel to the site boundary. Any stream classified greater than a fourth order requires a 40m VRZ buffer from top of bank.

Any non-permitted works to be conducted on site must not encroach on the VRZ buffers. Permissible activities as identified by the *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018) can be undertaken within the outer 50% of the riparian corridor, however, offsetting is required subject to the nature of the works.

All works within the riparian protection zone and ongoing management will be in accordance *NSW Department of Industry - Guidelines for controlled activities on waterfront land - Riparian corridors* (2018) and the issued General Terms of Approval for future development applications.

Riparian offsets have been provided for:

- Impacts within the 40m VRZ of Duncans Creek

In accordance with this assessment the pre and post development area of riparian zones including riparian corridors increased by 0.15ha with riparian offsets and riparian restoration zones.

Pre & post development area of riparian zones adjoining the site	Area (ha)
Duncan's Creek pre-development - area of mapped riparian zones	6.18ha
Nepean River pre-development - area of mapped riparian zones	4.57ha
Total riparian zone pre-development areas	10.76ha
Duncan's Creek post-development - area of mapped riparian zones	6.20ha
Nepean River post-development - area of mapped riparian zones (including full restoration area)	4.71ha
Total riparian zone post-development areas	10.91ha

Net gain (ha)	Gain of 0.15 ha
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Travers bushfire & ecology concludes that the proposed development has provided a net gain in riparian protection and revegetation including native vegetation protection zones immediately adjoining the riparian corridors.

A Controlled Activity Approval will be required for all works within waterfront land as defined under the *WM Act* (2000) and its Regulations.

5.2 Recommendations

Implementing the following measures will mitigate potential indirect impacts caused by the proposal:

- native landscaping to be used adjoining riparian zones;
- implementing stormwater works that catch and divert potential runoff through stormwater treatment devices and utilising existing drainage networks where possible;
- restoring riparian vegetation in areas disturbed by past works and effectively increasing the buffers through native landscaping in the site;
- undertaking target weed control and replacement with indigenous planting in any weed infested area;
- stabilising the channel and river banks;
- ensure all stormwater outlets dissipate the energy of water before delivery to any riparian; and
- ensuring stormwater treatment during and post construction is to a high standard for environmentally sensitive ecosystems.

A VMP has been prepared to specify the outcomes of all riparian management works in terms of areas to be protected, revegetation inclusive of planting densities and plant species to be used. A landscaping plan has been prepared for the site cognisant of the VMP requirements.

Controlled Activity Approval will be required for all works within waterfront land as defined under the *WM Act* and its Regulations.