



Travers

bushfire & ecology

watercourse assessment

Lot 1 DP 218016, Lot B DP 370979
& Lot 22 DP 564065
166 - 176 St Andrews Road,
Varroville, NSW

December 2018
REF: A16228W



Watercourse Assessment

Lot 1 DP 218016, Lot B DP 370979
& Lot 22 DP 564065
166-176 St. Andrews Road, Varroville

Report Authors: Michael Sheather-Reid
Plans prepared: Sandy Cardow, Alexandra Scott
Date: 12/12/18
File: 18NETT02

This document is copyright ©

Disclaimer:

This report has been prepared to provide advice to the client on matters pertaining to the particular and specific development proposal as advised by the client and / or their authorised representatives. This report can be used by the client only for its intended purpose and for that purpose only. Should any other use of the advice be made by any person including the client then this firm advises that the advice should not be relied upon. The report and its attachments should be read as a whole and no individual part of the report or its attachments should be interpreted without reference to the entire report.

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
85 624 419 870
PO Box 7138
Kariong NSW 2250

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

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

Executive Summary

This watercourse assessment report has been prepared by *Travers bushfire & ecology* to verify the existing watercourses on site and to identify the riparian buffer vegetated riparian zone (VRZ) constraints in accordance with the NSW Office of Water *Controlled Activities On Waterfront Land - Guidelines for Riparian Corridors on Waterfront Land* (July 2012).

Based on ground truthing, this report identifies that watercourses do affect the site within Lot 1 DP 218016, Lot B DP 370979 & Lot 22 DP 564065, 166-176 St. Andrews Road, Varroville. The watercourses are grouped three catchments including:

- Western watercourses – Catchment A consisting of second and third order streams divided into 3 sub-catchments.
- South Eastern watercourses – Catchment B consisting of first and second order watercourse and associated drainage line.
- North Eastern watercourses – Catchment C affecting only drainage lines.

All works within the riparian protection zone and ongoing management will be in accordance with NSW Office of Water *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* (July 2012) and the issued General Terms of Approval for future development applications.

Alternative solutions and riparian offsets are appropriate within this site for highly degraded watercourses and approvable under a Controlled Activity Approval from the NSW Office of Water in accordance with the requirements of the *Water Management Act 2000 (WM Act)*.

Riparian offsets have been provided for:

- Impacts within the riparian zone for various works
- Loss of first order streams(drainage lines) within the site

In accordance with this assessment the pre and post development area of riparian zones provided is as follows:-

Pre & post development area of riparian zones	Area (Ha)
Pre development area of mapped riparian zones (inclusive of all dams)	20.49ha
Post development area of protected riparian zones (inclusive of all dams and RZ offsets)	22.10 ha
Net gain or loss (ha)	Gain of 1.61ha

Travers bushfire & ecology concludes that the proposed masterplan has provided a net gain in riparian protection and revegetation including native vegetation protection zones immediately adjoining the riparian corridors.

A vegetation management plan (VMP) has been prepared for all riparian corridors 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.

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

Table of Contents

1.0	Introduction	1
1.1	Proposed Macarthur Memorial Park	2
1.2	Staging.....	5
1.3	Site description.....	5
2.0	Mapped Watercourses	7
3.0	Validation of Watercourses	11
3.1	Catchment A1 – Watercourse 1.....	11
3.1.1	<i>Recommended management</i>	12
3.1.2	<i>Watercourse photos</i>	12
3.1.3	<i>Drainage lines</i>	12
3.2	Catchment A3 – Watercourses 2, 3, 4, 5, 6, 7 & 8, Dams 2, 3, 4, 5, 6, 7, 8 & 9 and associated drainage lines	13
3.2.1	<i>Recommended management</i>	13
3.2.2	<i>Watercourse and dam photos</i>	14
3.2.3	<i>Drainage lines 4, 5, 6, 7, 8, 9, 10, 11, 12 & 13</i>	22
3.3	Catchment B – Watercourses 9, 10 and 11, Dams 10 & 11 and associated drainage lines	27
3.3.1	<i>Recommended management</i>	27
3.3.2	<i>Watercourse photos</i>	28
3.3.3	<i>Drainage lines 1, 2 & 3</i>	31
3.4	Catchment C – Drainage lines 14 & 15.....	32
3.4.1	<i>Recommended management</i>	32
3.4.2	<i>Drainage lines 14 & 15</i>	32
4.0	Riparian VRZs & Controls	35
4.1	Objectives for riparian corridor management	35
4.2	Riparian corridors	35
4.3	Riparian corridor widths.....	36
4.4	Permissible works and activities within riparian corridors.....	37
4.4.1	<i>Riparian corridor off-setting for non-riparian corridor uses</i>	38
4.5	Proposed stormwater works	39
5.0	Conclusions & Recommendations	44

Figures

Figure 1 – Subject Site – Proposed Macarthur Memorial Park	1
Figure 2 – Overall site plan	3
Figure 3 – Staging plan	4
Figure 4 – Catchments, mapped watercourses and stream order	9
Figure 5 – Validated watercourses	10
Figure 6 – Proposed riparian zones	34
Figure 7 – Proposed riparian management for Masterplan (Zoom 1)	40
Figure 8 – Proposed riparian management for Masterplan (Zoom 2)	41
Figure 9 – Proposed riparian management for Masterplan (Zoom 3)	42
Figure 10 – Proposed riparian management for Masterplan (Zoom 4)	43

Tables

Table 1– Site features	6
Table 2– Dam and their features.....	7
Table 3 - Recommended riparian corridor widths	37
Table 4 - Riparian corridor matrix	38
Table 5 – Riparian protection pre and post development.....	45

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

This watercourse assessment recommends the removal of a number of topographic mapped first order streams due to their current condition which are presenting as simple drainage sales onsite. The proposed Masterplan incorporates the existing drainage swales into the sites drainage design as part of the drainage network and provides for riparian offsets within the main riparian corridors.

1.1 Proposed Macarthur Memorial Park

A master plan has been developed (Figure 2) which has been designed based on ecological, riparian and bushfire constraints. The project is intended to be staged over 150 plus years as shown on Figure 2. The master plan provides for the following built facilities:

- one chapel with the capability to be divided into three separate chapels seating 150 in each
- one condolence room
- one café

In addition to these built assets, the vision for the memorial park is to provide for the following:

- a distinctive landscaped memorial park providing concealed, private and low lying burial spaces to minimise visual impact;
- a sculpture park, offering opportunities for local and Australian artists; and
- an arboretum for future preservation and education of generations to come.

The design of the proposed memorial park has avoided impacting on significant ecological constraints of the site. Minor impacts on existing vegetation areas are identified by a purple line representing the proposed pathways on Figure 4.

The master plan has been assessed to identify the bushfire constraints and minimum APZs required for the proposed future built assets on site (refer Bushfire Protection Assessment, *Travers bushfire & ecology, 2015*).

The site is currently zoned under the Campbelltown Local Environmental Plan (LEP) – District 8 (Central Hills Lands) 2008 as 7(d1) Environmental Protection (Scenic) and part 6(c) Open Space (regional).

Figure 2 shows the master plan and Figure 3 shows the indicative staging plan.



Issue:	Rev:	Description:	Date:

Project title:
**MACARTHUR MEMORIAL PARK
VARROVILLE**

Drawing title:
Overall Site Plan

Principal consultant:
Florence Jaquet
Landscape architect

A: 8 River Street, Camberwell 3124
E: flo@fj.com.au
M: 0419 083 841

Job no: 1210	
Drawn by: OK	
Checked by: FJ	
Scale: 1:2500	Drw no:
CAD file name: L200 SITE PLAN.dwg	Sheet no:
Plot date: 28/08/2018	

Figure 2 – Overall site plan

STAGE 1 (From 2019 to 2104)

- All buildings and services constructed.
- Outbuildings restoration.
- Entrances A to C.
- All roads within Stage 1 only (to the extent permissible under Bushfire Regulation).
- All landscaping and furniture within Stage 1.
- Shelters as required.
- The rest of the site remains UNCHANGED.

STAGE 2 (From 2105 to 2130)

- All roads within Stage 2 only
- All landscaping and furniture within Stage 2.
- Shelters as required.
- The rest of the site remains UNCHANGED.

STAGE 3 (From 2131 to 2140)

- All roads within Stage 3 only
- All landscaping and furniture within Stage 3.
- Shelters as required.
- The rest of the site remains UNCHANGED.

STAGE 4 (From 2141 to 2155)

- All roads within Stage 4 only
- All landscaping and furniture within Stage 4.
- Shelters as required.
- Entrance C
- The rest of the site remains UNCHANGED.

STAGE 5 (From 2156 to 2170)

- All roads within Stage 5.
- All landscaping and furniture within Stage 5.
- Shelters as required.

The above stages are based on current statistical information and projections.



Figure 3 – Staging plan

In addition to these built assets, the vision for the cemetery is to provide for the following:

- a distinctive landscaped cemetery providing concealed, private and low lying burial spaces to minimise visual impact;
- a sculpture park, offering opportunities for local and Australian artists; and
- an arboretum for future preservation and education of generations to come.

1.2 Staging

The *Catholic Cemeteries Metropolitan Trust*, which manages several government cemeteries in the Sydney's metropolitan area, has purchased this site with the view to providing a landscaped cemetery for the whole community in Sydney's west.

Typically, each stage would represent 10 years of burial demand, slowly extending the footprint of the cemetery, one manageable "bite" at a time. The northern half of the site is expected to reach capacity in approximately 105 years and full capacity in approximately 170 years. Should the current trend of double interment continue, these numbers would double (i.e. half capacity in 210 years and full capacity in 340 years).

1.3 Site description

The site is approximately 113.6ha in size. It lies between Camden Valley Way and the Hume Highway, south of St James Rd and encompasses several parcels of land known as Lot B, 22 and 1, on St Andrews Rd, Varroville

The site is characterised by undulating grassed hills and pockets of forested areas. It enjoys panoramic views to the Blue Mountains, Sydney CBD and the Campbelltown valley. It sits within the Scenic Hills area and surrounds the historic Varroville House.

The site encompasses the Bunbury Curran hilltop. From this local high point, the land drops steeply to a valley along the western boundary whilst the eastern boundary offers a lower ridge protecting it from the eastern views. This lower ridge continues towards Varroville House (which is not part of the property), effectively separating the site into two distinct precincts with different exposure and outlook.

The land presents several constraints for development, including steep topography, the presence of Cumberland Plain Woodland, heritage curtilage extending beyond the boundary of Varroville House, riparian zones, waterways and historical dams.

The first European land owner was Dr Robert Townson who obtained the large landholding (which contained this property) as part of the 1809 colonial land grants. He established the property as pasturage and vineyards. His grapes were said to have been recognised as amongst the best in the colony. Captain Charles Sturt was also amongst the owners (c 1830s) and is thought to have established the western lakes. Varroville House, a substantial single storey house (not part of the proposed cemetery) was established in 1858-59 and is historically significant.

The subject site mostly drains in a south easterly direction into Bunbury Curran Creek, then into the greater Georges River Catchment. The watercourses of the site and its associated catchment are split by St Andrews Road and in part flow through Mount Carmel Catholic High School.

Table 1– Site features

Location	166 - 176 St Andrews Road, Varroville
Local government area	City of Campbelltown
Lot & DP	Lot 1 DP 218016, Lot B DP 370979 & Lot 22 DP 564065
Grid reference	299000E 6235700N
Elevation	50-100m AMSL
Topography	Situated on a steady SE sloping landscape parallel to St Andrews Road with a steeper incline towards the vegetated northern boundary.
Geology and soils	Geology; Shale carbonaceous claystone, laminate, coal in parts. Unnamed sandstone member – fine to medium grained quartz-lithic sandstone.
Catchment and drainage	Catchment – Bunbury Curran Creek Small creeks and tributaries across the site drain SE joining until they reach Bunbury Curran Creek.
Vegetation	Where present, native vegetation has a riparian structure due to small creeks and tributaries running through the site. In most areas, trees are around 15-25m tall, there is a limited mid-storey mostly made up of weeds such as African Olive and a ground layer of grasses and herbs. The vegetation is highly modified throughout the study area due to previous clearing.
Existing land use	Rural, grazing and unmanaged
Clearing	The majority of the study area has been previously cleared for indicated land uses.

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 a number of farm dams and streams located within, and in the vicinity of, the site (refer Figure 3). 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.

Travers bushfire & ecology was engaged in 2013 and 2015 for the purposes of rezoning applications to determine the riparian constraints for the property associated with the existing watercourses within land surrounding the site. The 2015 constraints study was based on a detailed site investigation to verify the presence and environmental value of any streams and to provide recommendations on riparian setbacks that will apply to any future development.

This report provides an updated assessment for riparian constraints and impacts caused by the proposed Macarthur memorial Park. Offsets are proposed as part of the masterplan to accommodate any perceived loss in riparian protection.



Mapped Watercourses

2

Electronic aerial photography from *Google Earth Pro* and *Spatial Information Exchange* were viewed. Topographic mapping for the site (Figure 3) was also viewed as the key trigger of a nominated watercourse for assessment purposes.

This mapping shows that the site is affected by several unnamed watercourses (Figure 4) including:

- Western watercourses – Catchment A consisting of second and third order streams divided into 3 sub-catchments.
- South eastern watercourses – Catchment B consisting of first and second order watercourses and associated drainage line.
- North eastern watercourses – Catchment C affecting two drainage lines.

The following dams were inspected as part of the ground truthing for the study.

Table 2– Dam and their features

Dams	Location	Comments
Dam 1	Offsite	Not on site, retained in existing form
Dam 2	Onsite	Upgraded to provide structurally stable embankment and to provide ecological and flood retardation functions
Dam 3	Onsite	Upgraded to provide structurally stable embankment and to provide ecological and stormwater pollutant retention functions
Dam 4	Onsite	Upgraded to provide structurally stable embankment and to provide ecological and flood retardation functions
Dam 5	Onsite	Upgraded to provide structurally stable embankment and to provide ecological and stormwater pollutant retention functions
Dam 6	Onsite	Upgraded to provide structurally stable embankment and to provide ecological and stormwater pollutant retention functions
Dam 7	Onsite	To be removed
Dam 8	Onsite	Retained in existing form and ecology enhanced
Dam 9	Onsite	To be removed
Dam 10	Onsite	Outside stage 1, retain in existing form in medium term
Dam 11	Onsite	Outside stage 1, retain in existing form in medium term
Dam 12	Offsite	Not on site, this dam discharges drainage waters into the site

This report is based on ground truthing and validation as part of the rezoning of the site. This examined the presence of watercourses and dams that were within the site and immediately adjacent to the boundary. Subsequent to the initial ground truthing a boundary adjustment was made to the study area and consequently Dam 1 is no longer within the site but has been included in this report for consistency with previous studies and to avoid changing the numbering of the dams.

Dam 12 is also offsite but is only mentioned because it delivers drainage waters into the subject site but is not affected by the proposal.

Watercourses from Catchment A feed into Bunbury Curran Creek and cover a catchment area of 202ha. Consequently, the main watercourse appears to be a permanent flowing stream carrying significant quantities of potential stormwater drainage. Watercourses to the south east of St Andrews Road were not inspected. Approximately 50% of Catchment A is contained within the planning proposal area and forms the major portion of the site.

Catchment B containing the south eastern watercourses drains 35ha of the site. The watercourse below the existing dam is not well defined due to the artificial dam and is now directed overland through a spillway and grass pasture which was most likely to be River-flat Eucalypt Forest prior to clearance of the land for agricultural use. The dam and incised gullies above are most likely to have been artificially created as part of past land use and we expect this part of the landscape may have been intensively used for orchids or vines, given its close proximity to Varroville House, south easterly aspect and close proximity to dams.

Catchment (C) is not affected given that a very minor portion of the catchment is contained within the site (Figure 4). The mapped watercourses are in fact grassed swales with no channel formation and hence are not classed as watercourses but drainage lines.

This watercourse assessment has only addressed watercourses within the site.

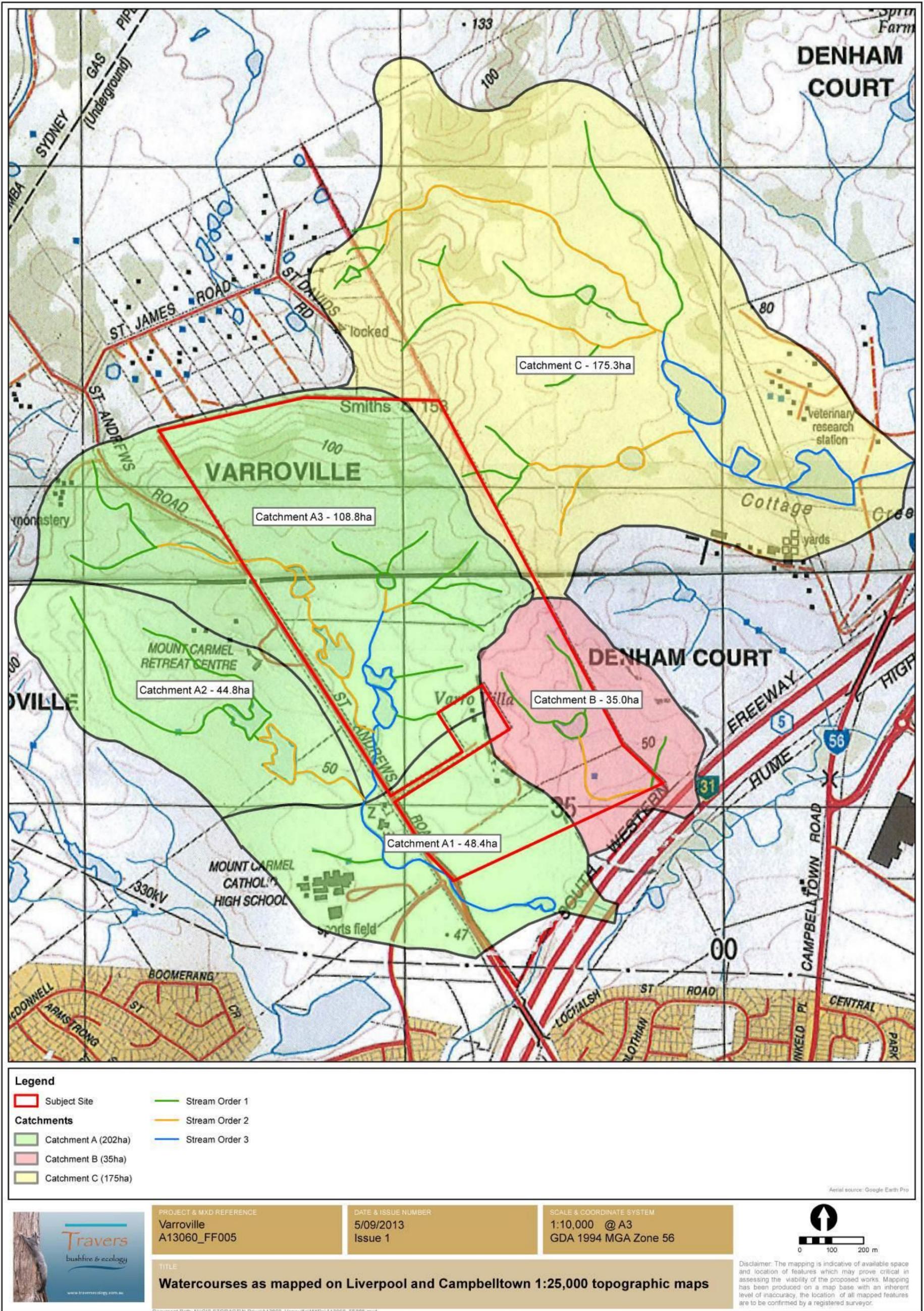
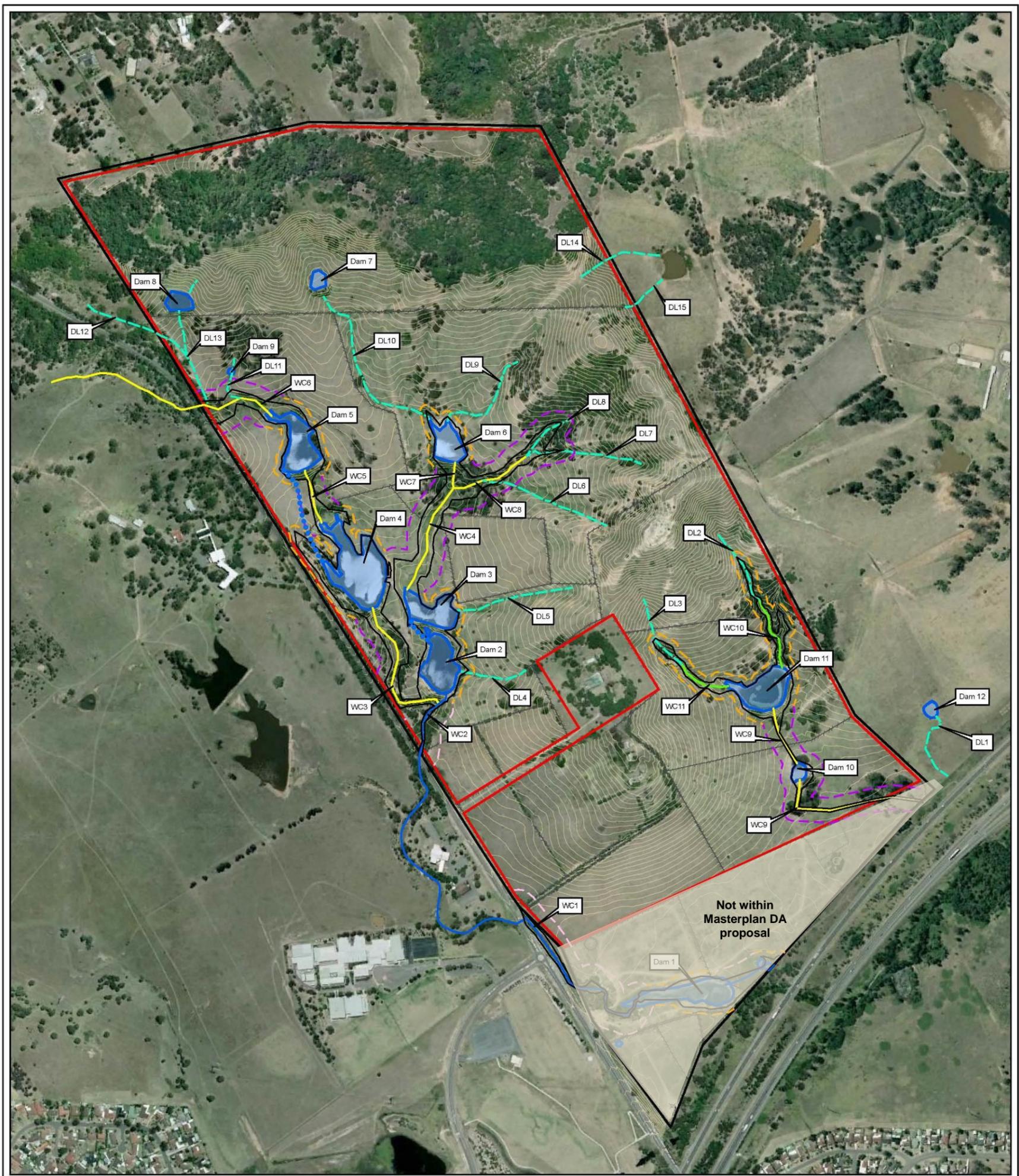


Figure 4 – Catchments, mapped watercourses and stream order
 (Liverpool and Campbelltown 1:25000 topographic maps)



Legend			
Site boundary	Spillway	Watercourse Classification	Vegetated Riparian Zone
Study Area	Dam	Stream Order 1	10m buffer from Top of Bank
Fenceline	Top of Bank	Stream Order 2	20m buffer from Top of Bank
Contour (1m)	Drainage lines	Stream Order 3	30m buffer from Top of Bank

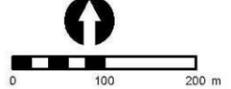
Aerial source: Google Earth Pro



PROJECT & MXD REFERENCE
 Varroville
 A13060_FF004

DATE & ISSUE NUMBER
 23/08/2013
 Issue 1

SCALE & COORDINATE SYSTEM
 1:6,500 @ A3
 GDA 1994 MGA Zone 56



TITLE
Validated Watercourses

Disclaimer: 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.

Document Path: N:\GIS STORAGE\EN Drive\A13060 Varroville\MXD\A13060_FF004.mxd

Figure 5 – Validated watercourses



Validation of Watercourses

3

An inspection of the site and its watercourses was undertaken on 27 June 2013, 2015 and 2017 to identify the presence or absence of watercourse features and to examine the impacts of the proposed works on riparian zones.

For each 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;
- the presence of flow along the stream and the associated flow velocity;
- the potential connectivity between any riparian vegetation and upstream or downstream riparian vegetation.

As identified on Figure 3, the site drains into four (4) sub-catchments as follows:

- Catchment A - 202ha consisting of three (3) sub-catchments (A1 - 48.4ha, A2- 44.8ha, A3 – 108.8ha)
- Catchment B - 35ha
- Catchment C - 175ha (small portion within site which drains into adjoining lands on the north eastern boundary)

The extent of each validated watercourse is shown on Figure 5 which also identifies drainage lines that are not watercourses. Watercourses in sub-catchment A2 are not considered as they are wholly contained within adjoining lands.

The existing topographic mapping appears to significantly over exaggerate the number of first order streams within the site and whilst swales are present they generally do not present as a stream. This is largely due to the ongoing agistment onsite and the improvement of pasture throughout.

Albeit the declassification of the watercourses within the site greater than equivalent area in riparian protection has been provided by the proposed development in the form of addition riparian offsets.

3.1 Catchment A1 – Watercourse 1

This is the lowest portion of the site with approximately 25% within the site, 50% on adjoining lands to the south west of St Andrews Road and the remaining 25% within the adjoining Crown Land. Watercourse 1 is located within the adjoining road corridor and is highly degraded. It will potentially require bank stabilisation and channel reconstruction to cater for storm flows. Buffers for watercourse 1 impact on the site and are considered in the master plan.

The inspection identified the following characteristics:

- Permanent flow, defined channels with highly incised banks;
- Sparse native riparian vegetation mostly exotic, waterlogged pasture on the flats;
- Ponding of water in channels and dams; and
- No direct vegetative connectivity downstream.

Physical evidence supports the presence of a modified third order watercourse that is capable of providing a long term vegetative link but potentially requires reconstruction, flood mitigation works and stabilisation.

3.1.1 Recommended management

Watercourse 1 is third order streams which require a 30m VRZ from top of bank. Management options include:

- Protect with a 30m VRZ from top of bank and revegetate corridor with Cumberland Plain Woodland (upper reaches) and River-flat Eucalypt Forest (lower reach on flats).
- Integrate drainage works with downstream management on Crown Lands.

3.1.2 Watercourse photos



Photo 1 – Watercourse 1 (upper portion within road reserve of St Andrews Road) facing downstream constructed channel, highly weed infested portion, however, stable

3.1.3 Drainage lines

There were no further drainage lines observed within the study area of catchment A1.

3.2 Catchment A3 – Watercourses 2, 3, 4, 5, 6, 7 & 8, Dams 2, 3, 4, 5, 6, 7, 8 & 9 and associated drainage lines

Figure 3 identifies Watercourse 2 as a third order stream. Watercourses 3, 4, 5, 6, 7 and 8 are identified as second order streams based on the existing topographic mapping (Figure 3). Based on the catchment size and presence of channelisation, this classification is appropriate.

The inspection identified the following watercourse features:

- Two (2) large online dams built with functional spillways (Dams 2 and 4);
- Three offline dams, Dams 7 & 8 are stable and usable in current condition, Dam 9 is very small and does not hold significant water;
- Topographic mapped first order streams (Figure 3) have been highly modified by long term grazing and present as swales within improved pasture (see section 3.2.3);
- Dams 2, 3 & 6 are online but stable with low weed infestation;
- Presence of a defined channel in the lower and upper reaches which appeared to have intermittent flows;
- Scattered remnant native trees hugging creek particularly on the lower reaches adjoining St Andrews Road;
- Mostly stable stream bed, often stabilised with weeds and Kikuyu;
- Mostly pasture species in Watercourse 4 but increasing native vegetation upstream in Watercourses 7 & 8, with low levels of weed infestation. The adjoining vegetated landscape upstream of Watercourse 8 is dominated by African Olive in the understorey;
- Low weed levels within the dams but moderate levels of weed infestation in the riparian vegetation; and
- Dams show high turbidity levels due to stock access and erosion from upper slopes.

Physical evidence supports the presence of a moderately watercourses which are mostly stable, however, lacking good native riparian vegetation. Sufficient canopy and ground covers are present in the lower reaches to regenerate Cumberland Plain Woodland with assisted revegetation works. Resilient remnant Cumberland Plain Woodland in upper reaches of Watercourses 7 & 8.

3.2.1 Recommended management

Watercourses 4, 7 & 8 contain three (3) online dams and mostly present as first order streams however the mapped stream order has been retained. Dams 2 & 3 are interconnected by a spillway and Dam 6 is located at the upstream end of Watercourse 7. This results in a highly controlled flow regime below Dam 2 which will generally only flow after a significant rainfall event which overtops the dams. Dam 7 is located high in the catchment which is linked by a grassed swale.

Watercourses 3, 5 & 6 are also similarly controlled by Dams 4 & 5 which result in intermittent flows.

Management options include:

- Retain Dams 2, 3, 4, 5 & 6 as an online storage protected with a 10m VRZ from top of bank;
- Stabilise spillway of Dam 2;
- Retain Dam 8 as an offline storage – target weed control required on banks to remove Blackberry;
- Remove Dam 9 or convert to a landscape feature (masterplan intends to retain it);

- Dam 7 is proposed to be removed;
- Protect Watercourse 2 with a 30m VRZ from top of bank and progressively revegetate corridor with Cumberland Plain Woodland;
- Protect Watercourses 3, 5 & 6 with a 20m VRZ from top of bank and progressively revegetate corridor with Cumberland Plain Woodland;
- Topographic mapped first order streams (Figure 3) have been highly modified by long term grazing and present as swales within improved pasture (see section 3.2.3);
- Target weed control required to promote regeneration of native species;
- Watercourse channels to be stabilised with native sedge species; and
- All nominated drainage lines are to be incorporated into the general landscape and are to be kept stable at all times with 100% grass cover.

3.2.2 Watercourse and dam photos

Note all site photos were taken after heavy rainfall and clearly indicate flowpaths, however channelization was not evident on the ground for the majority of the first order streams which present as grassed swales.



Photo 2 – Watercourse 2 (extension of Watercourse 1) St Andrews Road culvert showing dense *lantana* and *African Olive* understorey



Photo 3 – Watercourse 3 with defined channel (intermittent flows)



Photo 4 – Watercourse 4, intermittent channel with a wide grassed channel (minor flows after heavy rainfall)



Photo 5 – Watercourse 5, a wide grass swale in excess of 20m in width (intermittent flows)



Photo 6 – Watercourse 6 within site, upstream of Dam 5



Photo 7 – *Watercourse 6, upstream of site and beyond western boundary after heavy rains*



Photo 8 – *Watercourse 7, intermittent channel with a wide grassed channel after heavy rains*



Photo 9 – Watercourse 8 with shallow pools after heavy rains



Photo 10 – Dam 2 (approx. 5000m²)



Photo 11 – Spillway for Dam 2 - requires stabilisation



Photo 12 – Dam 3 (approx. 4100m²) (Source Google Earth Pro 2013)



Photo 13 – Dam 4 (approx. 9,950m²)



Photo 14 – Dam 6 (approx. 2,750m²)



Photo 15 – Dam 7 (approx. 1,200m²) (Source Google Earth Pro 2013)



Photo 16 – Dam 5 (approx. 5,100m²)



Photo 17 – Dam 8 (approx. 1,300m²) and Dam 9 (approx. 120m²) (Source Google Earth Pro 2013)

3.2.3 Drainage lines 4, 5, 6, 7, 8, 9, 10, 11, 12 & 13

Drainage lines 4, 5, 6, 7, 8, 9, 10, 11, 12 & 13 were mapped as first order streams but are confirmed by ground truthing as not being watercourses. This is demonstrated by lack of defined channels and lack of ponded or concentrated surface runoff after heavy rainfall.



Photo 18 – Drainage line 4, grassed swale with no evidence of drainage < 12 hours after heavy rain



Photo 19 – Drainage line 5, grassed swale with no evidence of drainage < 12 hours after heavy rain



Photo 20 – Drainage line 6, grassed swale with no evidence of drainage < 12 hours after heavy rain



Photo 21 – Drainage lines 7 & 8 junction, grassed swale with no evidence of drainage < 12 hours after heavy rain



Photo 22 – Drainage line 9, grassed swale with no evidence of drainage < 12 hours after heavy rain



Photo 23 – Drainage line 10, grassed swale with no evidence of drainage < 12 hours after heavy rain



Photo 24 – Drainage line 11, grassed swale with small dam at head no evidence of drainage < 12 hours after heavy rains



Photo 25 – Drainage line 12, grassed swale with light surface drainage
< 12 hours after heavy rains



Photo 26 – Drainage line 13, grassed swale with small dam at head no evidence of drainage
< 12 hours after heavy rains

3.3 Catchment B – Watercourses 9, 10 and 11, Dams 10 & 11 and associated drainage lines

Watercourse 9 is mapped as a second order stream and Watercourses 10 & 11 are mapped as first order streams in accordance with topographic mapping. The inspection identified the following watercourse features:

- Presence of a deep channels on Watercourses 10 & 11, immediately above Dam 11 which has evidence of past erosion;
- Stable grassed swales which extend upslope with intermittent flow;
- Watercourse 10 with significant bed erosion, canopy of Cumberland Plain Woodland and an understorey densely infested by African Olive and Box Thorn;
- Watercourse 9 is deeply incised but stable with a head cut at the top most point of the mapped watercourse being kept in check by a remnant tree but will require stabilisation;
- Portions of the mapped first order streams (Figure 3) present as grassed swales and did not carry any significant drainage after heavy rainfalls (See Section 3.3.3);
- Dam 11 is stable with ornamental waterlilies;
- Dam 10 is small and has been breached in the main wall but still holds water with no freeboard; and
- Water flows via spillway on north eastern aspect of dam through a grassed swale, water course becomes more defined in lower reaches as indicated by the remnant canopy.

Physical evidence supports the presence of a highly degraded watercourse with a small catchment area. It has low ecological value and suits a first order stream, however, in accordance with *NSW Guidelines for Controlled Activities of Waterfront Lands*, it has been mapped as a second order stream below the existing dam. Alternative management solutions are appropriate for Watercourses 9, 10 & 11 due to presence of unstable banks and intermittently defined channels and small catchment size.

3.3.1 Recommended management

The following works are recommended:

- Retain Dam 11 as an ornamental feature and stormwater control;
- Dam 10 should be filled and reconstructed to a drainage channel;
- Reconstruct and stabilise Watercourses 10 and 11 and revegetate with Cumberland Plain Woodland; and
- All nominated drainage lines are to be incorporated into the general landscape and are to be kept stable at all times with 100% grass cover.

3.3.2 Watercourse photos



Photo 27 – Watercourse 9 (lower reach)



Photo 28 – Watercourse 10, deep incised gully held in check by remnant native canopy and weeds



Photo 29 – Watercourse 11, looking upstream



Photo 30 – Dam 11 (approx. 5,200m²) (Source Google Earth Pro 2013)



Photo 31 – Dam 10 (approx. 650m²)

3.3.3 Drainage lines 1, 2 & 3

Drainage lines 1, 2 and 3 are confirmed by ground truthing as not being watercourses:



Photo 32 – Drainage line 1, site inspection revealed a grass swale below a small breached Dam 12 with no defined channel on the adjoining Lot (offsite)



Photo 33 – Drainage line 2, no evidence of channelisation or drainage after heavy rains



Photo 34 – Drainage line 3 looking downstream to Watercourse 10, grassed swale with no evidence of any surface drainage <12 hours after heavy rain

3.4 Catchment C – Drainage lines 14 & 15

Both drainage lines were mapped as a stream on 1:25000 topographic maps sheets, both were inspected for evidence of watercourses. Neither mapped stream showed evidence of channelisation and were the uppermost extent of the adjoining catchment.

3.4.1 Recommended management

All nominated drainage lines are to be incorporated into the general landscape and are to be kept stable at all times with 100% grass cover.

3.4.2 Drainage lines 14 & 15

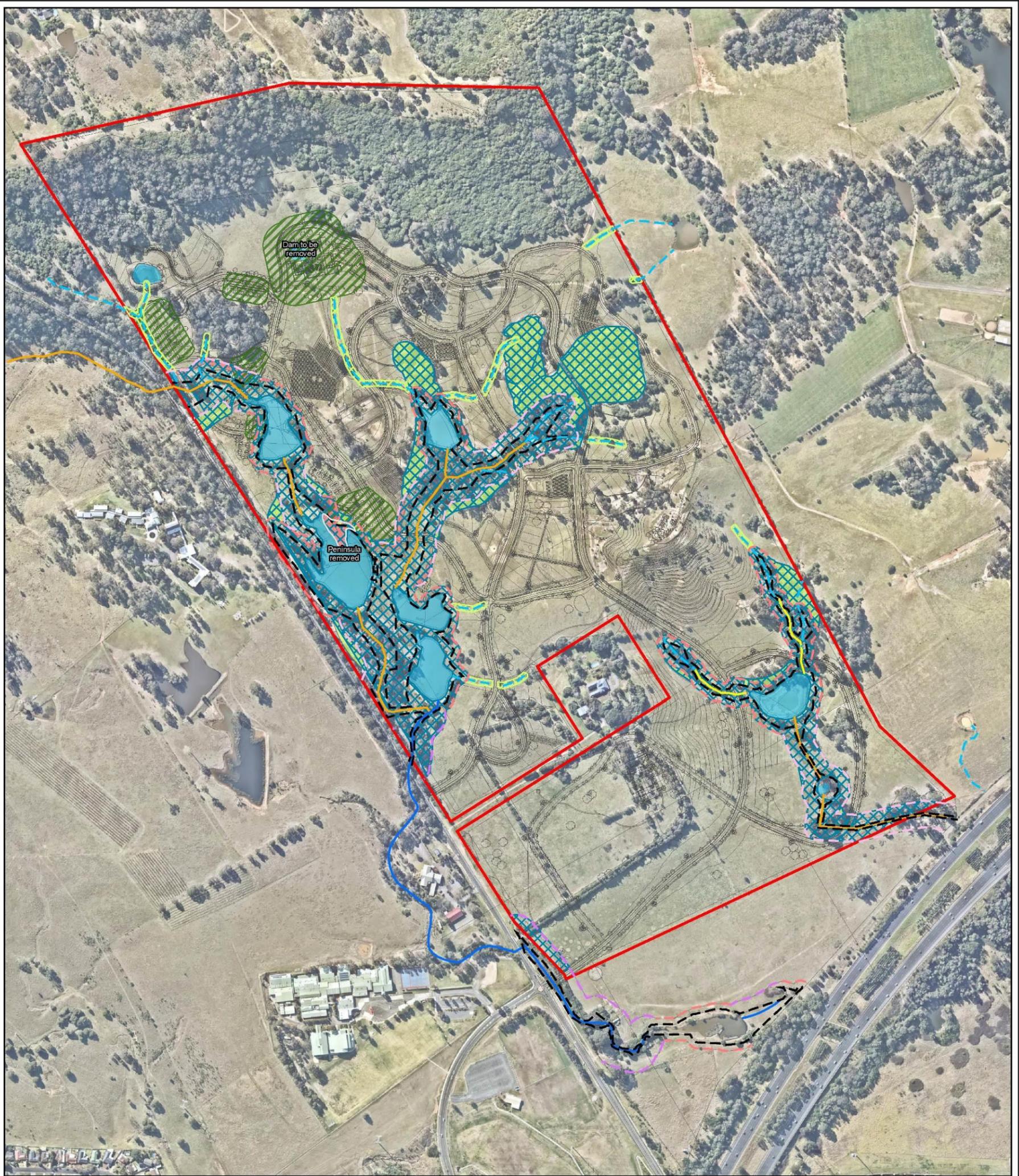
Drainage lines 14 & 15 are confirmed by ground truthing as not being watercourses.



Photo 35 – Drainage line 14, grassed swale with no evidence of drainage < 12 hours after heavy rain



Photo 36 – Drainage line 15, grassed swale with no evidence of drainage < 12 hours after heavy rain



Legend			
	Site boundary		Asset Protection Zone (APZ)
	Peninsula removed (0.14ha)		Riparian loss (0.56 ha)
	Drainage line		Riparian offset (4.45 ha)
	Top of bank		Riparian Protection Zone (17.65 ha)
Watercourse Classification			Turfed drainage swale (0.99 ha)
	1st order stream		
	2nd order stream		
	3rd order stream		
Vegetated Riparian Zone			
	10m buffer from top of bank		
	20m buffer from top of bank		
	30m buffer from top of bank		

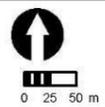
Aerial source: Nearmap



PROJECT & MXD REFERENCE
 Varroville
 A16228_RIP001

DATE & ISSUE NUMBER
 3/07/2018
 Issue 1

SCALE & COORDINATE SYSTEM
 1:6,000 @ A3
 GDA 1994 MGA Zone 56



TITLE
Proposed Riparian Zones (Overview)

Disclaimer: 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.

Document Path: N:\GIS STORAGE\EN Drive\A16228 - StAndrews\rd Varroville\MXDs\A16228_RIP001.mxd

Figure 6 – Proposed riparian zones



Riparian Buffers & 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 Office of Water *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* 2012). 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 3;
- Seek to maintain or rehabilitate a riparian corridor / vegetated riparian zone with fully structured native vegetation in accordance with Table 3;
- 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; and
- Treat stormwater run-off before discharging into the riparian corridor / VRZ.

WaterNSW however, does allow for a range of works and activities on waterfront land and in riparian corridors 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 carried out in, on or under waterfront land are regulated by the *WM Act*. WaterNSW 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 from WaterNSW before commencing the controlled activity.

WaterNSW has developed *Controlled Activity Guidelines* (2012) to assist applicants who are considering carrying out a controlled activity on waterfront land (Appendix I). On 1 July 2012 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. 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 undertake non-riparian corridor works or development within the outer 50% of a VRZ, as long as they offset this activity by connecting an equivalent area to the riparian corridor within the development site; and
- The riparian corridors matrix enables applicants to determine what activities can be considered in riparian corridors.

As stated in the *Controlled Activity Guidelines* for the preparation of VMPs, a riparian corridor 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; and
- 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.

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

WaterNSW recommends a VRZ width based on watercourse order as classified under the Strahler System of ordering watercourses and using current 1:25 000 topographic maps (see Figure 2, 5 and Table 3). The width of the VRZ should be measured from the top of the highest bank on both sides of the watercourse (*Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* 2012).

Figure 5 - The Strahler System

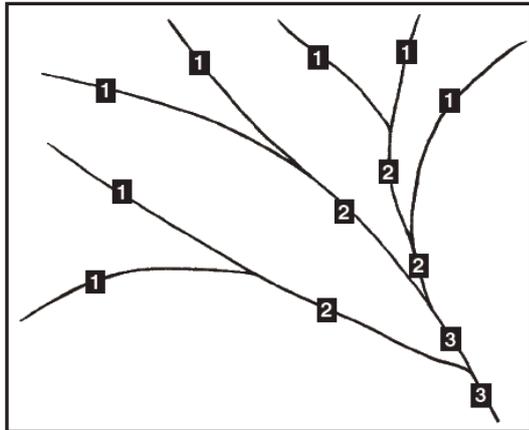


Table 3 - Recommended riparian corridor widths

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

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 Controlled Activity Guidelines is subject to the approval by WaterNSW and the development consent authority. Consequently, alternative solutions are assessed by WaterNSW 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, WaterNSW may determine that the watercourse is not waterfront land for the purposes of the *WM Act*.

The proposed riparian setbacks are consistent with the *Guidelines for Controlled Activities on Waterfront Lands (2012)*. 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, spacings 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 4 - 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 *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* (2012), non-riparian uses, such as APZs are allowed within the outer 50% of the vegetated riparian zone, as long as 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 riparian corridor.

Other proposed activities such as cycleways, paths, detention basins, stormwater outlet structures and essential services and stream realignment are permissible in accordance with the *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land* (2012).

In accordance with Figure 7, two buildings are proposed within the 10m riparian protection zone adjacent to dams, and one building is proposed adjoining a second order stream. Asset protection zones will also be required for these buildings which will potentially impact on the riparian protection zone.

Where buildings are adjacent to mapped first order stream, the building and associated APZ are not to encroach within 10m of the top of bank as a minimum standard. Where the proposed building and APZ impact on mapped riparian protection zone for a second order stream or higher, then the proposed building and associated APZ are not to encroach within 50% of the mapped riparian protection zone. Therefore in the case of a second order stream with a 20m riparian protection zone from top of bank, a minimum 10m riparian protection zone is to be provided with an equivalent area riparian protection offset.

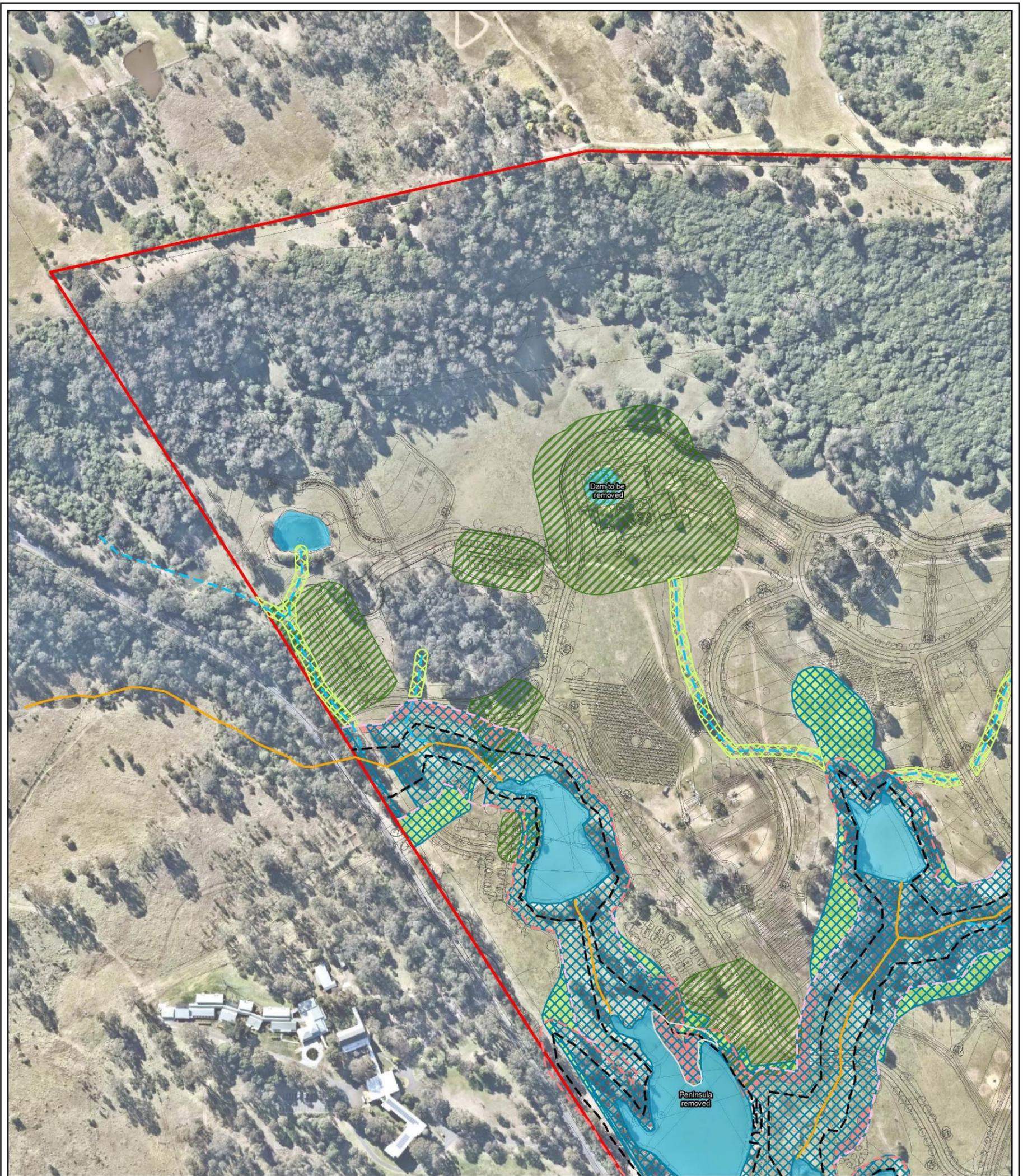
Where a building is proposed adjoining an existing on-line dam, then a building is recommended to be set back to 10m from top of bank in accordance with the NSW Controlled Activity Guidelines. Other structures such as pathways maybe approved at the discretion of WaterNSW with equivalent area riparian protection offsets.

4.5 Proposed stormwater works

Figure 6 - proposed riparian management for the Masterplan (overview) shows the location of proposed stormwater works and devices. Detailed zooms within the riparian zone are provided below in Figures 7, 8, 9 & 10. The structures are mapped indicatively only and it is fully expected detailed designs will be produced for the purposes of a controlled activity approval.

In all cases the installation of devices within corridors are to be in accordance with the *Guidelines for Controlled Activities on Waterfront Lands (2012)*.

The proposed devices and outlets do not present a significant impact on riparian corridor and can be installed appropriately with stabilisation and restoration of any riparian vegetation.



Legend		
Site boundary	Watercourse Classification	Asset Protection Zone (APZ)
Peninsula removed (0.14ha)	1st order stream	Riparian loss (0.56 ha)
Drainage line	2nd order stream	Riparian offset (4.45 ha)
Top of bank	3rd order stream	Riparian Protection Zone (17.65 ha)
	Vegetated Riparian Zone	Turfed drainage swale (0.99 ha)
	10m buffer from top of bank	
	20m buffer from top of bank	
	30m buffer from top of bank	

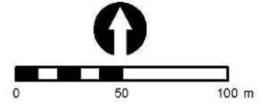
Aerial source: Nearmap



PROJECT & MXD REFERENCE
Varroville
 A16228_RIP001

DATE & ISSUE NUMBER
 3/07/2018
 Issue 1

SCALE & COORDINATE SYSTEM
 1:3,000 @ A3
 GDA 1994 MGA Zone 56

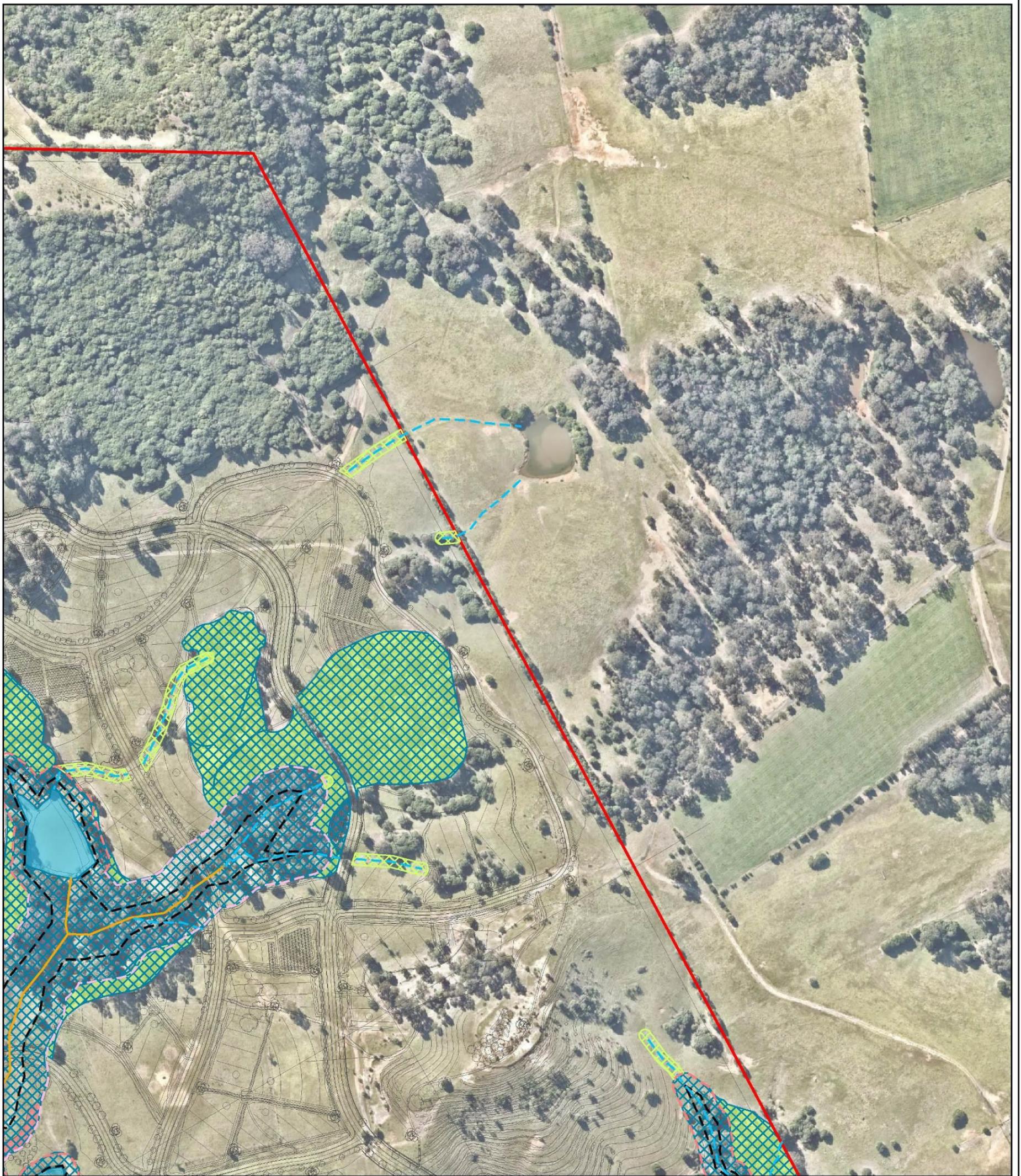


TITLE
Proposed Riparian Zones (Zoom 1)

Disclaimer: 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.

Document Path: N:\GIS STORAGE\EN Drive\A16228 StAndrewsRd Varroville\MXD\A16228 RIP001.mxd

Figure 7 – Proposed riparian management for Masterplan (Zoom 1)



Legend		
Site boundary	Watercourse Classification	Asset Protection Zone (APZ)
Peninsula removed (0.14ha)	1st order stream	Riparian loss (0.56 ha)
Drainage line	2nd order stream	Riparian offset (4.45 ha)
Top of bank	3rd order stream	Riparian Protection Zone (17.65 ha)
	Vegetated Riparian Zone	Turfed drainage swale (0.99 ha)
	10m buffer from top of bank	
	20m buffer from top of bank	
	30m buffer from top of bank	

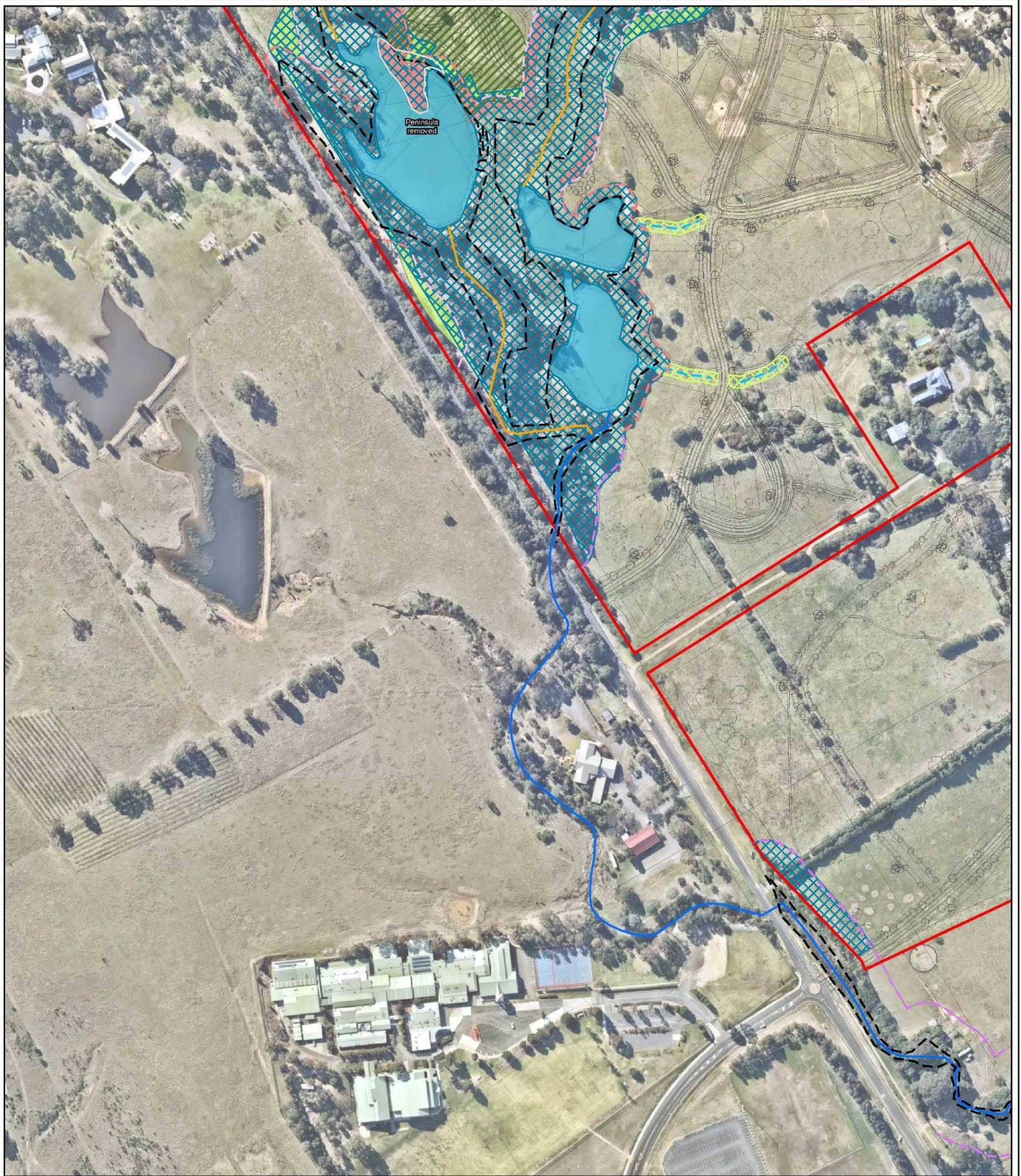
Aerial source: Nearmap

	PROJECT & MXD REFERENCE Varroville A16228_RIP001	DATE & ISSUE NUMBER 3/07/2018 Issue 1	SCALE & COORDINATE SYSTEM 1:3,000 @ A3 GDA 1994 MGA Zone 56	
	TITLE Proposed Riparian Zones (Zoom 2)			

Document Path: N:\GIS_STORAGE\Drive\A16228_S\AndrewsRd_Varroville\MXD\A16228_RIP001.mxd

Disclaimer: 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.

Figure 8 – Proposed riparian management for Masterplan (Zoom 2)



Legend		
Site boundary	Watercourse Classification	Asset Protection Zone (APZ)
Peninsula removed (0.14ha)	1st order stream	Riparian loss (0.56 ha)
Drainage line	2nd order stream	Riparian offset (4.45 ha)
Top of bank	3rd order stream	Riparian Protection Zone (17.65 ha)
	Vegetated Riparian Zone	Turfed drainage swale (0.99 ha)
	10m buffer from top of bank	
	20m buffer from top of bank	
	30m buffer from top of bank	

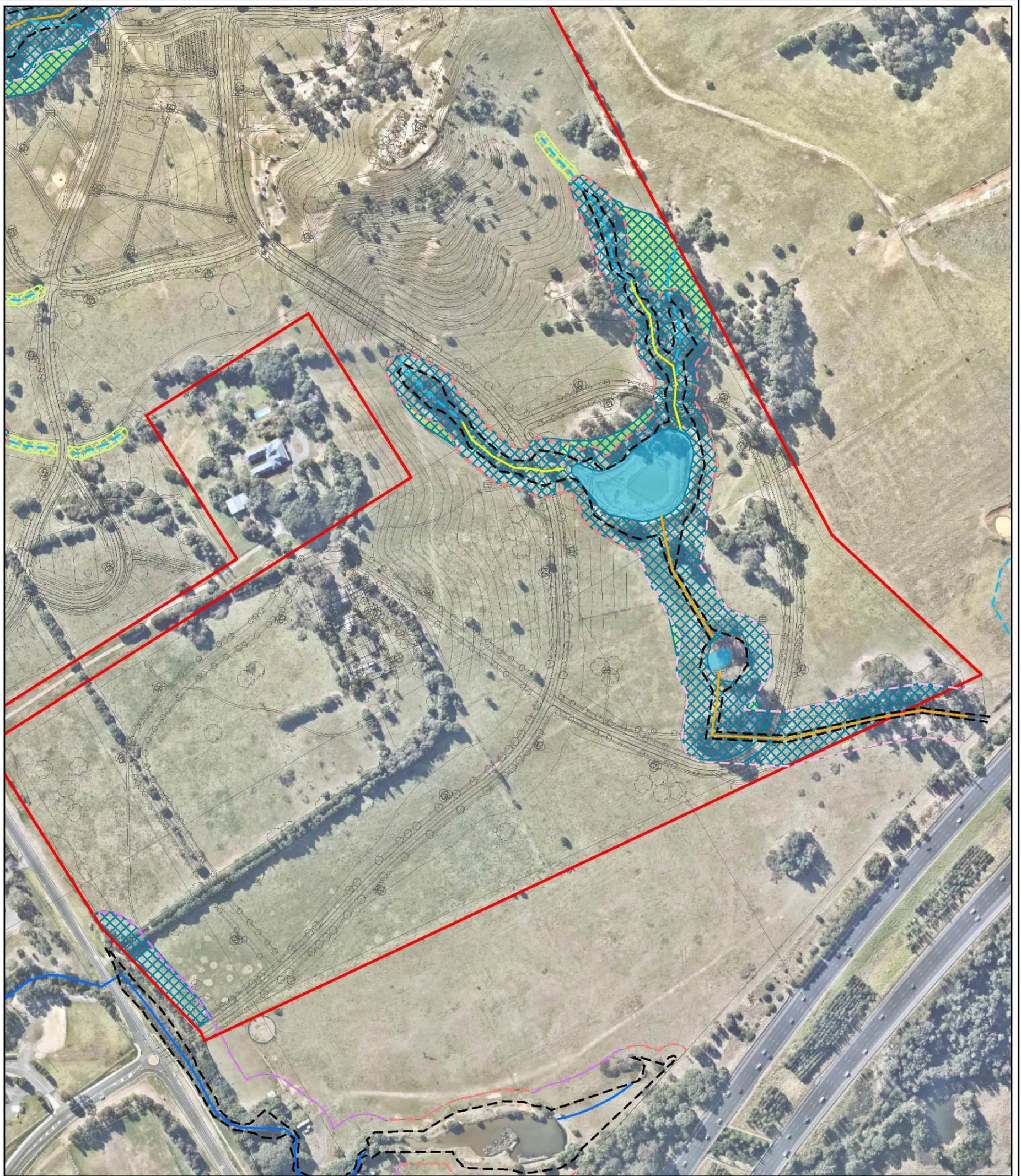
Aerial source: Nearmap

	PROJECT & MXD REFERENCE Varroville A16228_RIP001	DATE & ISSUE NUMBER 3/07/2018 Issue 1	SCALE & COORDINATE SYSTEM 1:3,000 @ A3 GDA 1994 MGA Zone 56	
	TITLE Proposed Riparian Zones (Zoom 3)			

Document Path: N:\GIS_STORAGE\Drive\A16228_S\AndrewsRd_Varroville\MXD\A16228_RIP001.mxd

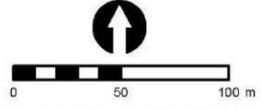
Disclaimer: The mapping is indicative of available space and location of features which may prove critical in assessing the viability of the proposed works. Mapping has been produced on a map base with an inherent level of inaccuracy, the location of all mapped features are to be confirmed by a registered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

Figure 9 – Proposed riparian management for Masterplan (Zoom 3)



Legend <ul style="list-style-type: none"> ▬ Site boundary Peninsula removed (0.14ha) ▬ Drainage line - - - Top of bank 	Watercourse Classification <ul style="list-style-type: none"> ▬ 1st order stream ▬ 2nd order stream ▬ 3rd order stream 	<ul style="list-style-type: none"> Asset Protection Zone (APZ) Riparian loss (0.56 ha) Riparian offset (4.45 ha) Riparian Protection Zone (17.65 ha) Turfed drainage swale (0.99 ha)
Vegetated Riparian Zone <ul style="list-style-type: none"> - - - 10m buffer from top of bank - - - 20m buffer from top of bank - - - 30m buffer from top of bank 		

Aerial source: Nearmap

	PROJECT & MXD REFERENCE Varroville A16228_RIP001	DATE & ISSUE NUMBER 3/07/2018 Issue 1	SCALE & COORDINATE SYSTEM 1:3,000 @ A3 GDA 1994 MGA Zone 56	
	TITLE Proposed Riparian Zones (Zoom 4)			

Disclaimer: 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.

Figure 10 – Proposed riparian management for Masterplan (Zoom 4)



Conclusions and Recommendations

5

Based on ground truthing, this report identifies that watercourses do affect the site within Lot 1 DP 218016, Lot B DP 370979 & Lot 22 DP 564065, 166-176 St. Andrews Road, Varroville.

The watercourses are grouped into three (3) catchments including:

- Western watercourses – Catchment A consisting of second and third order streams divided into 3 sub-catchments.
- South eastern watercourses – Catchment B consisting of first and second order watercourse and associated drainage line.
- North eastern watercourses – Catchment C affecting only drainage lines.

The classification of field validated watercourses is illustrated on Figure 3. The watercourses are partially degraded i.e. lack riparian vegetation but are on the whole stable. Watercourses 10 & 11 are highly degraded and have evidence of bed cutting.

Ongoing management of the site's riparian zones will generally be in accordance with the *Controlled Activity Guidelines for Riparian Corridors* as issued by the NSW Office of Water and the issued General Terms of Approval.

In accordance with the NSW Controlled Activity Guidelines, the following riparian protection zones apply:

- First order streams – 10 m from top of bank
- Second order streams – 20m from top of bank
- Third order streams – 20m from top of bank

As 'on-line' dams form part of the watercourse they are contained with waterfront land and approval from WaterNSW is required for any works within waterfront land. *Travers bushfire & ecology* recommends a riparian protection zone of 10m from top of bank be applied for any buildings. For 'off-line' dams – no protection zone is required.

In accordance with the *Controlled activities on waterfront land - Guidelines for Riparian Corridors on Waterfront Land (2012)*, non-riparian uses are allowed within the outer 50% of the vegetated riparian zone, as long as 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 riparian corridor. An equivalent area riparian corridor offset has be provided for any losses of riparian protection zone (Table 5).

The placement of buildings and any other non-riparian corridor uses are to be in accordance with the Table 4 - Riparian corridor matrix and the 'Averaging Rule' of the NSW Controlled Activity Guidelines (2012).

Riparian offsets have been provided for:

- Impacts within the riparian zone for various works
- Loss of first order streams(drainage lines) within the site

In accordance with this assessment the pre and post development area of riparian zones provided is as follows:

Table 5 – Riparian protection pre and post development

Pre & post development area of riparian zones	Area (Ha)
Pre development area of mapped riparian zones (inclusive of all dams)	20.49ha
Post development area of protected riparian zones (inclusive of all dams and RZ offsets)	22.10ha
Net Gain or loss (ha)	Gain of 1.61ha

Travers bushfire & ecology concludes that the proposed masterplan has provided a net gain in riparian protection and revegetation including native vegetation protection zones immediately adjoining the riparian corridors.

A vegetation management plan (VMP) has been prepared for all riparian corridors 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.