SOILANDWATER

TRAIL MANAGEMENT PLAN

JUMPING CREEK ESTATE

QUEANBEYAN NSW

Version 5

30 May 2019

FRANKLIN CONSULTING AUSTRALIA PTY LIMITED

abn 59 611 394 953
www.soilandwater.net.au

SOILANDWATER

OUR COMPANY

Franklin Consulting Australia Pty Limited, trading as Soil and Water, offers expert advice and services to the agriculture, development and environmental conservation sectors. We provide soil and water management advice, undertake land capability and soil assessment, erosion and sediment control, and soil conservation, catchment and property management planning. We have extensive experience in both government and private sectors in senior management and consulting roles.

We provide our services to individual land holders, sub-division developers, surveyors, commercial business owners, and land development and regulatory agencies.

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EXECUTIVE SUMMARY

Soil and Water (Franklin Consulting Australia Pty Limited) was engaged by Peet Limited to develop a Trail Management Plan to support a housing development application for the Jumping Creek Estate within Lot 5 DP 1199045, Queanbeyan NSW. The development involves residential dwellings, with a large residual area to be dedicated as Public Reserve which will be managed for conservation purposes with provision for recreation by residents and the public.

The Jumping Creek site is approximately 96.43 ha in area and is located near the locality of Greenleigh, approximately 3km south-east of the Queanbeyan CBD. The site is described as Lot 5 DP 1199045 (Figure 1). The site is a combination of undulating and flatter land, bounded by Greenleigh Estate (zoned E4 Environmental Living) to the north-west, the Queanbeyan River to the west, and steep escarpments to the north, east and south east (parts of which lie within the Cuumbeun Nature Reserve). Most of the surrounding escarpment land is zoned E2 Environmental Conservation.

Figure 1: Lot 5 DP1199045

This Trail Management Plan is one of three reports prepared by Franklin Consulting Australia, the others being a Vegetation Management Plan and Erosion Control Plan.

The focus of the trail management plan was to identify trails to retain as part of a strategic trail network that provides access across the site to enable efficient land management activities. The strategic trails network identified will facilitate the implementation of the land and vegetation management activities in the vegetation management plan and will provide opportunity for recreational activities in these areas. In accordance with the findings of the Bushfire Assessment Report by Ember Consulting, the strategic trail network is not formally required for fire management purposes. However, it provides the relevant management authority with the potential to access the environmental areas should it be required.

Works required to upgrade the trail network to an appropriate standard are identified and detailed. Redundant trails are also identified, and rehabilitation measures proposed. Trails within the areas where housing and related infrastructure are to be constructed, have not been considered in this report. The rehabilitation of trails in these areas will be undertaken as part of the groundworks to establish the development.

A site inspection was carried out Saturday 19 January 2019 during which a trail network of 11 trails was identified. Of these four were considered to provide a strategic management function and were critical to achieving the broader land management goals for the property. The remaining 7 trails did not fulfil a strategic management or land management/access function and were therefore considered to be redundant. The redundant trails will be removed to reduce the amount of sediment generated from unsealed trails, estimated to be in the order of 9.6 tonnes / year / kilometre (based on a 4-metre wide track) as well as reduce the costs associated with maintenance.

A staged works program to upgrade trails to be retained to the required standard will further reduce the amount of sediment being generated by unsealed trails on the site, as well as ensure that the land management functions of the network are delivered efficiently. Staging is designed to deliver the land management needs of the site progressively, commensurate with the phases of development. The monitoring program will ensure that the strategic trail network is maintained to an appropriate standard that ensures the land management needs of the site are delivered and impacts on the environment related to erosion and sedimentation, are minimised.

CONTENTS

1. INTRODUCTION

1.1 SCOPE

This Trail Management Plan will:

- identify existing trails, their condition, purpose and strategic value;
- develop a strategic trail network to be developed and maintained;
- outline appropriate standards for network trails;
- specify drainage and erosion control measures to support a stable and sustainable trail network; and
- outline a monitoring and maintenance program.

Existing trails which are not identified as supporting an essential land/vegetation management function, are considered redundant. Measures required to remove and rehabilitate these trails are identified. Trails within the area to be developed for housing or related infrastructure have not been considered as these will be removed/rehabilitated when undertaking the groundworks to construct the development.

The trail management plan should be considered in conjunction with the supporting Vegetation Management Plan, Erosion Control Plan and Bushfire Assessment Report by Ember Consulting.

1.2 REFERENCES

Vegetation Management Plan, Jumping Creek, Queanbeyan, Soil and Water (2018)

Erosion Control Plan, Jumping Creek, Queanbeyan, Soil and Water (2018)

Planning for Bush Fire Protection, NSW Rural Fire Service, August 2018

Soils and Construction: Managing Urban Stormwater, NSW Government, 2004

NSW RFS Fire Trail Design, Construction and Maintenance Manual, NSW RFS 2017

Track design and management, NSW Soil Knowledge Network (Presentation P. Fogarty) June 2018

1.3 METHODOLOGY

The following methodology was used to the identify the extent and nature of the trail network required on the site:

1. Identify access and trafficability needs based on the proposed landuse and requirements for the site including:

a. Manage ecological and biodiversity values

b. Provide recreational opportunities.

2. Identify the trails which link with existing and proposed access trail and formal road network to provide for the strategic land management needs of the site.
3. Identify existing trails which do not serve a strategic land management function and are therefore redundant and a priority for removal and rehabilitation.
4. Review the final lot layout to identify trails which will be developed as part of the formal road network within the site.
5. Review the final lot layout to identify which of the redundant trails will be removed/rehabilitated as part of the groundworks to establish the housing area and associated infrastructure.
6. Undertake an audit of the trail network to identify soil and water management works required to create a suitable trail network.
7. Develop a works program which recognises the staged development and soil and water management priorities.
8. Develop a maintenance and management program to ensure the trails remain in a condition suitable to support the strategic land management needs of the site.

2. STRATEGIC TRAIL NETWORK

The strategic trail network recommended for the site includes trails which are primarily designed and located to provide for the efficient and effective land management activities required across the undeveloped areas of the site. The trail network may also provide opportunities for recreational activities such as walking and bike riding and assist in bush fire management. It is noted that in accordance with the Bush Fire Assessment Report by Ember Consulting, the formal network of edge roads, that are a feature of the proposal, provide the required level of bush fire protection and comply with the acceptable solutions set out in Planning for Bush Fire Protection PBP (2006).

The network designed provides the number of trails to support land management activities. This recognises the potential negative impacts associated with an extensive network of trails which include:

- Increased cost associated with trail maintenance
- Increased potential for land and water degradation associated with erosion and sedimentation from a network of unsealed trails impacting downstream creeks and rivers
- Increased land degradation associated with public access including rubbish dumping, weed invasion, and damaging activities such as hunting, four-wheel driving and motorcycle riding
- Increased risk of fire initiated by public access, campers and picnickers.

For example, the sediment generated by unsealed trails on the shale soil type that exists on much of the site, and on gradients consistent with much of the trail network (5 or 10% slopes) has been estimated using the Universal Soil Loss Equation below:

Site condition	R	L	S	K	C	Erosion rate (t/ha/yr)
Natural	1300	80	5%	.022	.001	0.03
Bare surface	1300	80	5%	.022	1	34.0
Bare 15cm	1300	80	5%	.026	1	40.2
Bare 15cm	1300	80	10%	.026	1	94.9

Using these estimates the sediment delivered by an unsealed trail of 4-metre width and 1-kilometre length is approximately:

1km X 4m X 24t/ha/yr = 9.6 tonnes/year

Therefore, existing trails which are not essential for land management will be removed and rehabilitated.

The strategic trail network proposed is shown in **Figure 1,** including the redundant trails for removal. The Management Trails identified will serve multiple purposes however the capacity of the network to effectively support a variety of land management and recreational purposes relies on all being upgraded and maintained to an appropriate standard.

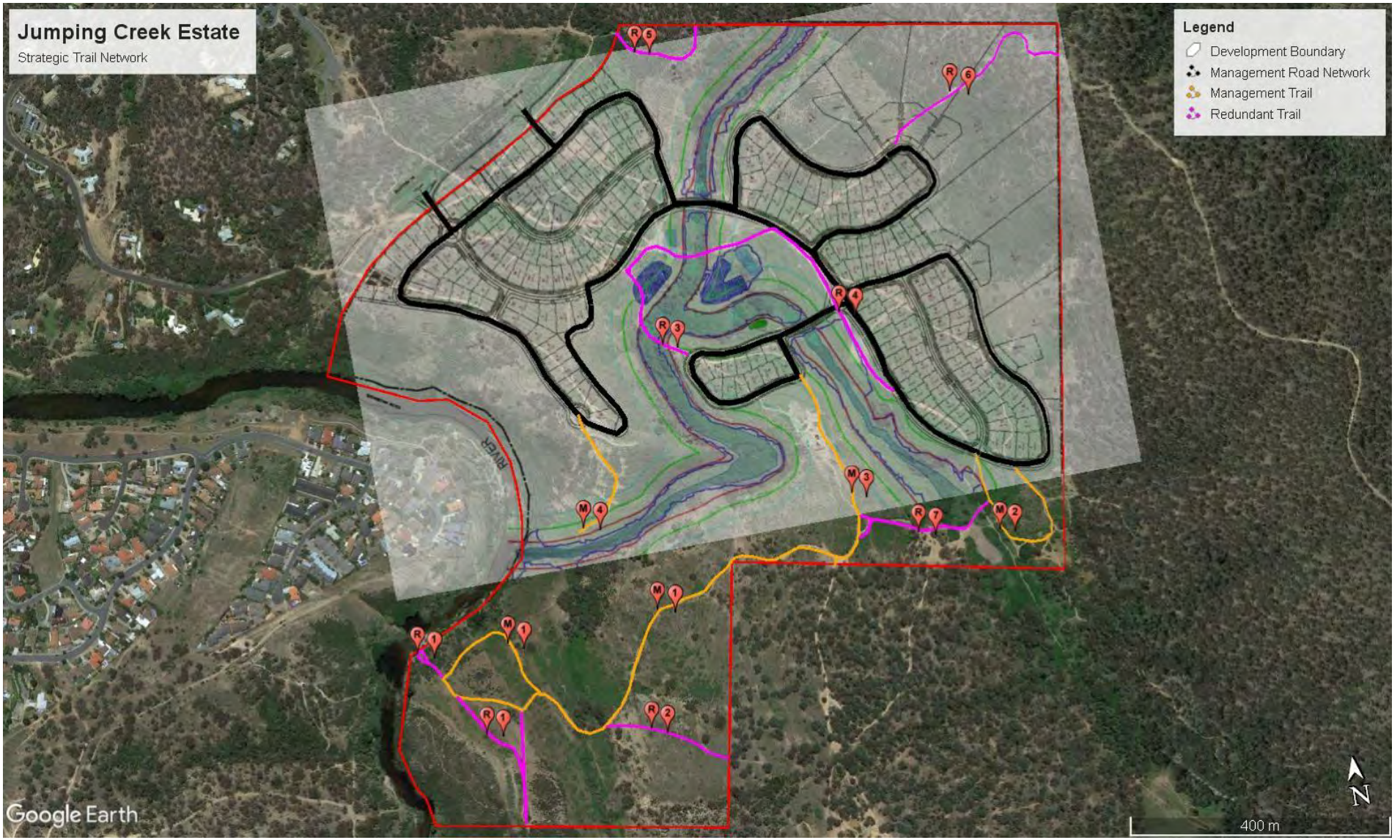


Figure 1: Strategic Trail Network

2.1 MANAGEMENT TRAIL NETWORK

The management trail network, links to the formal road network which provides perimeter protection and access to the urban lots within the development. The proposed management trails have the potential to assist bushfire management activities and during bushfire emergencies, however, they are not a formal part of the bushfire management strategy for the site.

For the purposes of this Plan the desired trail standard is consistent with **Table 1: Category 9 Fire Trail Requirements**, as detailed below. This is considered appropriate as a Category 9 appliance is a light four-wheel drive fitted with a water tank and pumping unit, which is consistent with the types of vehicles used in vegetation management activities such as weed spraying. The works program for Management Trails is generally consistent with delivering trails which meet this standard.

The Management Trail network proposed is shown in **Figure 2**.

Table 1: Category 9 Fire Trail requirements (*NSW Rural Fire Service, Fire Trail Standards – 14 August 2017*)

Requirement	Performance criteria	Acceptable solutions
Width	The width of the trail provides for safe, reliable and unobstructed passage by a Category 9 firefighting vehicle within acceptable operational limits.	The trafficable surface has a width of 3 metres except for short constrictions to 2.5 metres for no more than 30 metres in length where an obstruction cannot be reasonably avoided or removed. Curves have a minimum inner radius of 5 metres. The minimum distance between inner and outer curves is 5 metres.
Capacity	The construction and formation of the trail is trafficable under all weather conditions (other than due to flood, storm surge or snowfall) for a Category 9 firefighting vehicle.	Trail surfaces and crossing structures are capable of carrying vehicles with a gross vehicle mass of 4 tonnes and an axle load of 2 tonnes.
Grade and cross fall	The vertical profile of the trail provides for traction and safe working angle within the physical operational capability of a Category 9 firefighting vehicle. *Note: This includes design that does not impede the undercarriage of a vehicle.*	The maximum grade of a trail is not more than 15 degrees. The cross fall of the trail surface is not more than 6 degrees. Drainage structures, feature crossings, or other significant changes in the grade of the trail shall be in accordance with the *NSW RFS Fire Trail Design, Construction and Maintenance Manual*.
Clearance	A cleared corridor is provided around the trail which permits the unobstructed passage of a Category 9 firefighting vehicle	A minimum vertical clearance of 3 metres is provided above the surface of the trafficable surface clear of obstructions.

	and for a working corridor either side of the vehicle to enable firefighters to exit from, and access equipment in, the vehicle.	
Passing	The trail provides for two Category 9 firefighting vehicles to pass at appropriate intervals so as to avoid unacceptable delays in operations	Capacity for passing bays are provided every 250 metres comprising: › A widened trafficable surface of at least 5 metres for a length of at least 15 metres; or, › A 5.5-metre-wide and 6-metre long area clear of the trafficable surface with a minimum inner curve radius of 5 metres and minimum outer radius of 10 metres.
Turnarounds	The trail provides for a turning manoeuvre for a Category 9 firefighting vehicle to return in the direction from which it came at appropriate intervals and at the termination of a trail.	A turning area is provided at the termination of a trail and every 500 metres and is achieved by: › An area clear of the trafficable surface 5.5 metres wide and 6 metres deep, with a minimum inner curve radius of 5 metres and outer minimum radius of 10 metres; or › Turning circle of minimum 16 metre diameter.
Drainage	The fire trail is drained effectively to manage rainfall runoff to prevent damage to the trafficable surface.	Drainage of the trail is designed and constructed in accordance with the NSW RFS Fire Trail Design, Construction and Maintenance Manual.

The Management Trails network will enable the delivery of the ecological and biodiversity outcome detailed in the Vegetation Management Plan. These, in conjunction with the linking formal Road Network, break up the development into smaller management units which facilitate activities identified in the Vegetation Management Plan including:

- Weed control activities including noxious weed control and removal and management of environmental weeds
- Feral animal control activities including rabbit and fox control measures
- Strategic revegetation.

The proposed Management Trails will also support the implementation of the works program detailed in the Erosion Control Plan.

Trails which will support land management and access activities within the strategic trail network are shown in **Figure 2**.

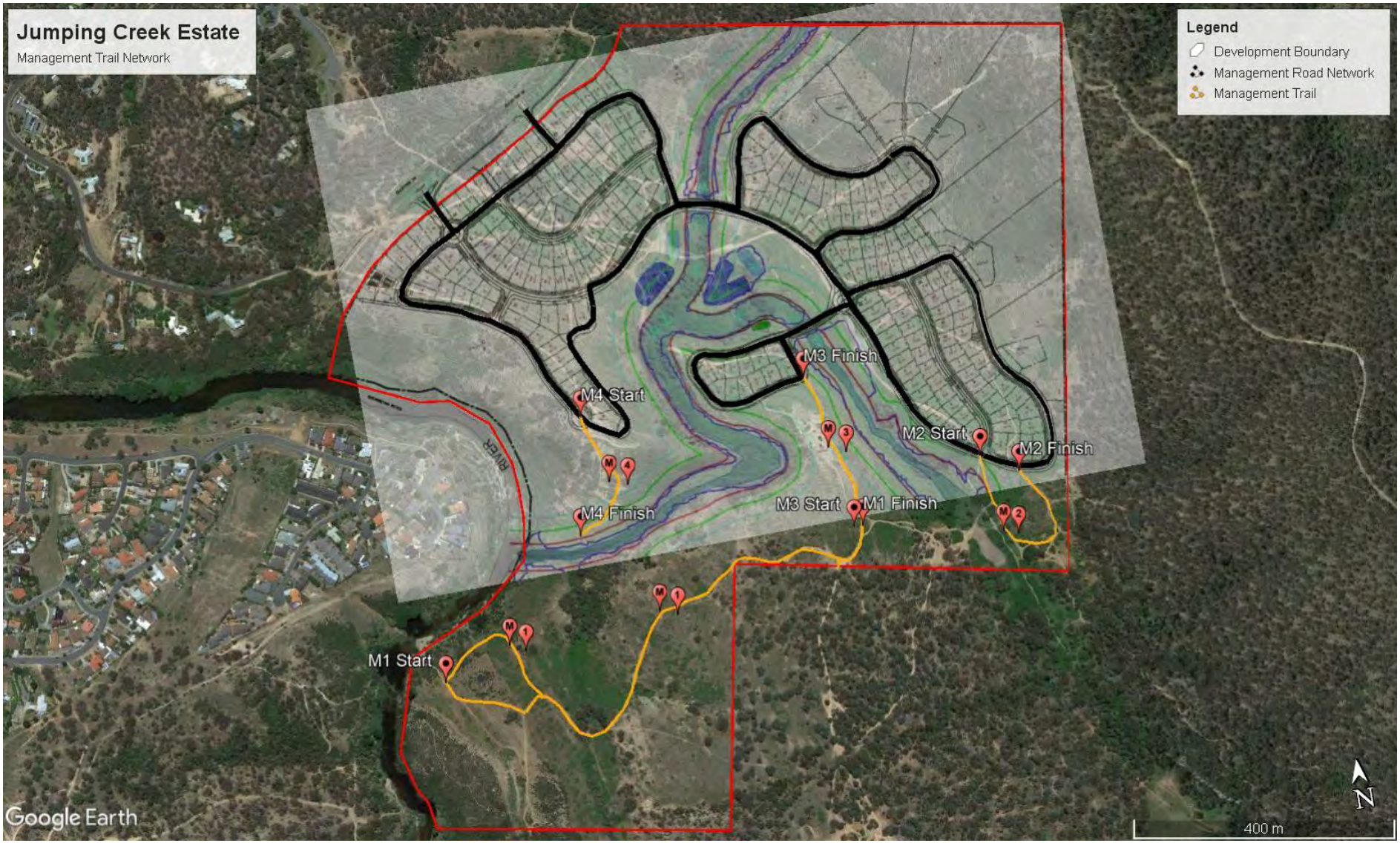


Figure 2: Management Trails

2.2 REDUNDANT TRAILS

Existing trails which are not a priority for management and access are considered redundant and will be removed and rehabilitated. Removal of the redundant trails will reduce the extent of unsealed track contributing sediment to creeks and rivers and requiring regular maintenance.

Removal and rehabilitation effort will reinstate a stable and vegetated surface with permanent soil and water management measures implemented to ensure the ongoing erosion risk is minimised.

Trails which are redundant and a priority for removal and rehabilitation are shown in **Figure 3**.

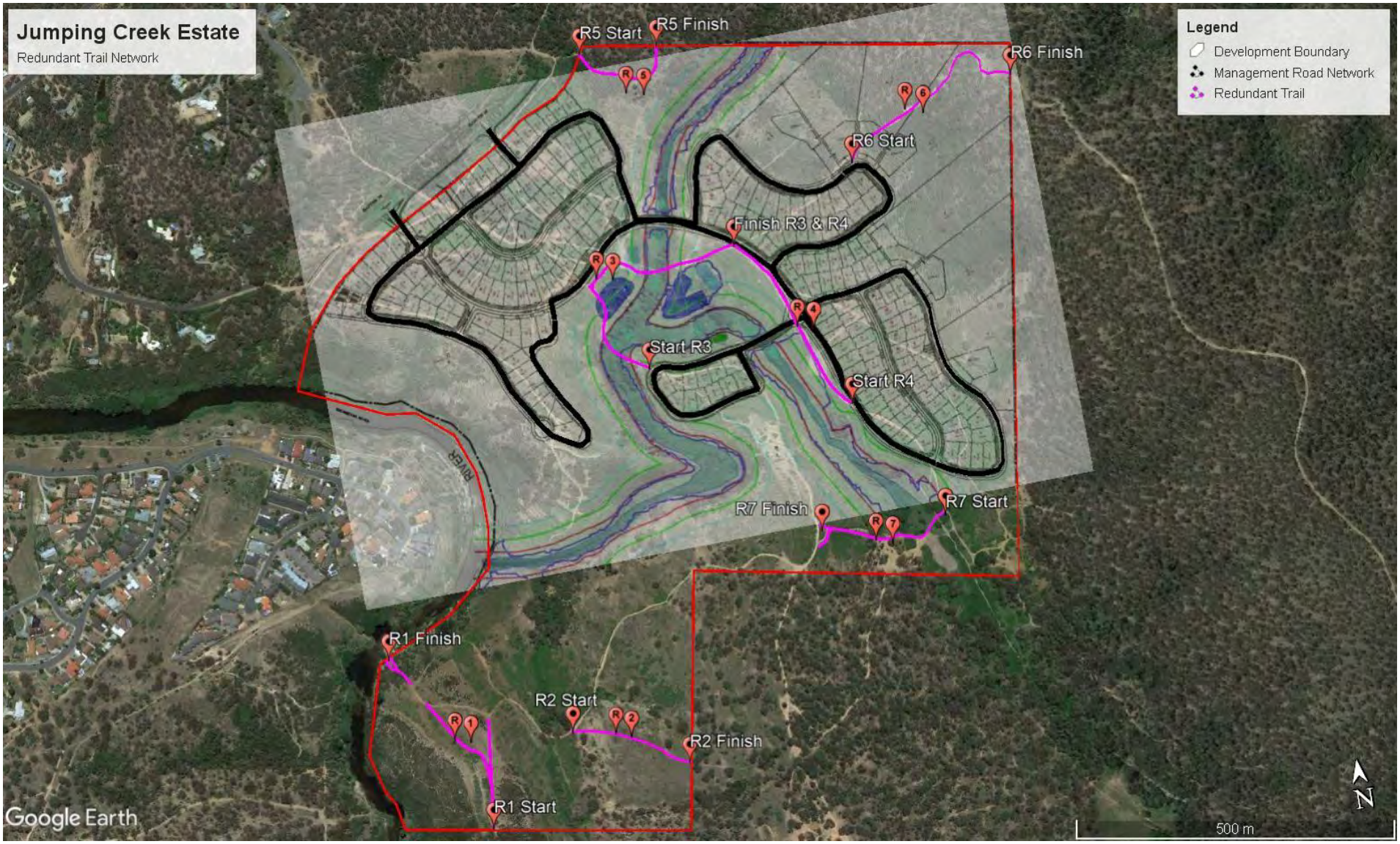


Figure 3: Redundant Trails

3. TRAIL AUDIT

MANAGEMENT TRAILS

<table>
<tr><th colspan="2">M1 - DESCRIPTION</th></tr>
<tr><th>SITE REF & LOCATION</th><th>DESCRIPTION AND SITE PICTURES</th></tr>
<tr><td>Start
Lat 35.378022
Lon 149.249556

End
Lat 35.376803
Lon 149.2569</td><td>The M1 Trail provides a strategic east-west linkage across the southern portion of the property. It provides the main connectivity through the area to be managed primarily for ecological and passive recreational activities. The trail links with the formal road network through connection with M3 at the northern end.

This is a sensitive environmental area and the Vegetation Management Plan recommends active weed and feral animal management as well as strategic revegetation. All of these activities will be facilitated by the access provided by this trail. The trail will also provide emergency vehicle access to the riparian area adjacent to the Queanbeyan River which may be a focal point for passive recreational activities.

The main section of the trail is generally in good condition. There are small sections associated with steeper grades and existing erosion, which will require significant reforming and shaping including road drainage work, refer Figures DSC 3825-7 & DSC 3799. Where the trail intersects minor drainage depressions pipe culverts will need to be installed, refer Figure 4.

The loop section of the trail is in reasonably good condition in the lower section which parallels the Queanbeyan River along the river flats and has limited definition. The moderately sloping section upslope of the river flats will require some permanent drainage works to prevent concentration of flows along rehabilitated sections.

 
DSC 3826: Relatively stable all-weather surface</td></tr>
</table>

DSC 3799: Deeply incised trail concentrating run-off

DSC 3822: Reasonably good condition trail on river flats

DSC 3823: Moderate-sloping sections upslope of the river flats require permanent drainage structures

DSC 3824: Permanent crossover banks required to limit concentration of runoff

M1	REMEDIAL WORKS

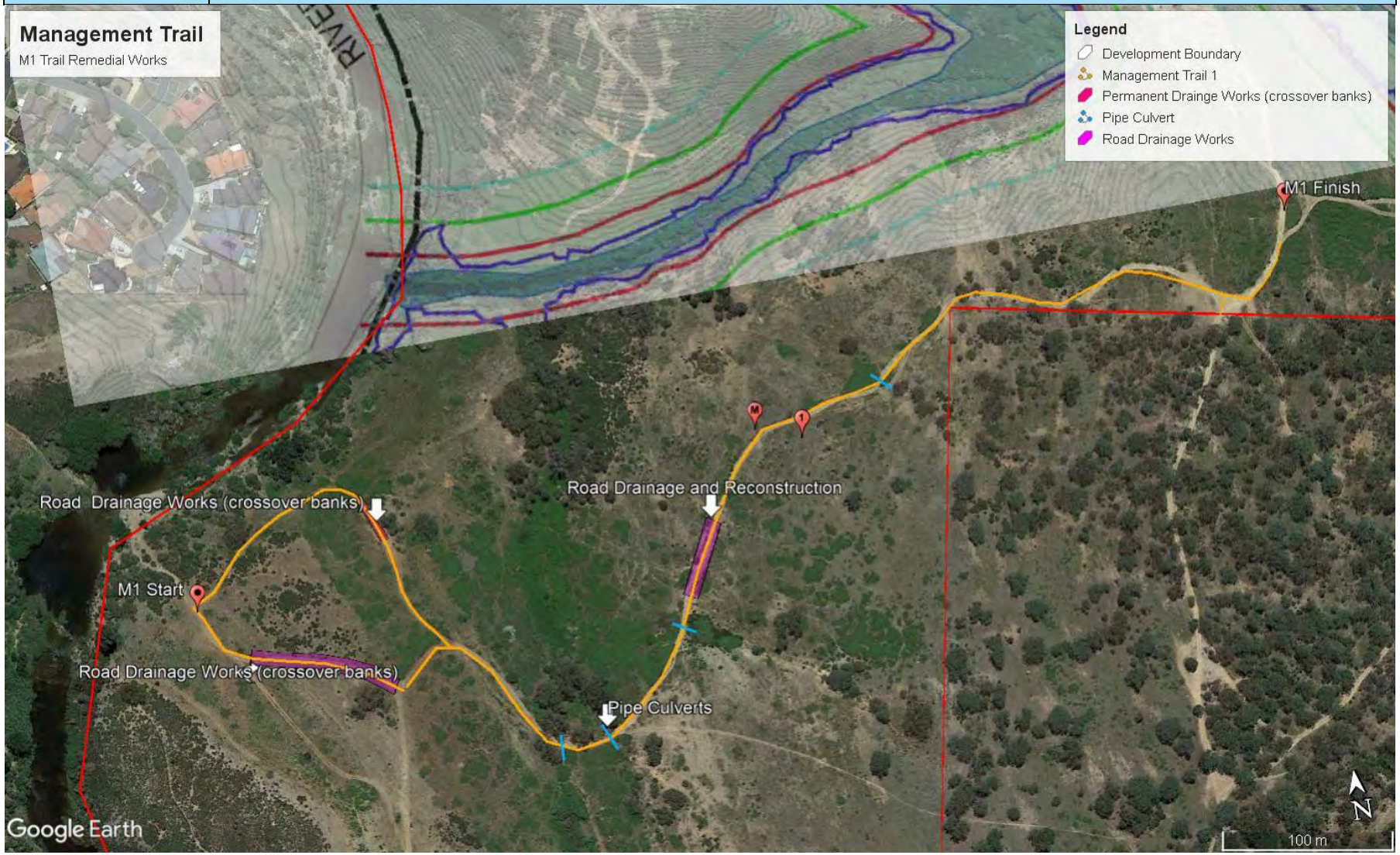


Figure 4: Trail M1 Remedial Works

<table>
<tr><th>M1</th><th>REMEDIAL WORKS</th></tr>
<tr><td>Culverts (4)
Lat 35.379039
Lon 149.251736

Lat 35.379022
Lon 149.252081

Lat 35.378503
Lon 149.252644

Lat 35.377383
Lon 149.254161</td><td>Concrete pipe culvert structures will need to be installed at all points where upslope drainage concentrates and cross Trail M1. The indicative locations for these structures are provided in Figure 4 and coordinates are provided in column 1 of this table. Additional locations requiring the installation of culverts may be identified during construction.

Pipe culverts will generally need to include concrete headwalls at upslope and downslope ends. To achieve the design culvert grades some inlets may need to be cut into the ground level. In these instances, a concrete drop inlet structure should be used to reduce the chance of erosion upstream of the structure.</td></tr>
<tr><td>Major drainage and road surfacing

SECTION 1
Start
Lat 35.377553
Lon 149.250736
End
Lat 35.377806
Lon 149.250811

SECTION 2
Start
Lat 35.378286
Lon 149.249878
End
Lat 35.378578
Lon 149.250756

SECTION 3
Start
Lat 35.378353
Lon 149.252756
End
Lat 35.377956
Lon 149.252989</td><td>There are three sections of Trail M1 that will require major reshaping and the installation of major road drainage works, refer Figure 4 and associated coordinates. These areas have eroded, are deeply rutted creating a hazard to traffic, and degrading downstream water quality due to erosion and sedimentation. The road surface needs to be reshaped to create a trafficable surface profile and road drainage structures installed including crossover banks and mitre/table drains. The design and spacing of these features should conform to the NSW RFS Fire Trail Design, Construction and Maintenance Manual. Spacing for drainage features varies depending on soil type and slope as explained below.

<table>
<tr><th>Road Grade</th><th>Soil Class A</th><th>Soil Class B</th><th>Soil Class C</th><th>Soil Class D</th></tr>
<tr><td>Up to 14% (8°)</td><td>70 to 90m</td><td>60 to 70m</td><td>20 to 30m</td><td>*</td></tr>
<tr><td>14 - 21% (8°-12°)</td><td>60 to 70m</td><td>50 to 60m</td><td>*</td><td>*</td></tr>
<tr><td>21-28% (12°-16°)</td><td>40 to 60m</td><td>*</td><td>*</td><td>*</td></tr>
<tr><td>28-36% (16°-20°)</td><td>30 to 40m</td><td>*</td><td>*</td><td>*</td></tr>
<tr><td>36-40% (20°-22°)</td><td>20m</td><td>*</td><td>*</td><td>*</td></tr>
</table>
Class A soils are stable, well aggregated with low potential to erode

Class B soils are coarse grain / sandy, have weaker structure throughout, are erodible but, because they are coarse grained, sediment doesn't travel far

Class C soils have medium to fine grain B horizon, are relatively stable but, because they have a high silt and/or clay content, their sediment will travel much further than Class B soil sediment.

Class D soils are highly erosive and dispersive and because they also have a high silt and clay content pose the greatest hazard.</td></tr>
<tr><td>All weather surface

Start
Lat 35.378022
Lon 149.249556
End
Lat 35.376803
Lon 149.2569</td><td>The entire length of Trail M1 should be trafficable in all-weather conditions. There are some sections of the trail where the shale /bedrock substrate provides an all-weather surface naturally, but for much of the trail a suitable gravel surface will need to be laid. This will also make the trail more useable for recreational purposes such as walking and bike riding, as well as making the trail more resilient to future erosion.</td></tr>
</table>

M2 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
Start Lat 35.376108 Lon 149.259031 **End** Lat 35.376675 Lon 149.259639	Trail M2 provides the short-looped access road into the south east corner of the property. This access will facilitate land management activities along the southern and eastern boundaries which required intensive weed and vegetation management. The trail is in good condition where it runs parallel to the downslope creek as it runs almost on the contour with a low grade. The short section which loops from the upper section to the lower section (near the mine site), is on a steeper grade and has extensive areas of erosion requiring some road drainage measures. The entire trail is currently not an all-weather trail with bare earth surface which may become un-trafficable and erodible when wet. There are multiple parallel trails in the area which can be consolidated once Trail M2 is formalised, refer **Figure 5**.

M2 - REMEDIAL WORKS

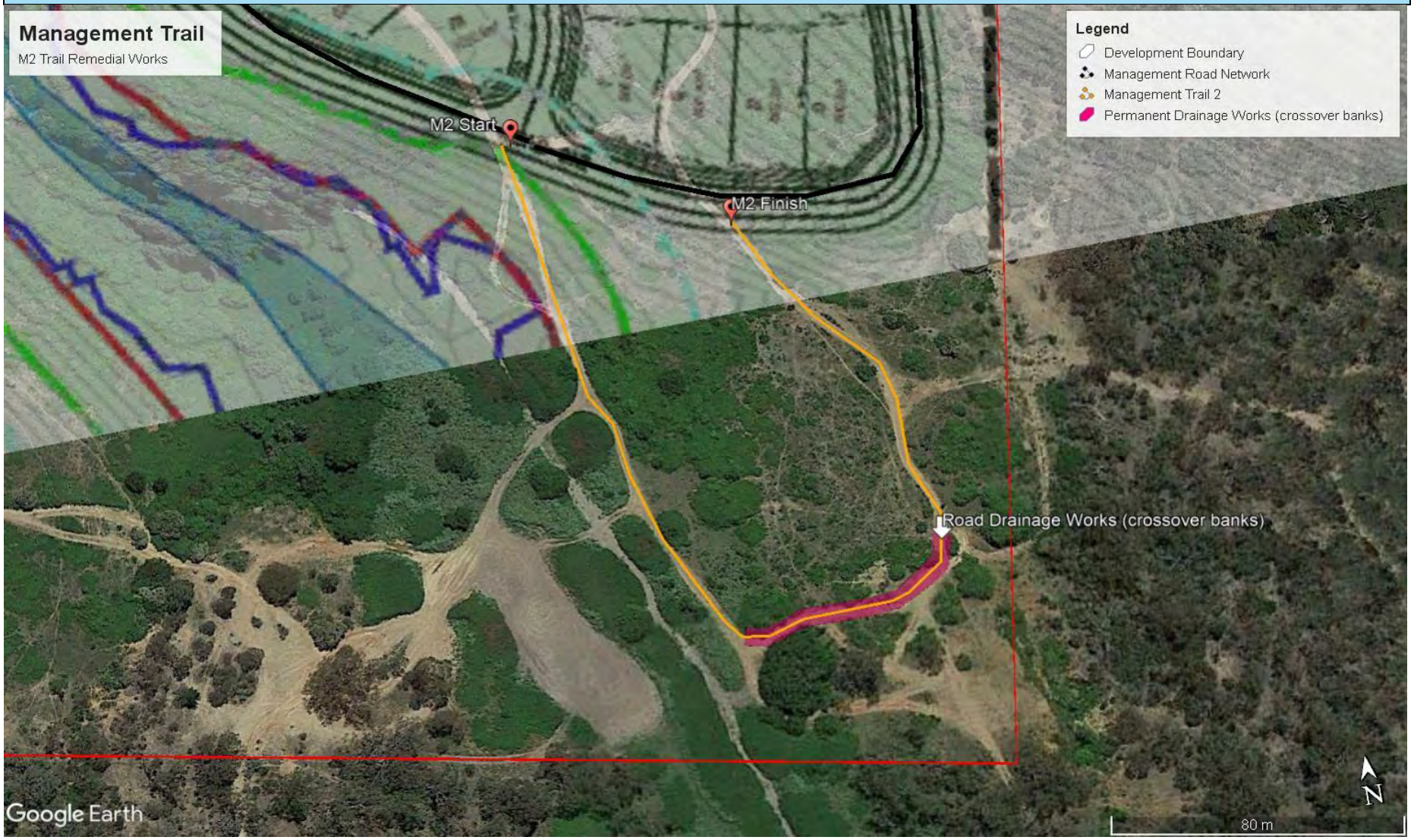
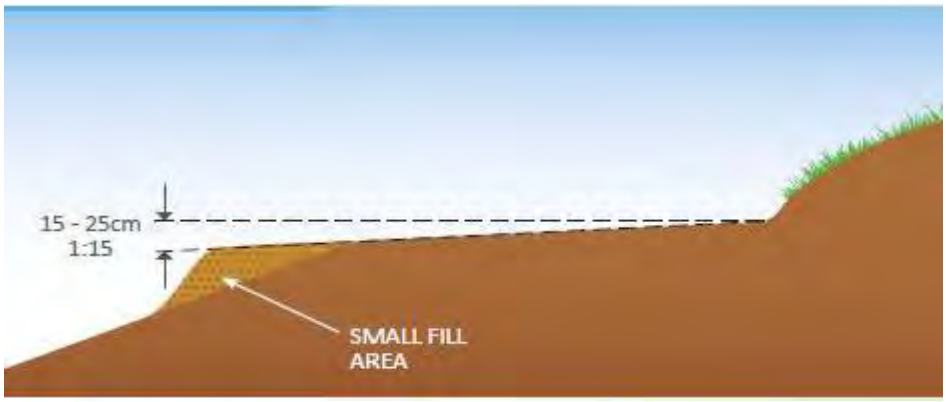


Figure 5: Trail M2 Remedial Works

M2	REMEDIAL WORKS
Road drainage crossover banks **Start** Lat 35.377436 Lon 149.259453 **End** Lat 35.377256 Lon 149.260097	The looped section of the M2 Trail is moderately sloping and includes areas of existing wheel rut erosion and will require the installation of trail drainage works, refer **Figure 5** and site coordinates. The trail surface needs to be drained regularly and drainage structures to be installed should include crossover banks. The design and spacing of these features should conform to the *NSW RFS Fire Trail Design, Construction and Maintenance Manual*.
All weather surface **Start** Lat 35.376108 Lon 149.259031 **End** Lat 35.376675 Lon 149.259639	The entire length of Trail M2 should be trafficable in all-weather conditions, refer **Figure 5**. The trail should be topped with a suitable gravel surface. Crossfall drainage is suitable for the sections of trail constructed along the contour as the area is low slope and built on *in-situ* soil material, refer below.   **Trail Cross-Fall Drainage (From RFS 2017)** An all-weather surface will make the trail more useable for recreational purposes such as walking and bike riding, as well as making the trail more resilient to future erosion.

M3 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
Start Lat 35.376794 Lon 149.25675 **End** Lat 35.374672 Lon 149.256303	The M3 Trail provides a linkage between the F1 Trail and the area of housing development proposed between the creeks. This will provide an alternative point of access/egress from this area during a bushfire emergency and will also facilitate land management activities in the riparian area along the creek. This trail will also provide access to the erosion control activities proposed in the old quarry site as detailed in the Erosion Control Plan. The trail is in reasonable condition with limited erosion in the steeper section leading up to Trail F1. These areas require trail drainage works. The trail surface is generally all-weather due to the underlying shale bedrock. A small section towards the junction with the formal road network at the northern end may require an all-weather gravel surface to be installed, refer **Figure 6**.  **DSC 3793: Steeper section of Trail M3 requiring drainage works**  **DSC 3794: Shale bedrock providing all-weather surface**

M3 - REMEDIAL WORKS

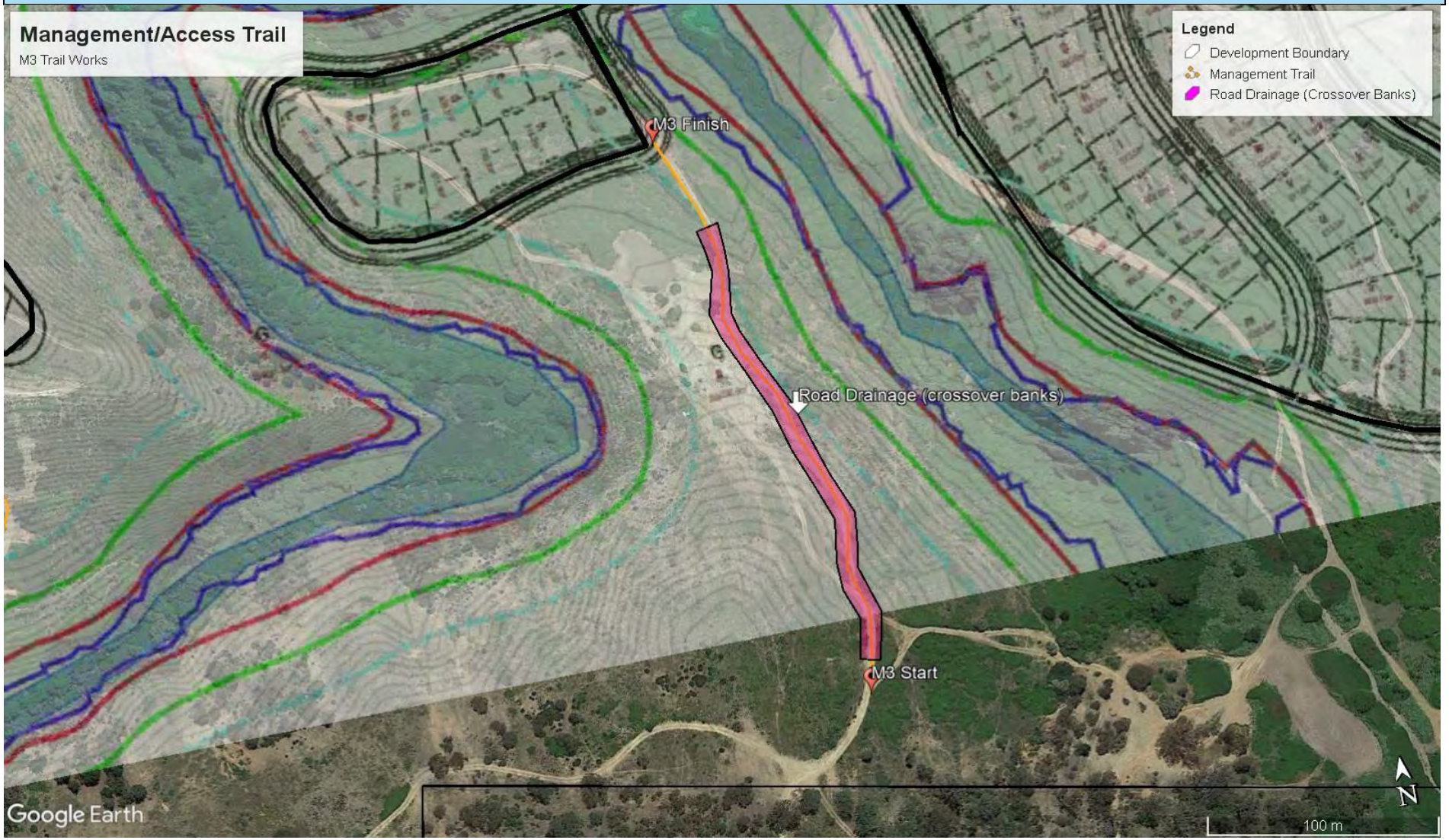


Figure 6: Trail M3 Remedial Works

M3	REMEDIAL WORKS
Road drainage (crossover banks) **Start** Lat 35.376853 Lon 149.256893 **End** Lat 35.375040 Lon 149.256495	The section of moderate sloping trail leading down from Trail F1 will require the installation of trail drainage works, refer **Figure 6** and coordinates provided in column 1. The trail surface needs to be drained regularly and drainage structures to be installed may include crossover banks and mitre/table drains. The design and spacing of these features should conform to the *NSW RFS Fire Trail Design, Construction and Maintenance Manual*.

M4 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
M4 **Start** Lat -35.374716 Lon 149.252499 **End** Lat -35.376324 Lon 149.252194	Trail M4 links the formal road network to the area around the junction of the Creek with the Queanbeyan River. The trail traverses a very steep slope leading down the creek flats. Access to the riparian zone will enable weed control and feral animal control measures in the Vegetation Management Plan to be implemented in this area. The trail will also provide an opportunity for passive recreational activities such as walking and bike riding. The trail is in relatively good condition and extensive erosion control measures have been implemented which are reducing erosion on the very steep sections of trail. There are minor sections where wheel ruts have eroded and sediment has built up in the channel of downslope crossover banks, refer **DSC 3768 & DSC 3770** and **Figure 7**.  **DSC 3765: Steep sections of trail protected by multiple crossover banks**  **DSC 3766: Crossover banks draining from the trail**

DSC 3768: Minor wheel rut erosion

DSC 3769: Trail in general good condition with all-weather surface

DSC 3770: Wheel rut erosion and deposition in channel of crossover

DSC 3773: Creek flat location for new turnaround bay

M4 - REMEDIAL WORKS

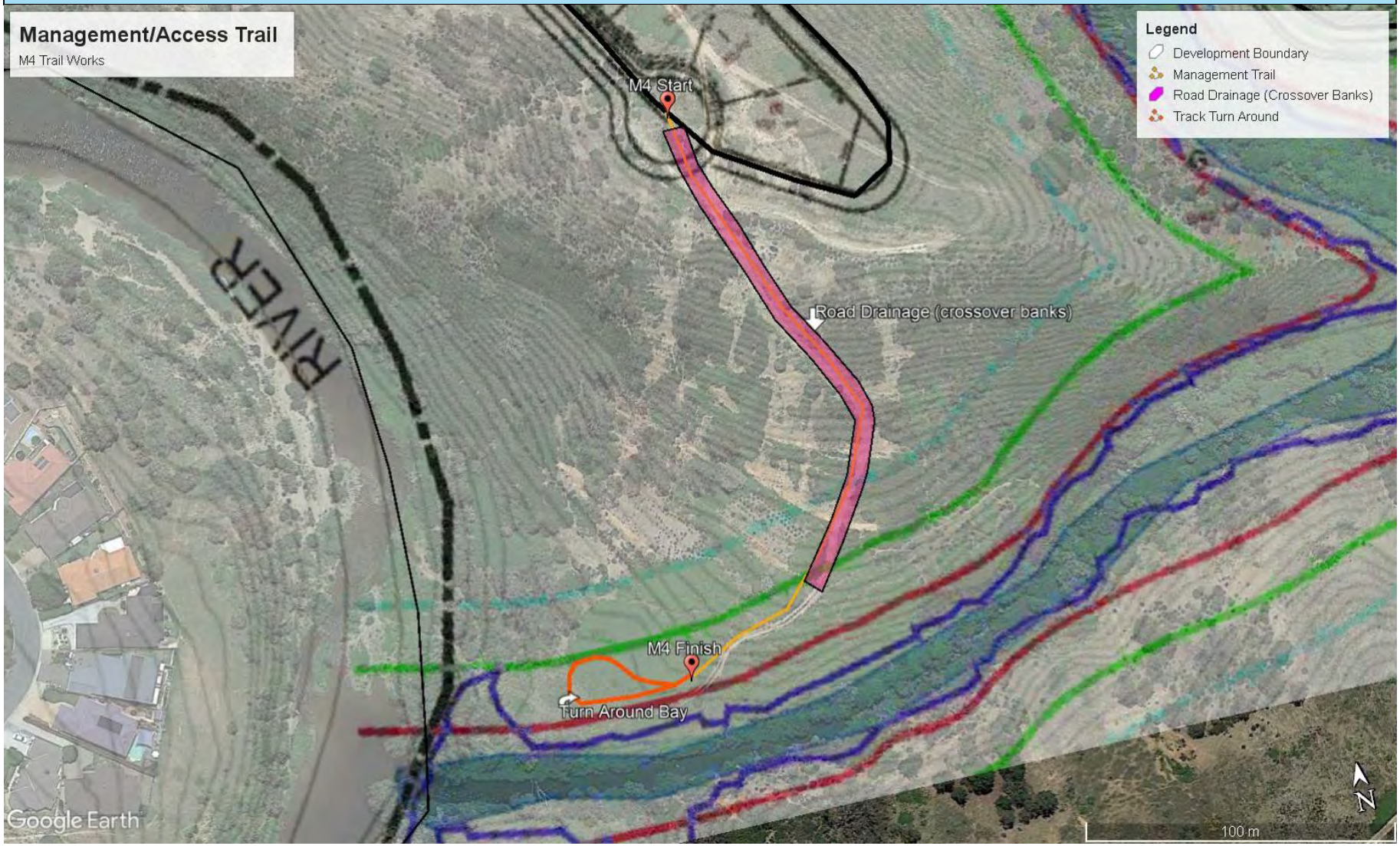


Figure 7: Trail M4 Remedial Works

M4	REMEDIAL WORKS
Road drainage (crossover banks) **Start** Lat -35.374758 Lon 149.252533 **End** Lat -35.376146 Lon 149.252681	The M4 Trail is in generally good condition with extensive road drainage structures already in place. These structures will require maintenance and sediment in channels will need to be cleaned out periodically to ensure adequate drainage and maintain trafficability of the trail. The minor wheel rut erosion can be addressed through filling with gravel.
Turn around bay **Site** Lat -35.376322 Lon 149.251928	A new turnaround bay will be constructed in the level area on the creek flats, refer **Figure 7** and column 1. The turnaround bay will have a radius sufficient for large four-wheel drive vehicles and will include drainage and an all-weather surface.

REDUNDANT TRAILS

R1 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
R1 **Start** Lat 35.380172 Lon 149.250536 **End** Lat 35. 377594 Lon 149.249217	Trail R1 runs from the southern property boundary towards the western boundary at the Queanbeyan River. The trail terminates at Queanbeyan River adjacent to an area used for swimming and fishing. The trail provides access to the riparian zone of the Queanbeyan River and the southern side of the major creek which drains the development site. The section of the trail along the ridge running north from the southern boundary is in reasonably good condition. Erosion is generally restricted to the steeper slopes immediately upslope of the Queanbeyan River. This area is heavily eroded and deeply rutted, refer **Figures DSC 3816, 3818, 3819 & 3820** and **Figure 8**. A large sediment plume has been created in the Queanbeyan River downslope of the eroded area. This material will be mobilised in the next flood event creating downstream problems. The very steep section immediately upslope of the River will require extensive rehabilitation to address the erosion and sedimentation problems, refer **Figure8**. The long moderate sloping trail section leading to the eroded area will also require permanent drainage works to reduce the ongoing risk of erosion.  **DSC 3816: Deeply rutted trail leading to Queanbeyan River**

DSC 3818: Wheel ruts leading to sediment plume in Queanbeyan River

DSC 3819: Trail section to be decommissioned and rehabilitated

DSC 3820: Rehabilitation area to be contour ripped and revegetated

R1 - REHABILITATION WORKS

Figure 8: Trail R1 Rehabilitation Works

R1	REMEDIAL WORKS
Deep contour rip / topsoil / seed / mulch **Start** Lat 35.379433 Lon 149.250653 **End** Lat 35.378875 Lon 149.250222 **Start** Lat 35.378461 Lon 149.249908 **End** Lat 35.378328 Lon 149.249806 **Start** Lat 35.377981 Lon 149.249556 **End** Lat 35.377811 Lon 149.2494	Trail R1 should be totally rehabilitated. Two sections will require deep ripping the trail on the contour (level) to increase infiltration. In sections which are eroded additional topsoil material should be imported to bring the surface up to natural ground level and create a free draining profile. The ripped and topsoiled area should be seeded with an appropriate species mix which recognises the species listed in the Vegetation Management Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination. The use of soil ameliorants and fertiliser to assist in revegetation should be determined through soil testing.
Permanent drainage works (crossover banks) **Start** Lat 35.378864 Lon 149.250219 **End** Lat 35.378467 Lon 149.249919	The long moderately sloping trail section, refer **Figure 8,** should include permanent drainage structures (crossover banks) to ensure the rehabilitated trail section drains and runoff does not concentrate. The design and spacing of these features should conform to the *NSW RFS Fire Trail Design, Construction and Maintenance Manual* although some allowance can be made for the lower runoff rates expected from the rehabilitated trail.
Rehabilitate deeply eroded section **Start** Lat 35.377819	The section immediately upslope of the Queanbeyan River which has severely eroded will be decommissioned and rehabilitated, refer **Figure 8** and coordinates. Rehabilitation will involve the installation of a crossover bank upslope of the erosion to divert run-on water away from the area. The eroded area will be deep ripped on the contour and shaped to reduce concentration of runoff. The area will then be topsoiled prior to seeding and mulching. Species to be sown should reflect the species list provided in the Vegetation Management Plan although the use of sterile cover crop to provide rapid groundcover protection from erosion

Lon 149.249392 **End** Lat 35.377594 Lon 149.249194	may also be required. The requirement for soil ameliorants (eg Gypsum) and fertiliser should be determined through soil testing prior to rehabilitation.
Light rip / seed / mulch **Start** Lat 35.380161 Lon 149.250575 **End** Lat 35.3786 Lon 149.250753	Rehabilitation along the relatively low slope section along the ridge running from the southern boundary, refer **Figure 8**, should involve very light cultivation type ripping of the trail to increase infiltration and provide a seed bed. The ripped area should be seeded with an appropriate species mix which recognises the species listed in the Vegetation Management Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination.

R2 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
Start Lat 35.379017 Lon 149.252156 **End** Lat 35.379708 Lon 149.254058	The R2 Trail links M1 with the to the eastern boundary. This access track is informal and is essentially redundant. The trail is in good condition and there is little active erosion. The trail lacks definition in places and the surface is not in all-weather condition, refer **Figure 9**.  **DSC 3804: R2 Trail in good condition**  **DSC 3805: Poorly defined R2 Trail**

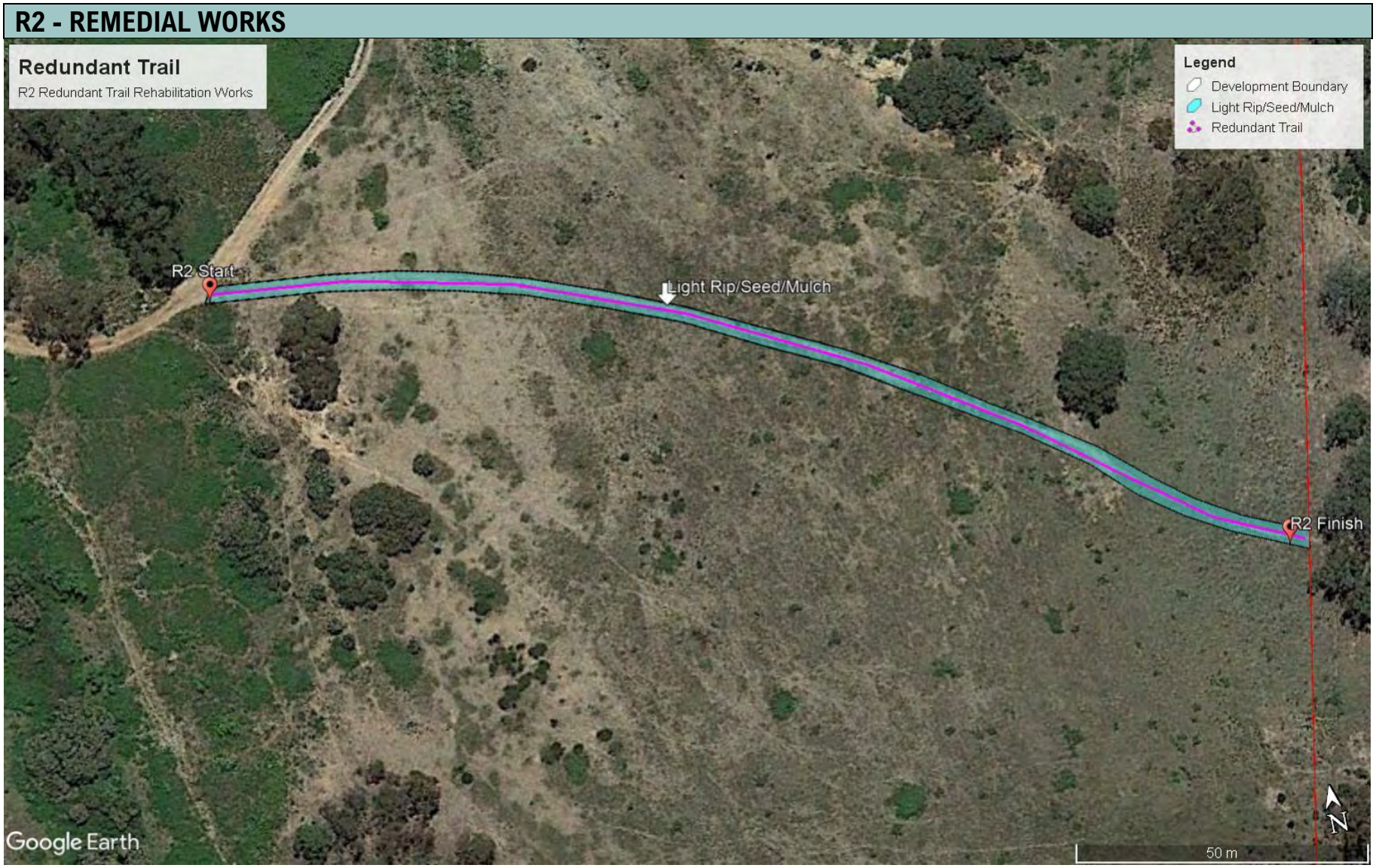


Figure 9: Trail R2 Rehabilitation Works

R2	REMEDIAL WORKS
Light rip / seed / mulch **Start** Lat 35.379017 Lon 149.252156 **End** Lat 35.379708 Lon 149.254058	Rehabilitation along the entire length of this track low slope section which parallels the Queanbeyan River and consists of River flats, refer **Figure 9**, should involve very light cultivation type ripping of the trail to increase infiltration and provide a seed bed. The ripped area should be seeded with an appropriate species mix which recognises the species listed in the Vegetation Management Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination.

R3 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
Start Lat 35.374142 Lon 149.254481 **End** Lat 35.3726222222 Lon 149.256261	Trail R3 joins the proposed housing area between the creeks with the formal road network and includes two major creek crossings. The linkage is made redundant by the formal road network. The removal of the two creek crossings will also be beneficial to the stability of the riparian zone and water quality. The trail is in poor to fair condition with deeply eroded and rutted sections contributing sediment directly to the creek. These sections will require extensive rehabilitation including reshaping and topsoiling prior to revegetation. There is a small section on the eastern side of the creek which is in fair condition and will require a less intensive rehabilitation effort. The creek crossings will require the installation of permanent drainage structures as part of the rehabilitation, to reduce the potential contribution of sediment to the watercourse, refer **Figure 10**.  **DSC 3786: Trail sections leading to the creek crossing**  **DSC 3785: Creek crossings will require upslope permanent drainage features**

DSC 3784: Location for creek drainage structure

DSC 3781: Deeply rutted areas will require building up with topsoil

DSC 3780: existing trail will be deep ripped prior to revegetation

DSC 3842: The second creek crossing to be rehabilitated

R3 - REMEDIAL WORKS

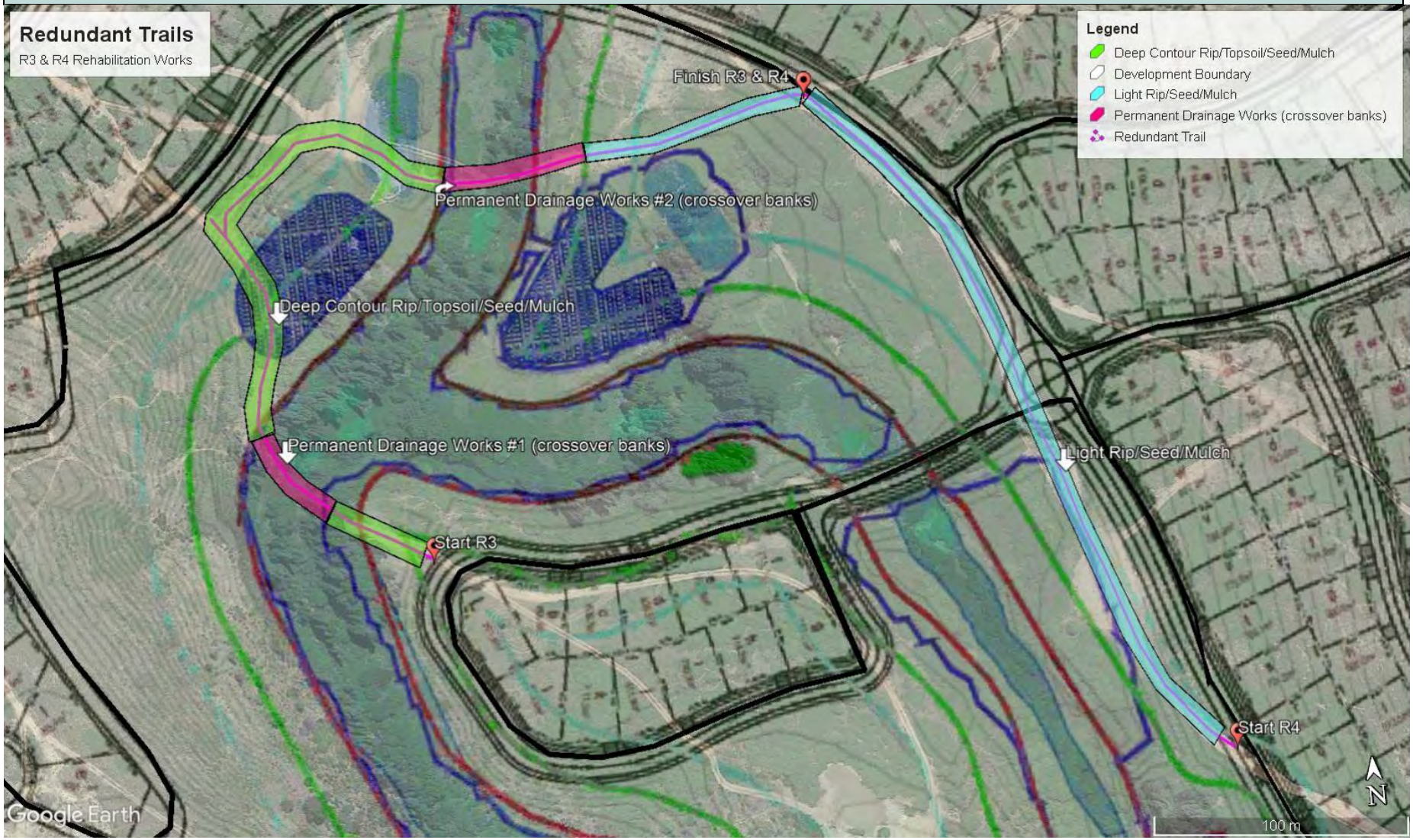


Figure 10: Trail R3 Rehabilitation Works

R3	REMEDIAL WORKS
Deep contour rip / topsoil / seed / mulch **Start** Lat 35.374146 Lon 149.254461 **End** Lat 35.372636 Lon 149.256257	Trail R3 should be totally rehabilitated. Rehabilitation along the severely eroded sloping sections, refer **Figure 10**, should involve deep ripping the trail on the contour (level) to increase infiltration. In the sections which have eroded, additional topsoil material should be imported to bring the surface up to natural ground level and create a free draining profile. The ripped and topsoiled area should be seeded with an appropriate species mix which is consistent with the Landscape Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination. The use of soil ameliorants and fertiliser to assist in revegetation should be determined through soil testing.
Permanent drainage works (crossover banks) **#1** **Start** Lat -35.373933 Lon 149.254060 **End** Lat -35.373645 Lon 149.253805 **#2** **Start** Lat -35.372810 Lon 149.254688 **End** Lat -35.372749 Lon 149.255309	The creek crossing section, refer **Figure 10,** should include permanent drainage structures (crossover banks) located immediately upslope of the steep trail sections leading to the creek crossing. Similar structures will be required on both sides of the creek crossing. These drainage structures should direct runoff to a well vegetated safe disposal area. The design of these features should conform to the *NSW RFS Fire Trail Design, Construction and Maintenance Manual.*
Light rip / seed / mulch **Start** Lat -35.372749 Lon 149.255309 **End** Lat -35.372636 Lon 149.256257	Rehabilitation along the low slope trail section east of the creek crossing, refer **Figure 10**, should involve very light cultivation type ripping of the trail to increase infiltration and provide a seed bed. The ripped area should be seeded with an appropriate species mix which is consistent with the Landscape Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination.

R4 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
Start Lat 35.375080 Lon 149.257840 **End** Lat 35.372636 Lon 149.256257	Trail R4 is immediately adjacent to the formal road network and parallels the creek on the eastern side. The construction of the formal road network will make this trail redundant, refer **Figure 11**. The trail is in poor condition with deep wheel ruts and water ponding in several areas. Rehabilitation of the trail will require reshaping of these areas to create a free draining landscape. Soil depth in these areas is reasonable and additional topsoil will not be required.  **DSC 3841: Areas of water ponding on the trail**  **DSC 3840: Deep wheel ruts and water ponding along the trail**  **DSC 3839: Low slope trail will require minimal rehabilitation**

DSC 3838: Small section of moderate slope and limited erosion

DSC 3837: Minor erosion on sloping sections of trail

R4 - REMEDIAL WORKS

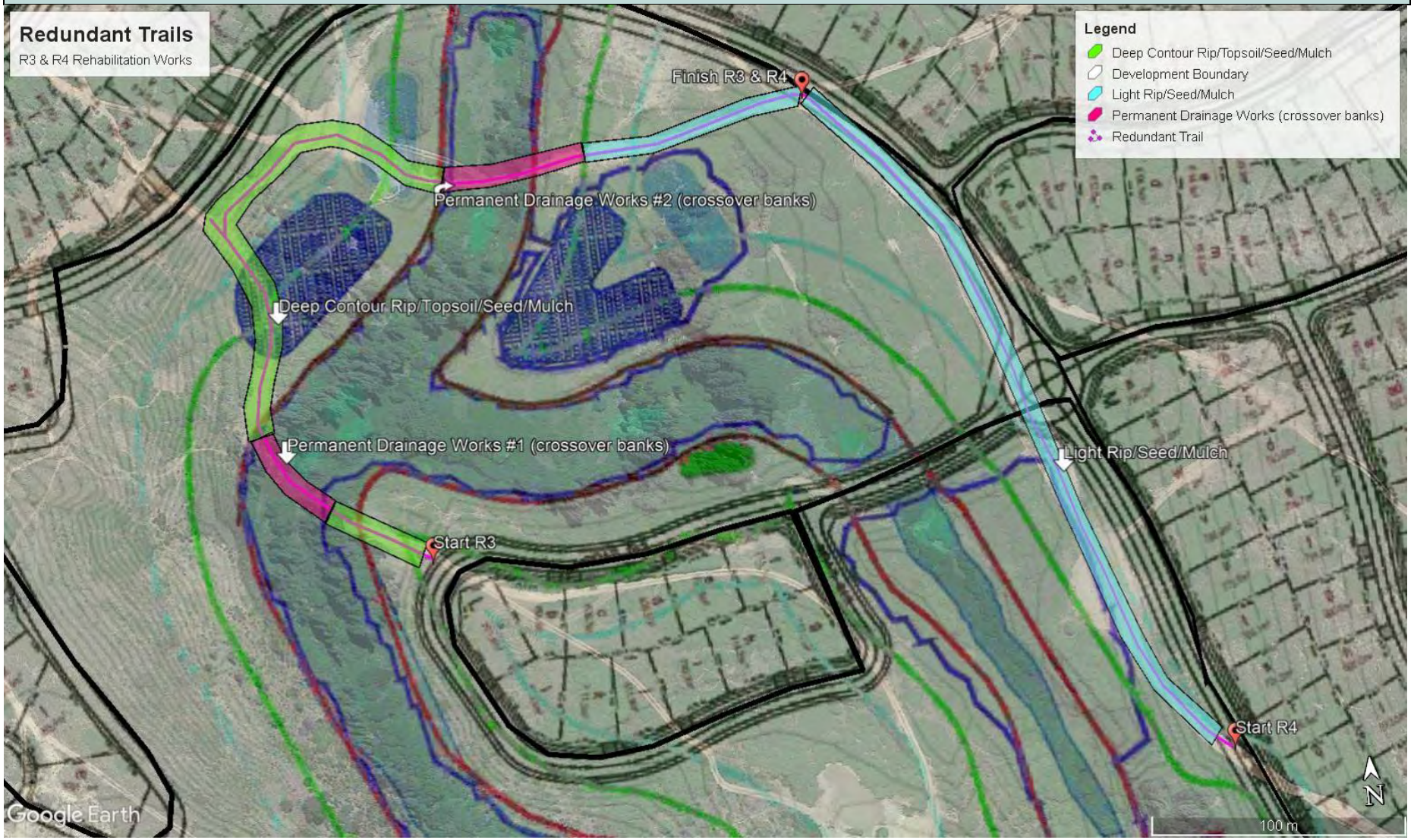


Figure 11: Trail R4 Rehabilitation Works

R4	REMEDIAL WORKS
Light rip / seed / mulch **Start** Lat -35.375080 Lon 149.257840 **End** Lat -35.372636 Lon 149.256257	Rehabilitation along the low slope trail section east of the creek crossing, refer **Figure 11**, should involve very light cultivation type ripping of the trail to increase infiltration and provide a seed bed. The ripped area should be seeded with an appropriate species mix which is consistent with the Landscape Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination. Short areas of erosion, refer **Figures DSC 3837-8**, will require reshaping as part of light ripping, to create a free draining landscape.

R5 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
Start Lat 35.369619 Lon 149.254166 **End** Lat 35.369677 Lon 149.255499	Trail R5 is part of an access trail between the Ellerton Drive Extension boundary and the existing dwelling on the adjacent property to the north of the development. The trail will be made redundant by the construction of Ellerton Drive which will provide alternative access point to the property, refer **Figure 12**. The trail is in reasonable condition with minor erosion along wheel ruts in the moderately sloping areas.  **DJI 0001 R5**  **DJI 0002 R5**

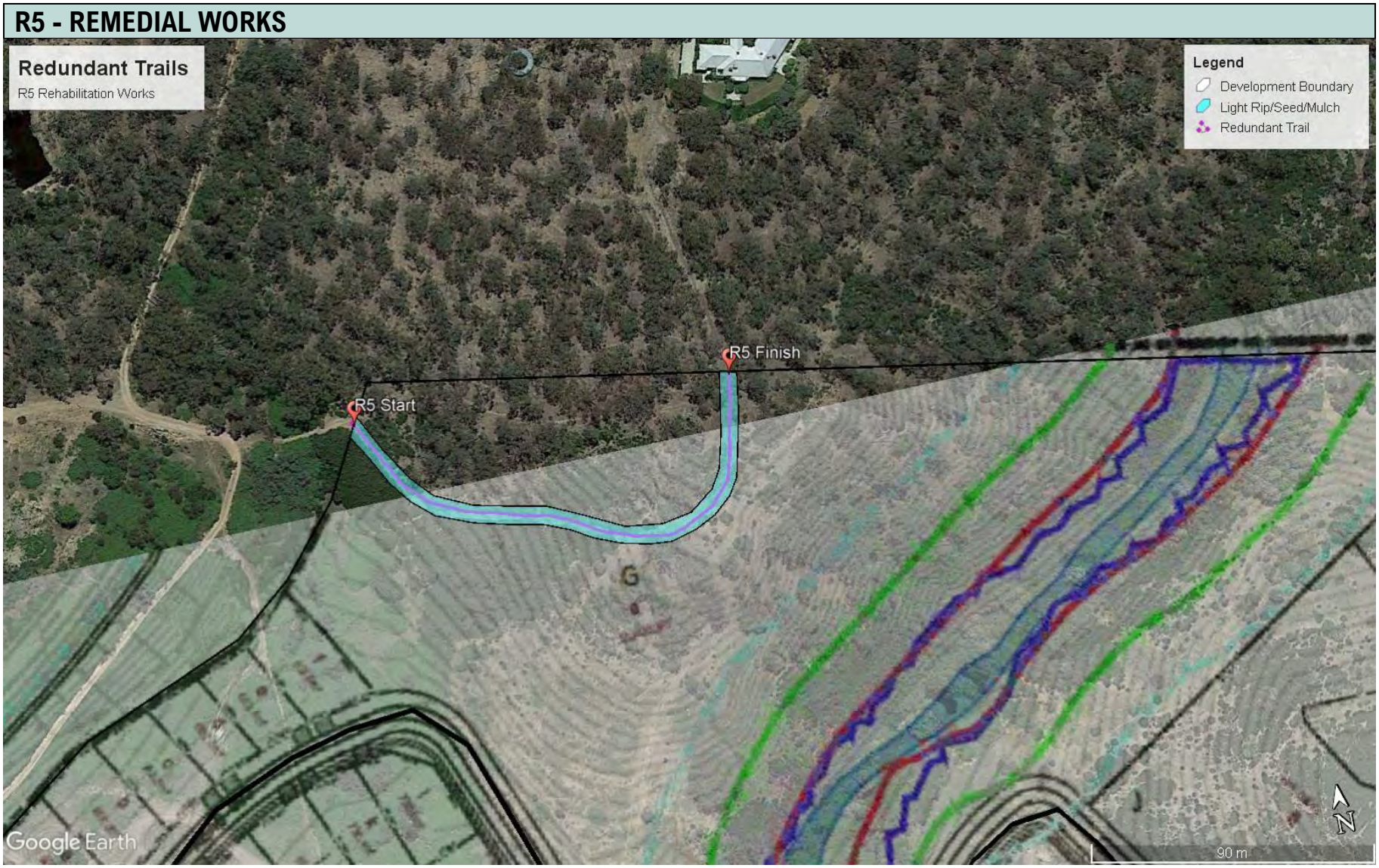


Figure 12: Trail R5 Rehabilitation Works

R5	REMEDIAL WORKS
Light rip / seed / mulch (all R5) **Start** Lat -35.369619 Lon 149.254166 **End** Lat -35.369677 Lon 149.255499	Rehabilitation along the trail, refer **Figure 12**, should involve very light cultivation type ripping of the trail to increase infiltration and provide a seed bed. The ripped area should be seeded with an appropriate species mix which is consistent with the Vegetation Management Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination. Short areas of wheel rut erosion will require minor reshaping as part of light ripping, to create a free draining landscape

R6 - DESCRIPTION	
SITE REF & LOCATION	**DESCRIPTION AND SITE PICTURES**
Start Lat -35.371747 Lon 149.258497 **End** Lat -35.370862 Lon 149.261463	The R6 Trail provides a strategic link (via the formal road network) between the existing fire trail to the east (on Cuumbeun Nature Reserve) and the F1 Trail, which traverses the property from East to South West. The Trail is marked on maps of the local area and has existed for a long time. The trail transects one of the large lots in the north east of the development and will be made redundant by the construction of the formal road network with linkage to Ellerton Drive. The Trail is generally in poor to fair condition and will require significant rehabilitation works including permanent road drainage works in the form of graded banks, refer **Figures DJI 0001-3_R6** and **Figure 13**.  **DJI 0001_R6: Deeply rutted steep trail sections**

DJI 0002_R6: Extensive areas of loose cobble and gutters

DJI 0003_R6: Extensive areas of outcropping rock near the eastern boundary

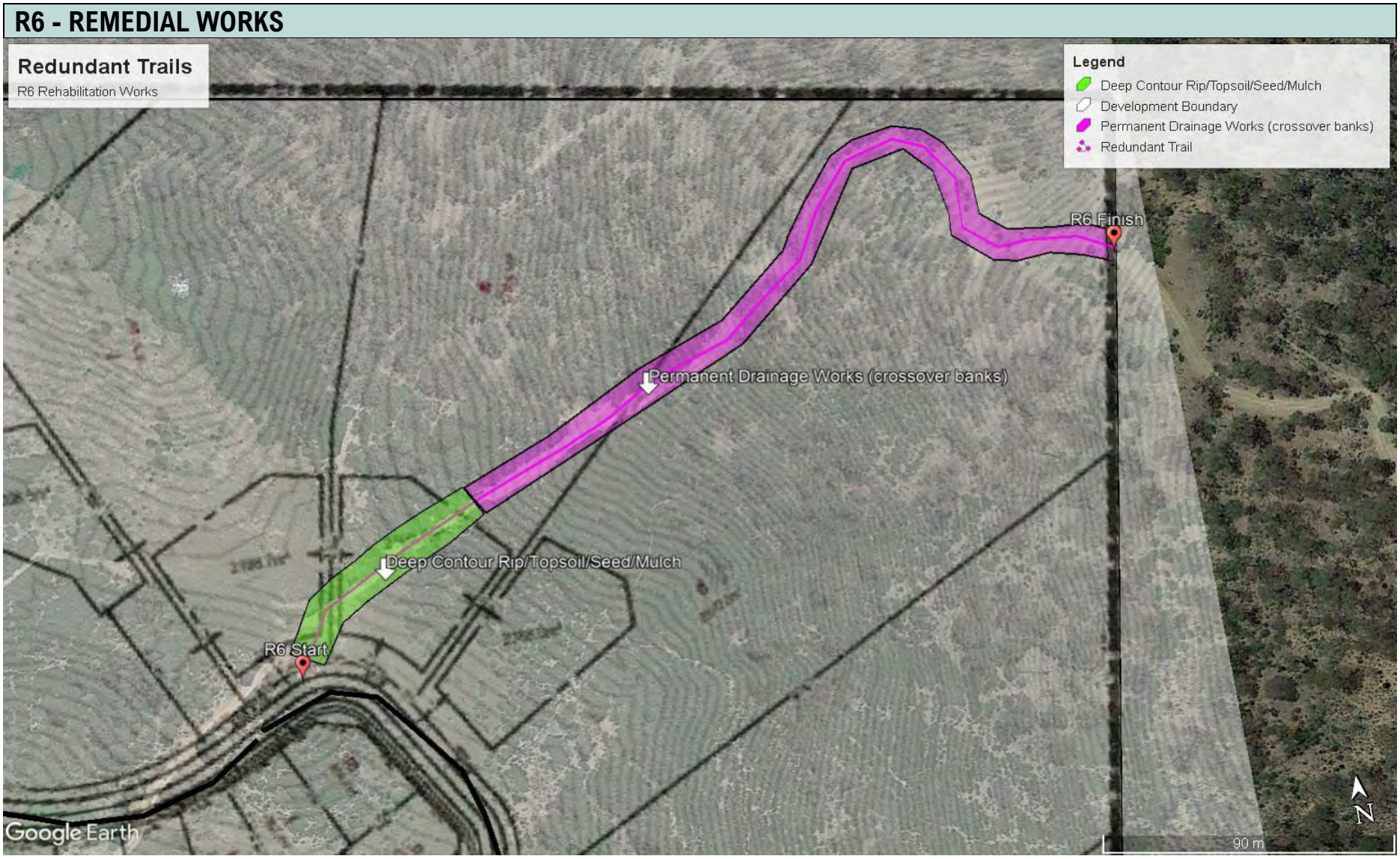


Figure 13: Trail R6 Rehabilitation Works

R6	REMEDIAL WORKS
Permanent drainage works (crossover banks) **Start** Lat -35.371747 Lon 149.258497 **End** Lat -35.370862 Lon 149.261463	The moderate to steeply sloping trail section, refer **Figure 13,** should include permanent drainage structures (crossover banks) to ensure the rehabilitated trail section drains and runoff does not concentrate. The design and spacing of these features should conform to the *NSW RFS Fire Trail Design, Construction and Maintenance Manual* although some allowance can be made for the lower runoff rates expected from the rehabilitated trail.
Deep contour rip / topsoil / seed / mulch **Start** Lat -35.371747 Lon 149.258497 **End** Lat -35.370862 Lon 149.261463	Trail R6 should be totally rehabilitated. Rehabilitation along the severely eroded sloping sections, refer **Figure 13**, should involve deep ripping the trail on the contour (level) to increase infiltration. In the sections which have eroded, additional topsoil material should be imported to bring the surface up to natural ground level and create a free draining profile. The ripped and topsoiled area should be seeded with an appropriate species mix which is consistent with the Landscape Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination. The use of soil ameliorants and fertiliser to assist in revegetation should be determined through soil testing.

R7 - DESCRIPTION

SITE REF & LOCATION	DESCRIPTION AND SITE PICTURES
Start Lat 35.376847 Lon 149.259111 **End** Lat 35.376786 Lon 149.256964	The R7 Trail creates an east west link between the M2 and M3 Trails. This trail is severely eroded and includes a major creek crossing at the eastern end, prior to joining with M2, refer **Figure 14.** The trail is redundant due to the access provided by M1 and M3 to the west and M2 and the formal road network to the east. The topography and creek crossing also make the trail impractical to upgrade to a suitable standard for retaining as part of the management trail network. The current condition of the trail is generally poor and will require significant rehabilitation works including permanent drainage measures in the form of crossover banks, refer **Figures DSC 3825 & 3827** and **Figure 14**.

DSC 3825: Deeply rutted section of trail

DSC 3827: Eroded table drain

Figure 14: Trail R7 Rehabilitation Works

R7	REMEDIAL WORKS
Permanent drainage works (crossover banks) **Start** Lat 35.377075 Lon 149.258206 **End** Lat 35.376878 Lon 149.256975	The moderate to steeply sloping trail section, refer **Figure 14,** should include permanent drainage structures (crossover banks) to ensure the rehabilitated trail section drains and runoff does not concentrate. The design and spacing of these features should conform to the *NSW RFS Fire Trail Design, Construction and Maintenance Manual* although some allowance can be made for the lower runoff rates expected from the rehabilitated trail.
Light rip / seed / mulch (all R5) **Start** Lat 35.376778 Lon 149.2591 **End** Lat 35.377075 Lon 149.258206	Rehabilitation along the trail, refer **Figure 14**, should involve very light cultivation type ripping of the trail to increase infiltration and provide a seed bed. The ripped area should be seeded with an appropriate species mix which is consistent with the Vegetation Management Plan. Fast growing cover crop species with sterile seed may be used to provide a rapid groundcover to protect from erosion. The seeded area should be covered with a light mulch to further limit erosion and promote germination. Short areas of wheel rut erosion will require minor reshaping as part of light ripping, to create a free draining landscape

4. STAGED WORKS PROGRAM

The soil and water management plan will be implemented across the development in four distinct phases in **Figures 15-18** below:

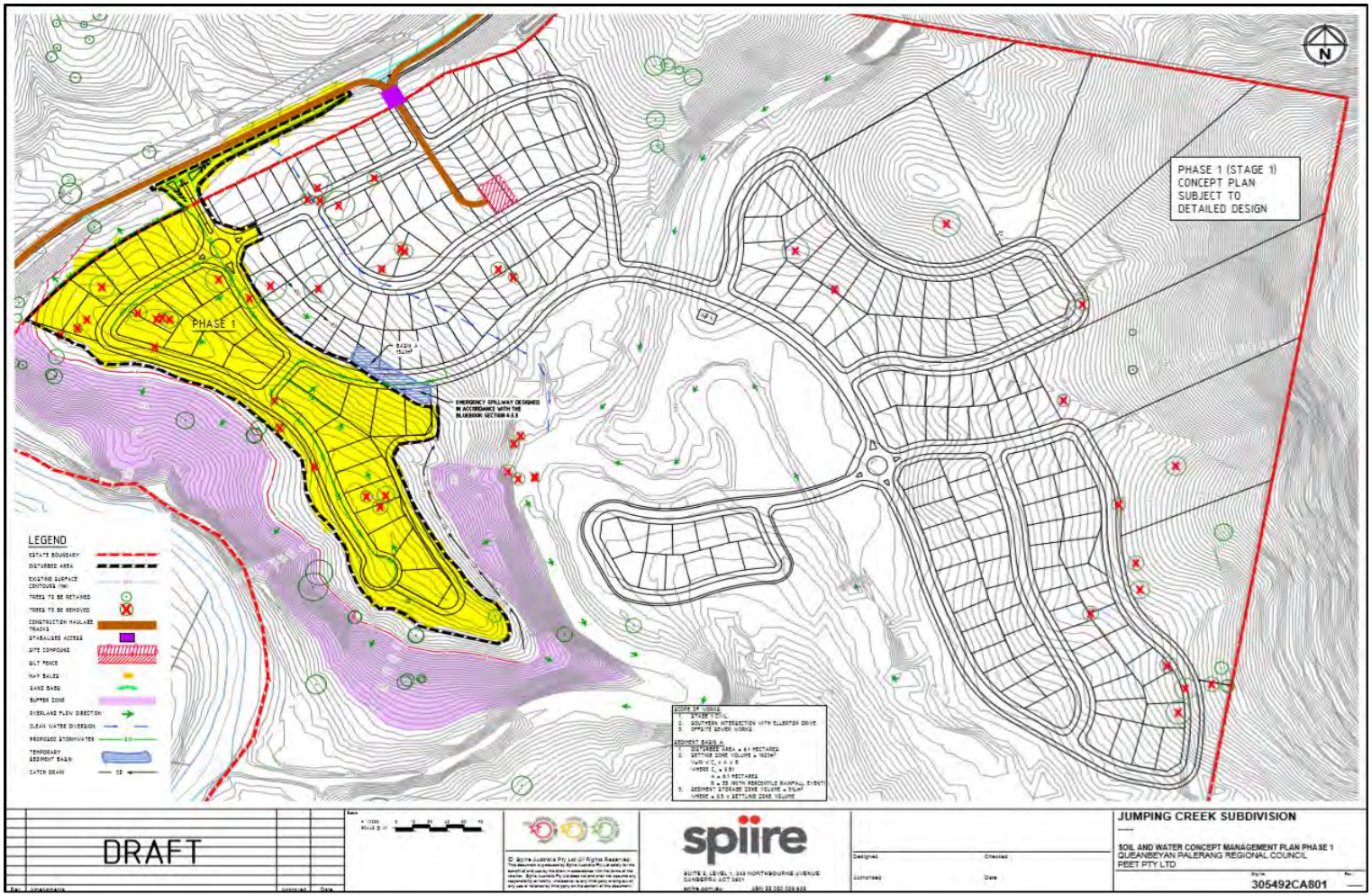


Figure 15: Soil and Water Management – Phase 1

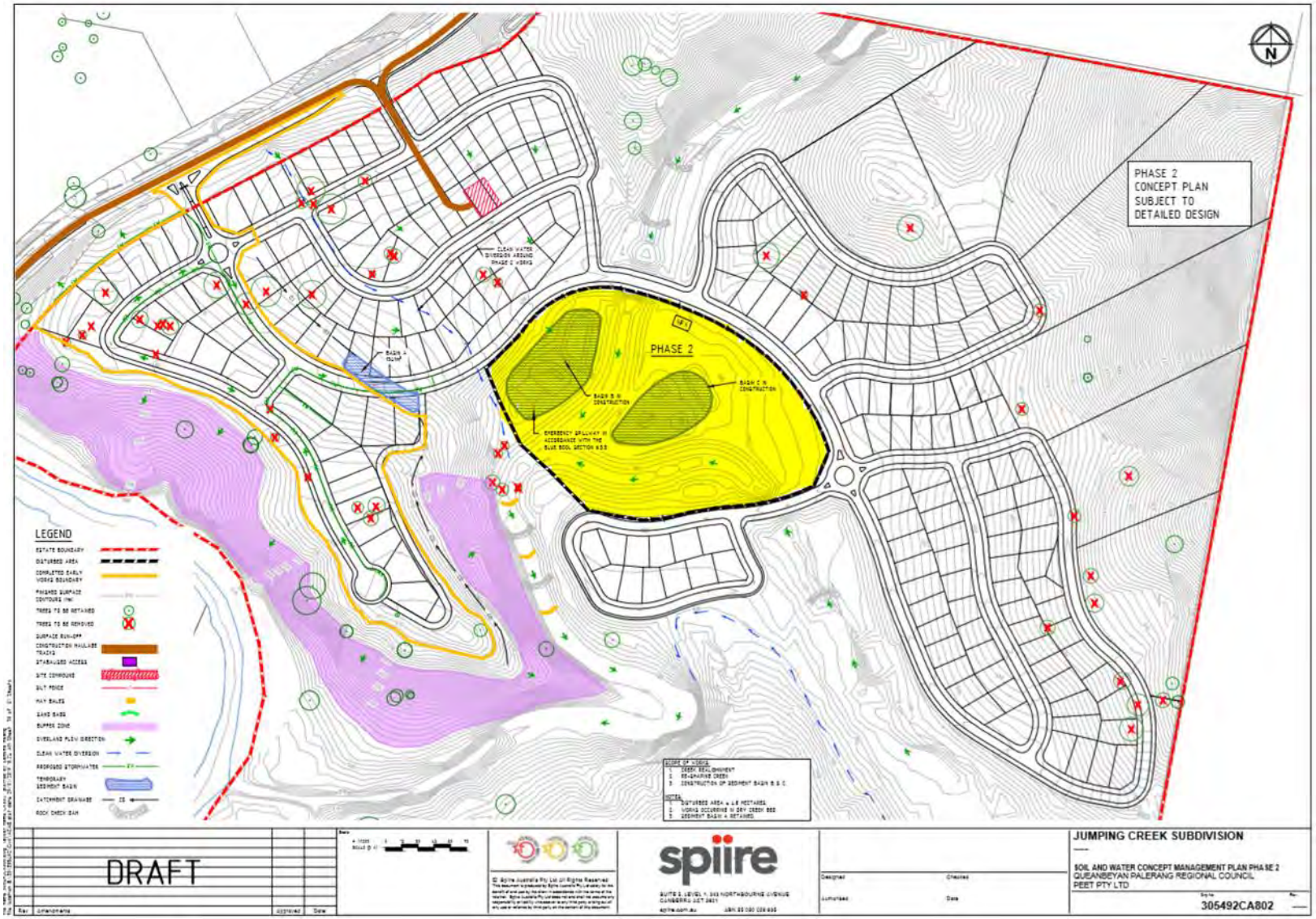


Figure 16: Soil and Water Management Phase 2

Figure 17: Soil and Water Management Phase 3

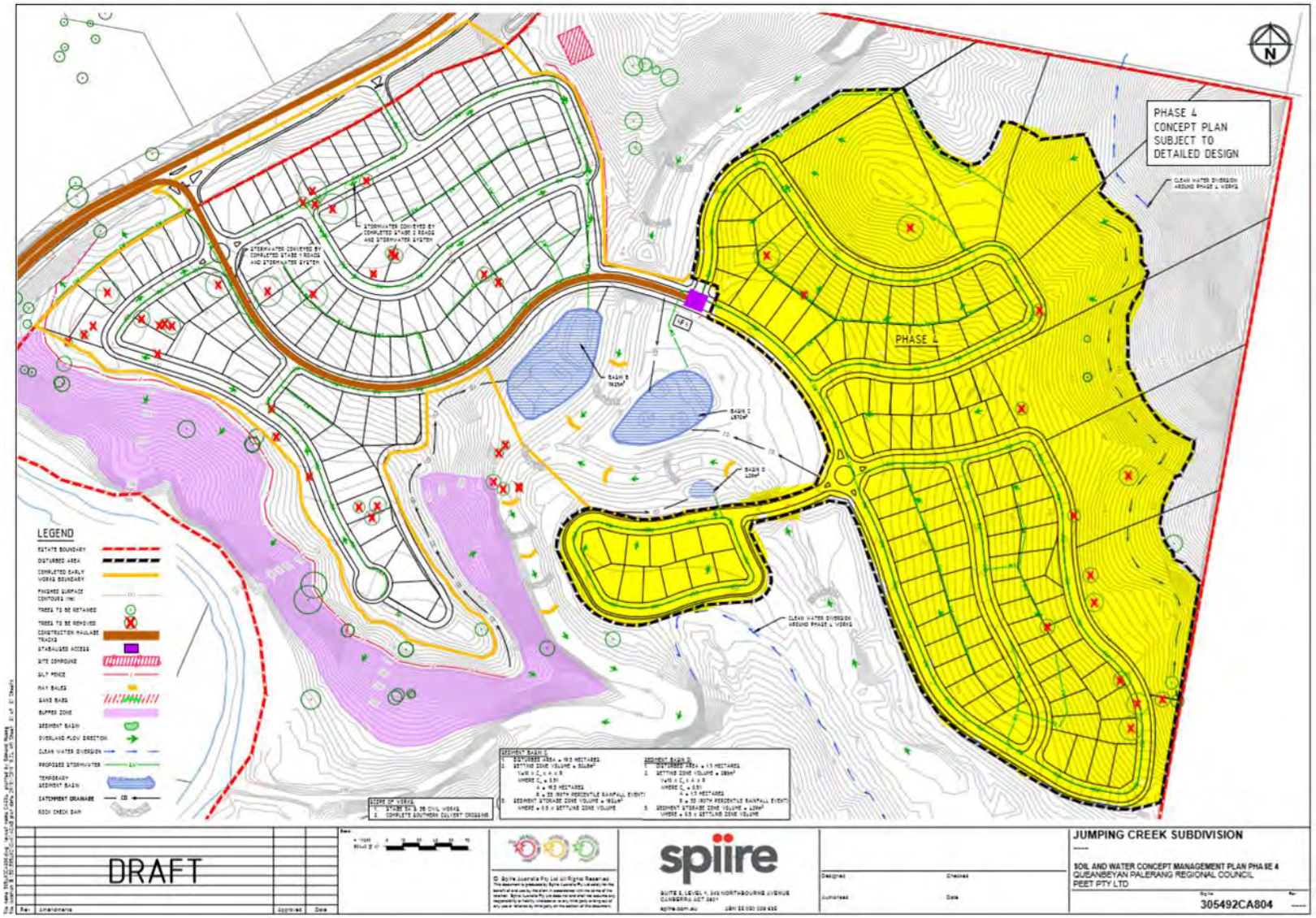


Figure 18: Soil and Water Management Phase 4

The remediation and rehabilitation work proposed will be staged to recognise both the priority of the works and phases of the broader soil and water management plan. Works will be undertaken in conjunction with the construction activities associated with each phase of the soil and water management activities. The appropriate scheduling of works within each Stage will be undertaken by the developer prior to commencement of works. For trails which may be utilised as fire management trails, NSW Rural Fire Services should be consulted when planning works.

4.1 STAGE 1 TRAIL WORKS (SOIL & WATER MANAGEMENT PHASE 1)

SITE REF	REMEDIATION WORKS REQUIRED
M4	Trail drainage works- maintain and upgrade trail works including desilting channels and upgrading crossovers where required Construct new turn around bay at the end of the trail including trail drainage and an all-weather surface.

4.2 STAGE 2 TRAIL WORKS (SOIL & WATER MANAGEMENT PHASE 2)

SITE REF	REMEDIATION WORKS REQUIRED
R3	Rehabilitate the heavily eroded sections of trail by reprofiling, deep contour ripping, topsoiling then revegetating with seed and mulch. Construct permanent drainage structure above both sides of each (2) creek crossings. Rehabilitate the lightly eroded sections of trail by lightly ripping (cultivating) then seeding and mulching.

4.3 STAGE 3 TRAIL WORKS (SOIL & WATER MANAGEMENT PHASE 3)

SITE REF	REMEDIATION WORKS REQUIRED
R5	Rehabilitate the lightly eroded sections of trail by lightly ripping (cultivating) then seeding and mulching. Small sections of eroded wheel ruts may require minor shaping to create freely drained rehabilitated trail.

4.4 STAGE 4 TRAIL WORKS (SOIL & WATER MANAGEMENT PHASE 4)

SITE REF	REMEDIATION WORKS REQUIRED
M1	Install pipe culverts at creek and drainage depression crossings Remediate heavily eroded sections of trail by reshaping and structuring the trail surface and installing adequate trail drainage. Install cross over banks and other trail drainage structures on long moderately sloping section. Install road drainage and all-weather surface along the length of the trail
M2	Install cross over banks and other trail drainage structures as required. Install all-weather surface along the length of the trail.
M3	Install cross over banks and other trail drainage structures as required. Small section at lower end of the trail may require all-weather surface.
R1	Rehabilitate the heavily eroded sections of trail by reprofiling, deep contour ripping, topsoiling then revegetating with seed and mulch. Construct permanent drainage structures along moderately sloping section of trail to be rehabilitated. Rehabilitate the severely eroding section of trail next to the river by constructing upslope crossover bank then deep ripping, topsoiling and revegetating. Install all-weather surface along the length of the trail.
R2	Rehabilitate the entire length of lightly eroded trail by lightly ripping (cultivating) then seeding and mulching.
R4	Rehabilitate the lightly eroded trail by lightly ripping (cultivating) then seeding and mulching. Small sections may require some reshaping to create a freely draining rehabilitated trail profile.
R6	Remediate heavily eroded sections of trail by reshaping and structuring the trail surface and installing adequate trail drainage. Location of lower section of trail may be revised to avoid Building Envelopes on proposed large subdivision lot.
R7	Rehabilitate heavily eroded steeper sections of the trail by installing permanent drainage measures (crossover banks), and revegetating Rehabilitate lower sloped sections by light ripping prior to seeding and mulching.

5. MONITORING, MAINTENANCE AND MANAGEMENT PROGRAM

Monitoring, maintenance and management should commence as soon as works have been undertaken and continue into the long term. It is expected that the roles and responsibilities for these activities will change overtime as the development is progressively completed and sections of public land revert to Council for ongoing management. The role of community groups, associations and/or local Landcare groups should also be considered in developing long term plans. Refer **Table 2**.

Monitoring, maintenance and management should include a scheduled program of activities plus event-based triggers requiring additional activity. For some sites the frequency and event-based triggers will change over time in response the changing vulnerability of sites resulting from the construction of drainage and revegetation outcomes.

Table 2: MONITORING AND MANAGEMENT PROGRAM

MONITORING SITE	FREQUENCY	ADDITIONAL INSPECTIONS TRIGGERED BY SPECIFIC EVENTS	RESPONSIBILITIES	MANAGEMENT ACTIONS FROM INSPECTIONS
Management Trails	**3-monthly** monitoring inspections during the first **12 months** following construction /upgrade. Then **annual** inspections prior to land management activities (eg.weed spraying/rabbit control)	During the first **12 months** – inspections after all major rainfall runoff events. Then inspections after >1 in 1-year rainfall events.	Developer, community group, contractors	Identify maintenance requirements to ensure trafficability of trails.
Rehabilitation Trails	**3-monthly** monitoring inspections during the first **2 years** following construction /upgrade. Then **annual** inspections at the end of summer when groundcover is at its lowest.	During the **first 18 months** – inspections after all major rainfall runoff events. Then inspections after >1 in 1-year rainfall events.	Developer, community group, contractors	Identify maintenance requirements to minimise erosion and sedimentation.

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