Yarra Ranges Shire Council

Warburton Mountain Bike Destination Project

Preliminary Surface Water & Geotechnical Assessment

December 2019

Executive summary

Scope and Purpose

The purpose of this preliminary surface water and geotechnical impact assessment is to inform the development of Referrals to government under the *Environment Effects Act 1978* and *Environment Protection and Biodiversity Conservation Act 1999*, to guide the selection of appropriate planning approval pathways for the Warburton Mountain Bike Destination Project.

Surface water assessment results

The aquatic environment in the waterways in the vicinity of the proposed development are considered in good to excellent condition, largely meeting SEPP (Waters) water and environmental quality objectives. In addition, it is likely that two threatened fish species have the potential to inhabit the Yarra River. As such, the proposed development must allow for protection of these sensitive water receptors.

The results from this preliminary desktop assessment have identified that 114 crossings may pose a high risk to downstream water quality (with 49 rated medium risk and one crossing rated low risk). It should be stressed that these ratings are preliminary inherent risks (based on location, soil type and stream order) without any mitigation measures in place or site assessments.

Based on the proposed waterway crossing construction method, all water course crossings are constructed as dry tyre crossings utilising elevated structures or bridges. Based on this method, the residual risks indicate that waterway crossing risks are likely to be lowered at these identified crossing locations – especially where “dry tyre” crossings will be constructed.

Geotechnical assessment results

The proposed trail network and associated ancillary infrastructure, traverse varying geology, soils and landform/slope conditions across a large project area. These result in varying risks associated with:

- Soil erosion
- Slope instability and geotechnical hazards, such as landslides

Some of the project components are contained in areas of land which are susceptible to landslip. A number of geotechnical studies have been undertaken and parts of the trail network traverse parts of the Yarra Ranges Erosion Management Overlay (EMO). All land included in the EMO has been identified as having a sufficiently high risk of potential instability to warrant specific review of these risks.

A preliminary geotechnical assessment has been completed by correlating some of the principal factors that contribute to potential landslides and geotechnical risk, such as;

- Slope grade/classes
- Geology
- The current Yarra Ranges Council landslide inventory
- Previous mapping and Landslip Zoning of the Shire of Yarra Ranges
- The Erosion Management Overlay (EMO)

The results of the analysis and review identifies areas of higher risk, where further visual inspection as part of a risk assessment (in addition to any geotechnical assessments triggered by the EMO) should be considered and reviewed.

Recommendations

Geotechnical

- A revised construction management plan should be prepared to better define the specific management and construction controls across the trail network and related ancillary infrastructure components.
- Undertake geotechnical assessments (including Landslip Risk Assessment) in accordance with the Yarra Ranges Planning Scheme – Schedule to the Erosion Management Overlay (10/03/2016-C151) where proposed earthworks greater than 0.6 m (cut or fill) and ancillary infrastructure are covered by the EMO and areas identified as higher risk as presented in Figure 8. This assessment should include a visual assessment of all the high risk areas identified in Section 3.3 to identify presence and assess the risk of potential geotechnical hazards.
- From the preliminary geotechnical risk assessments, the following trails are likely to require full geotechnical risk assessment: Trails 1, 2, 5, 11, 17, 18, 19, 20, 21, 22 and 23.
- Trails 6, 8 and 15 may require a full geotechnical risk assessment, this will depend on the design of the trails. Some features may require ground truthing prior to deciding on a full assessment for these trail routes.
- It is noted that routes for trails 9 and 10 have not been provided and therefore have not been assessed.
- Geotechnical investigations should be undertaken to inform design and any potential geotechnical risks at the following proposed developments:
  - Visitor hub
  - Bridges – three locations
  - Mt Tugwell trail head
  - Mt Donna Buang trail head

Surface Water

- Meet standards of Melbourne Water's Constructed Crossing Guidelines for new crossings (Melbourne Water, 2011), Shared Pathway Guidelines (Melbourne Water, 2009) and DELWP guidelines (O'Connor et al., 2017). Noting that:
  - Ensure that all new crossings must allow for unrestricted passage for aquatic fauna
  - Proposed bridge crossings over waterways should not increase flood levels or flow velocities and should not present significant flow obstruction in any flood event. This will usually necessitate clear spanning of waterways
  - The underside of a 'pedestrian' bridge should be set at or above the 1 in 10 year ARI flood level and should not result in an increase up to and including the 1 in 100 year ARI level
  - Bridge abutments must have a minimum offset of five metres from the top of bank or be outside the slipline, whichever is greater, or unless otherwise agreed by Melbourne Water. The setback distance may vary due to the creek bank profile and condition.

  - Any culvert crossings should make allowance for fish migration through any barrier. Recessed culverts, which enable a build-up of natural substrate, enable greater fish passage than perched culverts. Culvert crossing pipe sizing must meet the 1 in 10 Average Recurrence Interval (ARI).
- Meet SEPP (Waters) water quality objectives in tributaries that will be crossed by the trail network by minimising erosion risk
- Minimise native vegetation removal where possible
- Prepare an Environmental Management Plan that includes:
  - Hygiene Protocols for both construction and operation phases to minimise spread of weeds and Phytophthora
  - An ongoing operational plan detailing the maintenance regime to be applied to the trails to allow for potential erosion and other impacts outlined to be managed
  - Regular inspection of erosion and sediment control measures, particularly following heavy rain, to maintain ongoing functionality
  - Siting of stockpiles at least 20 metres from waterways
  - No refuelling of equipment within 20 metres of waterways
  - Construct adequate bunds for fuel/hazardous chemicals
- In any Environment Effect Statement referral consider impacts on aquatic fauna
- An approach to lower the risk at the identified crossing points will need to include ground-truthing of all crossing points either during detailed design or at construction. Selection of approved dry tyre crossing infrastructure or alternative method would be based on approved treatment methods detailed in the Construction Environment Management Plan (CEMP), detailed design drawings and approved project protocols.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.4 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

1.1 Background

The Warburton Mountain Bike Destination Project (the Project), is situated near Warburton in the Yarra Ranges, approximately 70 kilometres north-east of Melbourne as shown in Figure 1. The project will involve the creation of world-class mountain bike trails, new accommodation and a visitor's hub, to stimulate economic growth in the region through tourism and recreation.

The trail network would be eligible for International Mountain Bike Association Gold Trail status, attracting national and international visitors.

The visitor's hub would be situated near the golf course, with direct access to the trails from the accommodation facilities. There would be a total of 44 trails comprising of formalised existing trails as well as new trails, providing both downhill and cross-country style experiences.

1.2 Purpose of this report

GHD has been engaged by Yarra Ranges Shire Council to undertake preliminary impact assessments for surface water and geotechnical risks in relation to the project.

The purpose of this preliminary surface water and geotechnical assessment is to inform the development of Referrals to government under the *Environment Effects Act 1978* and *Environment Protection and Biodiversity Conservation Act 1999*, to guide the selection of appropriate planning approval pathways for the project.

1.3 Scope

The scope of work is to prepare a preliminary surface water and geotechnical impact assessment report for the project as part of the EES Referral process. This will include the following:

- A review of existing information in relation to geotechnical risks and surface waters, including watercourse characterisation
- A summary of the existing conditions including soils, geology, land stability, water quality, flow characteristics and aquatic values
- Identification of preliminary geotechnical risk areas
- Identification of stream crossing sites and environmental sensitivity ratings of crossings. Performance criteria for crossing construction and placement
- Identification of possible crossing types and preliminary assessment of construction and operation surface water impacts and likely mitigation measures through a risk assessment process
- Recommendations to support the EES and EPBC referral process

1.4 Limitations

This report has been prepared by GHD for Yarra Ranges Shire Council and may only be used and relied on by Yarra Ranges Shire Council for the purpose agreed between GHD and the Yarra Ranges Shire Council as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Yarra Ranges Shire Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.5). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Yarra Ranges Shire Council and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.5 Assumptions

This assessment is preliminary only and no ground assessment has been undertaken. The assessment has relied on a number of data sources which are therefore assumed to be the most up-to-date data in relation to the project and publically available:

- Published geological, landform and soil mapping
- Index of Stream Conditions Victoria (Victorian Data Warehouse)
- Government produced literature including zones, overlays, soils, landscape, meteorological, EVC and topographical data
- Yarra Ranges Landslide Inventory and Mapping Online Tool (as at 6 June 2019)
- LiDAR imagery
- World Trail - Warburton Mountain Bike Trail Destination Product Review, Draft May 2019 V 1.1
- World Trail – Revised Warburton Mountain Bike Trail Network dated August 2019
- Cox Architecture – Warburton Mountain Bike Hub Master Plan, Preliminary Master Plan Report, 7 October 2016
- Cox Architecture – Warburton Mountain Bike Trails, Trail Construction Plan

These data sources have been referenced, where relevant, throughout the report and a complete list of references is provided in Section 6 at the end of this report.

2. Project background

2.1 The project

For the purposes of this assessment, the project includes the following key components.

2.1.1 Mountain bike trails

Approximately Forty Four (44) mountain bike trails totalling approximately 186 km are proposed as part of this project (Appendix A).

The trail alignment as presented in Figure 2 is based on a preliminary version of the trail plan which total 36 trails and is based on a the Warburton Mountain Bike Hub Master Plan (Cox Architecture), with further trail refinements based on draft recommendations within the Product Review, Warburton Mountain Bike Trail Destination by World Trail (World Trail, May 2019 and further refinement in August 2019 (World Trail August 2019).

The trails are a combination of new MTB trails, existing MTB trails and existing vehicle tracks incorporated into the network.

The trails are proposed to be approximately 1.2 metres wide with a head clearance of approximately 2.5 metres. No tree removal is proposed as part of the trail construction, however some groundcover and understorey vegetation will be removed.

Further details of the trail network and construction is provided in section 2.2.

2.1.2 Main Trail Head (Visitor Hub)

The main trail head and associated facilities are based on those shown in the Warburton Mountain Bike Hub Master Plan (Cox Architecture), however the location is now proposed to be at the Warburton Golf Course. Discussions are ongoing in relation to the securing of potential additional land for the main trailhead.

The actual trailhead and associated facilities would be located at the southern end of the golf course adjacent to Dammans Road. Facilities will include carparking for approximately 250 cars, a shuttle shelter, and four or five wash bays. The existing golf course building is proposed to be retained and upgraded.

2.1.3 Bridges

Three longer span shared use bridges are proposed crossing over roads and waterways, including the Frenchman's Creek Bridge, Old Warburton Road Bridge, and the Yarra River Bridge.

The Old Warburton Road bridge is proposed to be a truss style shared use bridge spanning approximately 23 metres across the Old Warburton Road and uphill ground slope. The Yarra River bridge is proposed to be a combined suspension and truss bridge approximately spanning a total of 121 metres adjacent to the existing Mayer bridge.

The locations and design of these bridges are currently in concept development stage.

2.1.4 Mt Tugwell trail head

A satellite trail head is proposed to be located close to the top of Mt Tugwell (Mt Bride Road). This will include eight carparks, a shuttle bus and trailer turnaround and loading/unloading bay, toilet, and picnic area.

2.1.5 Mt Donna Buang trail head

A trail head is proposed to be located on the top of Mt Donna Buang, including an upgrade to the existing carparking and summit facilities such as toilets and picnic area. No new structures are planned at this location.

2.2 Construction methodology

Limited construction details are provided for ancillary infrastructure such as bridges, trail head and visitor hub facilities with only general details provided on these infrastructure components.

Based on a preliminary construction methodology provided by World Trail (World Trail 2019, dated 23 July, updated again on 9 August and the final trail plan dated 29 November 2019), it is understood that the trails are proposed to be constructed as follows:

- The trails are situated within a combination of disturbed and undisturbed areas. Across the approximately 180 km trail network, the core summary and segments of the trail network include:
  - 44 trails, which include:
  - Some are loop trails, some are point-to-point trails
  - Roughly 67% are cross-country trails and 33% are gravity trails. Some trails fall into both categories
  - Breakdown of trail difficulty ratings (as per MTBA's *Australian Mountain Bike Trail Guidelines*) is:
    - Easy – 28.7%
    - Easy / Intermediate – 11.7%
    - Intermediate – 44.6%
    - Intermediate / Difficult – 3.9%
    - Difficult – 11.0%
  - Breakdown of trail composition is:
    - Proposed new MTB trails - 159.6 km (88.4%)
    - Existing MTB trails to be incorporated into network – 14.9 km (8.2%)
    - Existing vehicle track to be incorporated into network – 6.0 km (3.4%)
  - 35.3% of the trails are located on the north side of the valley; 64.7% of the trails are located on the south side of the valley
- Construction of new trails in undisturbed areas will generally be constructed with an initial bench width of 1.2 m, but this reduces over time to a ride line of 0.3-0.6 m wide. Tree branches will be lopped to 2.5 metres high (with construction corridor restricted to a total of 2 m - refer to Section 2.2.1 and Warburton MBT Ecological Protocols dated 18 October 2019).
- Typically the maximum trail grade will be 20% with exposure either side of the trail including slopes of up to 50% (1 in 2).

- There will be four (4) types of basic trail construction, which are further detailed in Section 2.2.1:
  - Standard Benching (Machine) – this type of construction is used when the trail traverses a cross slope and where the removal of native vegetation is involved. It's the standard technique for constructing new trails in reasonably undisturbed landscapes.
  - Standard Benching (Hand) – this is very similar to 'Standard Benching – Machine' except that it is used in situations where it may not be possible or desirable to use a mini-excavator.
  - Rock Armouring – is used to harden the trail surface, generally on steep gradients, where the soil would likely be displaced by water or trail users, leading to erosion. No rock armouring is proposed on waterway crossings. The armouring is also used crossing potential wet areas where there is no stream flow or indicator vegetation, however the ground may seasonally soften. By hardening the base of the trail where it crosses the potential wet area, users can still use the trail without it becoming boggy or muddy.
  - Elevated Structures – the construction of bridges/elevated structures to enable a trail to cross over a waterway or area of soft or boggy ground. The structures will vary in height above the ground, with heights typically less than 1 m above the ground other than the major crossing locations. Based on the proposed waterway crossing construction mythology, all water course crossings are constructed as dry wheel crossings utilising elevated structures or bridges.

2.2.1 Detailed Construction Method

Based on the methodology provided by World Trail (and also outlined in Warburton MBT Ecological Protocols dated 18 October 2018), it is understood that further ground-truthing of the network is proposed and during construction further protocols are implemented.

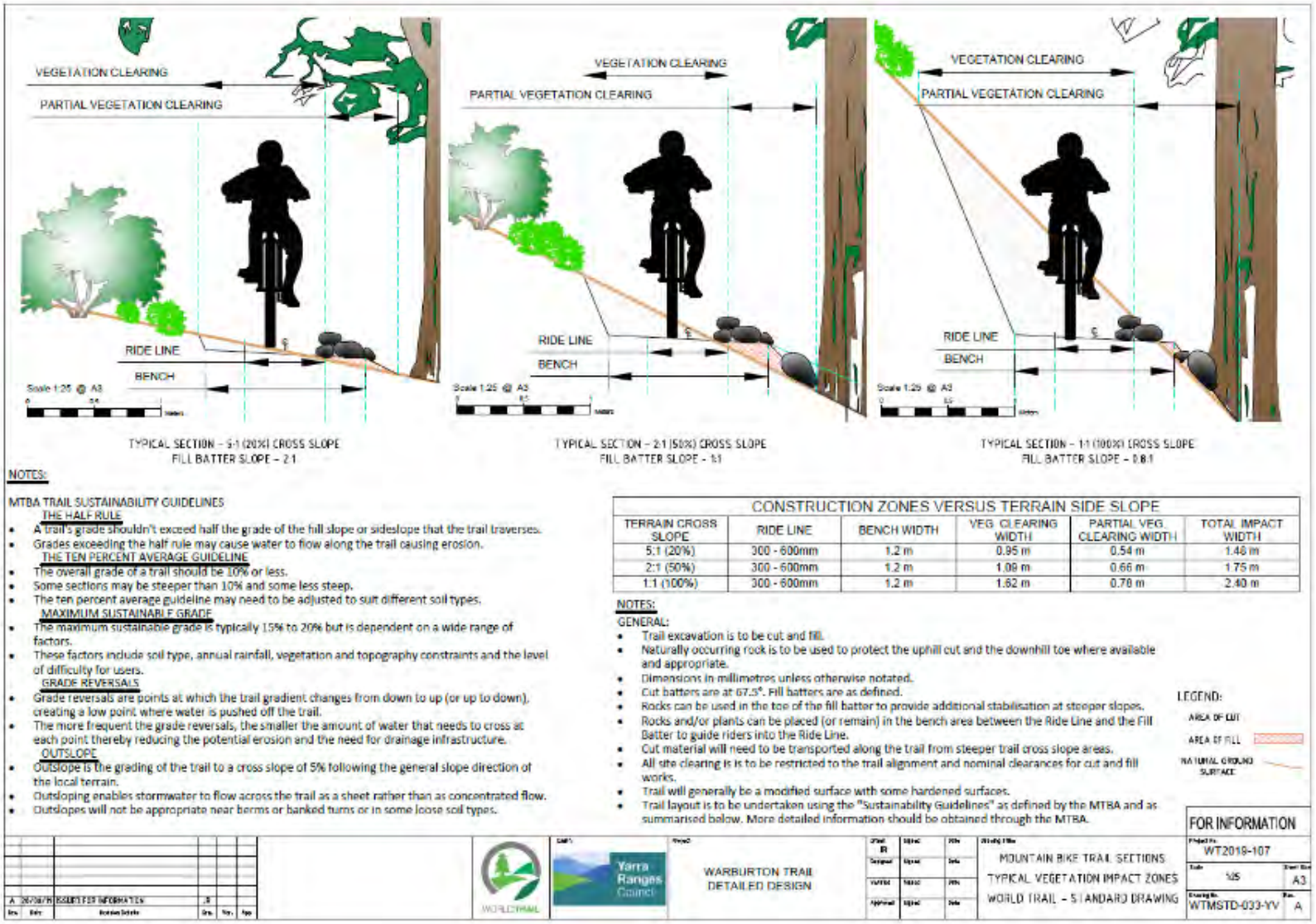
It is understood detailed design documentation and a Construction Environmental Management Plan (CEMP) will be prepared and would take precedence over the preliminary world trail standard drawings and construction method described in this report. To inform the preliminary assessment, the following general methodology, staging and typical design is assumed:

- Review the ground-truthed corridor up to 100-200 m ahead of excavator. The ground-truthed corridor is marked using coloured flagging tape tied to trees/vegetation during the ground-truthing stage and mapped with GPS. The ground-truthed corridor is generally defined to include 10 m (this may vary depending on environmental values) either side of the flagged alignment (i.e. the centre line).
- Determine the exact alignment to be taken within the ground-truthed corridor. In areas of high environmental values, this is often undertaken with botanists/zoologists/ecologists to minimise impacts on local environmental values

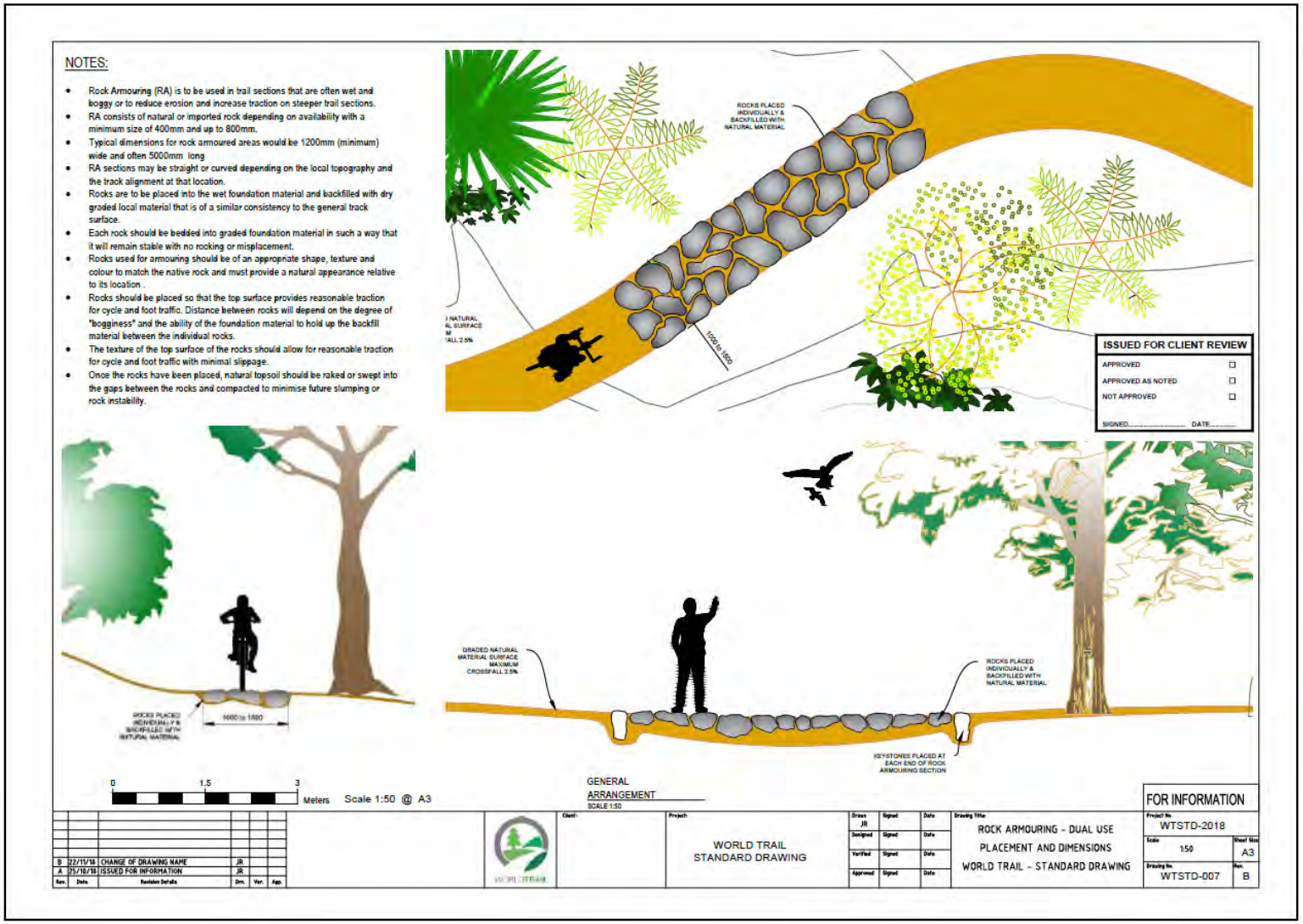
- Clear the construction corridor of vegetation. The construction corridor is defined as the horizontal corridor from the top of the upslope batter to the toe of the downslope batter and the vertical corridor to about 2.5 m high (sufficient to allow passage of the excavator). Clearing of the construction corridor is usually undertaken manually using motorized tools such as brushcutters, chainsaws and hedgetrimmers and hand tools like loppers, hand saws and secateurs. Large trees (greater than 200 mm DBH) do not need to be removed, as the trail can be routed to avoid them, however, it is likely that small boughs and limbs may need to be removed. All vegetation that is removed is cut into small pieces and dispersed throughout the surrounding area - no large windrows or stockpiles should be present. At this stage, all vegetation is removed except for ground covers, herbs and grasses (which are left in place for later removal by the excavator).
- Cut the bench using a balanced cut and fill technique. The topsoil and mineral earth removed from the inner side of the bench are used to build up the outer edge of the bench. The excavator works forwards, cutting the bench ahead of it and then moving forward onto the bench. The bench must be wide enough and stable enough for the excavator to operate safely on. Using a rubber-tracked mini-excavator with a minimum track width of about 900 mm, the bench is generally constructed at 1 m width. On steeper slopes, the outer edge of the bench may need to be retained. In MTB trail construction this is generally done using dry stone rock walls, built from rock sourced during the construction of the bench.
- Define the ride line by placing rocks, logs and other obstacles as necessary. Large obstacles work best and should be manoeuvred into placed by the excavator. The ideal ride line is generally on the inner side of the bench, at the toe of the upslope batter, where the soil is firm and compacted. Obstacles are manually and deliberately placed to control rider speed and position riders towards the inside of the bench, away from the soft outer edge.
- Clean up the trail tread, removing loose rocks and roots, compacting the tread, back sloping the batter and managing drainage (for example, ensuring the trail is outsloped where practical). This step is undertaken manually, by trail labourers working behind the excavator.

Examples of typical trail final construction are provided in the following images courtesy of World Trail and YRC.

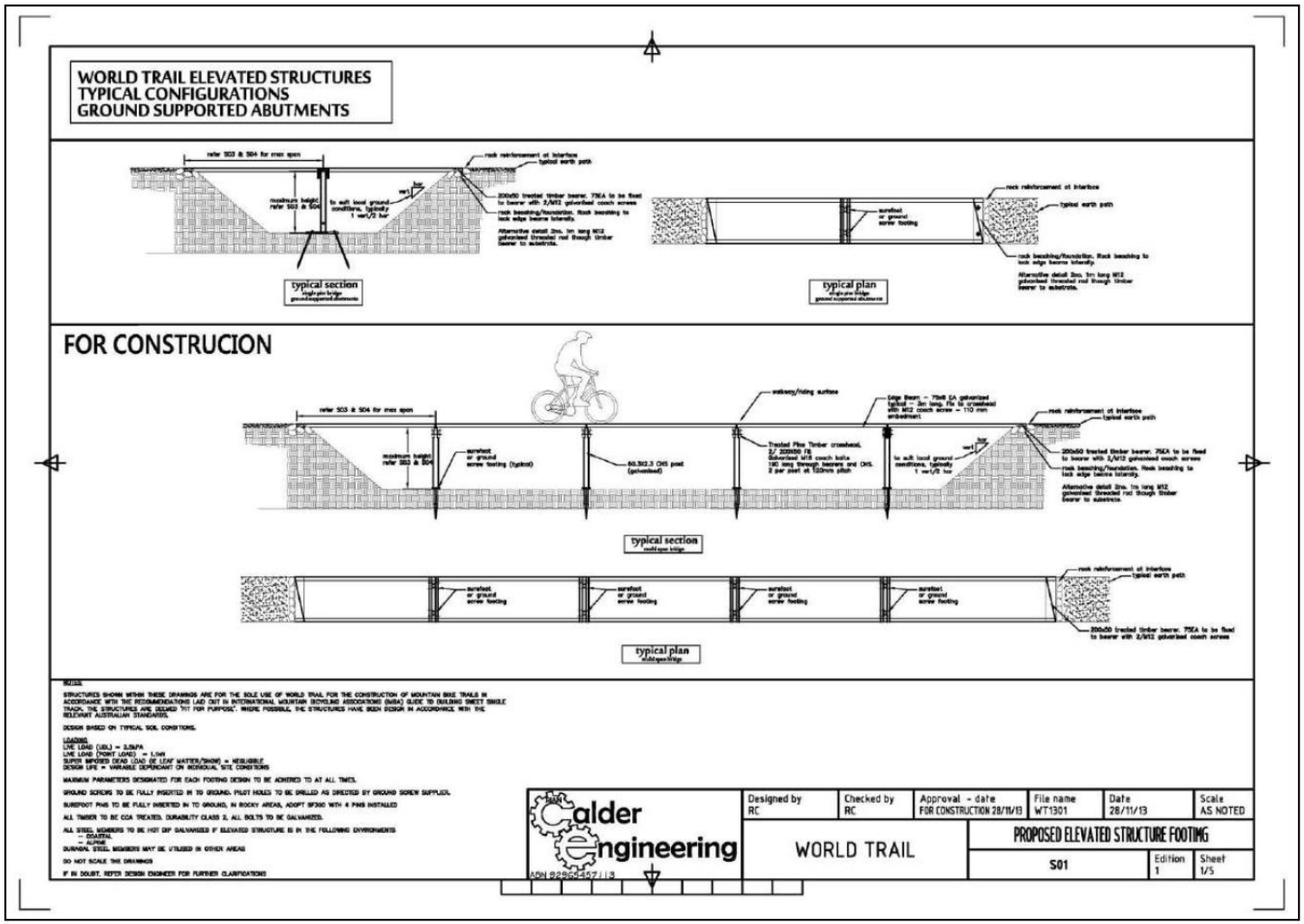
Plate 1 Typical construction method examples (courtesy of World Trail)



Indicative cross-sections for standard benched trails (courtesy of World Trail)



Typical Rock Armouring Detail (Courtesy of World Trail)



Typical Configurations for Ground Supported Structures (courtesy of World Trail)

3. Geotechnical assessment

3.1 Methodology

This preliminary geotechnical impact assessment has been prepared in general accordance with the following:

- Schedule to the Erosion Management Overlay - Yarra Ranges Planning Scheme
- Practice Note Guidelines for Landslide Risk Management 2007 - Australian Geomechanics Society, Vol. 42 No 1 March 2007

3.1.1 Schedule to the Erosion Management Overlay (EMO) – Yarra Ranges Planning Scheme

Subject to the projects final planning approvals, the Yarra Ranges Shire contains areas of land which are susceptible to landslip, including land in the Warburton area. A number of geotechnical studies have been undertaken, in various forms and the Shire of Yarra Ranges has subsequently adopted a shire wide slope stability classification system and guidelines for the development of land potentially affected by landslip.

All land included in the EMO has been identified as having a sufficiently high risk of potential instability to warrant specific review of these risks prior to the issue of a planning permit. Key environmental factors including vegetation cover, drainage, rock and soil disturbance are important in managing the risk of landslip.

The EMO is shown in Figure 6.

3.2 Climate

3.2.1 Rainfall & Temperature

It is noted the project site covers a large area with varying elevation (from 150 to 1250 m) and associated terrain, which are likely to experience different climatic conditions, particularly in respect to rainfall and temperature. This change in elevation across the project area is likely to experience extremes and variations in heavy rainfall, snowfalls and frosts particularly during the winter months.

To briefly summarise the climate conditions, data was obtained from two stations near Warburton:

- Rainfall at Warburton (O'Shannassy Reservoir station 86090 from BOM website on 14 June 2019)
- Temperature at Coldstream (station 086383 from BOM website on 14 June 2019)

The data is summarised in Table 1 which is based on the period 1915 to 2019 for rainfall and 1995 to 2019 for temperature records.

The long-term mean rainfall at the site is 1380 mm. It is expected that most precipitation occurs as rainfall with winter (May to August) the wettest season.

Temperatures are lowest during June and July, with the long-term minimum temperatures ranging from 3.9 °C in July to 12 °C in January and February. Temperatures are warmest in January with the maximum temperatures ranging from 13.4 °C in July to 28.1 °C in January.

Table 1 Summary of climate data

Month	Temperature °C		Rainfall (mm)
	Maximum	Minimum	Average
Jan	28.1	12	67.7
Feb	27.8	12	63.9
Mar	25.4	9.9	73.3
Apr	20.7	6.9	100.5
May	16.7	5.7	125.6
Jun	14	3.9	131.6
Jul	13.4	3.9	149.5
Aug	14.7	4.3	170.8
Sep	17.2	5.5	147.0
Oct	19.8	6.6	138.6
Nov	22.8	8.8	111.9
Dec	25.3	9.9	96.2
Annual	20.5	7.5	1380.4

Note: Site elevation 240 m at Warburton and 80 m at Coldstream. Record length: rainfall, temperature, evaporation: 1889 to present (May 2019).

3.2.2 Site topography & geomorphology (landform)

The start of the trails network (Warburton golf course) is located west of Warburton and sits at an approximate elevation of 155 m. It lies within a gently sloping to flat valley system formed by the Yarra River comprising fans and colluvial aprons. The Yarra River runs from east to west and is locally fed by drainage systems coming from the hillsides north and south of Warburton.

North of Warburton is moderate to very steep forest covered mountain terrain with narrow crests and well incised gully systems running north to south, feeding the Yarra River below. The northern extent of the site is defined by the summit of Mt Donna Buang at an elevation of 1250 m.

South of Warburton which will incorporate a condensed trail network is also heavily forested with moderately to steeply sloping low hill topography. The ridgelines in this area are broader with more rolling undulating hills. The elevation in the south reaches approximately 800 m which defines the southern extent of the site and end of the trail network.

The variation in slope angles between the centre of the site within the Yarra River valley and in the hillsides north and south of Warburton are highlighted on Figure 3.

3.2.3 Soils

The soil conditions throughout the region have been identified based on descriptions found in local land systems reports and the Coffey report: Landslip Zoning of the Shire of Yarra Ranges (1999) (ref: M2964/1-CF).

Figure 4 displays the geographical distribution of the local land systems and soil units with further description provided in Table 2.

The flat lying flood plain and lower terraces associated with the Yarra River and its tributaries comprise alluvium of sandy silt, clay and gravel deposits. The lower slopes and foot slopes of the steeper terrain to the north and south of Warburton generally comprise colluvial deposits of poorly sorted sand, gravel, silt, clay, and cobbles to boulder sized weathered rocks sourced from igneous and metamorphic rock and residual soil.

Distinct weathering profiles have developed on the mountainous/hilly terrain north and south of Warburton which are characteristic of the underlying geological material. The north comprises a variable but often thick cover of residual soil described as friable red-brown-orange soils.

The soil profile on the slopes of the southern terrain ranges from residual soil 1 to 3 m thick overlying extremely weathered to highly weathered rock to deep residual soil profiles often containing corestones.

Table 2 Landform, soils and erosion hazards

Land System	Soils	Landform/Slopes	Erosion/Hazards
Mri (Mount Riddell)	Friable red and brown gradational soil, deep dark topsoil but frequently shallow and very strong on the steepest slopes and spurs, and on some crests	Hillslopes <20%	Low sheet erosion
		Hillslopes >20%	**High sheet erosion after disturbance**
Don (Don Valley)	Brown loamy undifferentiated soil stony at depth.	Valley bottoms 2-3%	**Access deterioration and stream deterioration**
	Deep, red and reddish brown gradational soil. Yellow brown mottled duplex at base of aprons and fans.	Fans and aprons 8 to 20%	Low sheet erosion
		Hillslopes 8 to 20%	Low sheet erosion
		Old landslip areas 8 to 20%	**Moderate landslip**
Dee (Deep Creek)	Brown or reddish brown gradational	Hills with steep slopes 20 to 50%	Low gully erosion associated with road and track construction.
		Moderately steep slopes	
		Drainage lines	**Deterioration of stream banks at places of concentrated disturbance**.
Mil (Millgrove)	Stream banks – uniform brown loamy soil	Stream channel and banks <0.75%	Stream bank erosion. Access deterioration.
	Yellowish red gradational soil	Higher alluvial terraces <2%	Water logging
	Mottled yellow brown duplex soil		

Land System	Soils	Landform/Slopes	Erosion/Hazards
	Red gradational soil		
	Red gradational soil with much weathered gravel in subsoil.	Old fans/lower slopes 3 to 6%	-
Res (Reefton Spur)	Deep grey brown and yellowish brown loam	Drainage lines 1.5 to 2.5%	**Moderate gullying** **Moderate deposition**
	Upper slopes and crests mainly yellowish brown and reddish brown gradational friable soil of greatly variable depth. Lower slopes and footslope colluvial deposits have similar soils but can have yellow brown duplex soil with deep A horizons.	Exposed slopes 30 to 70%	**High sheet erosion**
		Sheltered slopes 30 to 70%	**Moderate sheet erosion**
		Spurs and ridge crests	Low sheet erosion
Mmy (Mt Myrtalia)	Red and brown gradational soil. Local boulder outcrop.	Exposed slopes 15 to 50%	**High sheet erosion local outcrop**
	Brown gradational soil with deep dark topsoil.	Broad crests <15%	Low sheet erosion
	Brown and red gradational soil with deep dark topsoil.	Sheltered slopes 15 to 50%	**High sheet erosion**
	Undifferentiated brown loamy soil with deep dark topsoil.	Valley bottoms often narrow 3 to 4%	**Streambank deterioration**
Sib (Siberia Gap)	Acid swamp peats	Peat swamps 0 <2 %	Stream incision
	Brown or reddish brown gradational soil, locally stony. Rocky outcrop on upper parts of hillocks.	Hillocks – 10 to 20%	Low gully erosion associated with road or track construction.
		Undulating area 4 to 10%	
		Steeply incised stream valleys 15 to 30%	
Sev (Seville)	Grey brown loam, yellow brown mottled duplex soil	Drainage lines <1.5%	Waterlogging. Low flash flooding.
	Yellow brown duplex soil, mostly with mottled subsoil. Yellow gradational soil in higher rainfall parts.	Moderately steep slopes and broad rounded crests 5 to 20%	Moderate to low sheet erosion.
	Yellow brown duplex with shallow stony gradational soil	Steep slopes 20 to 30%	**High sheet erosion.**

3.2.4 Geological setting

The geological setting for the region described below has been determined based on the 1:250,000 Geological Survey of Victoria map of Warburton (1997) and the Coffey Report (ref: M2964/1-CF).

The geology of the area is made up of five major units and can be roughly divided between the north and south and highlighted as Figure 5. These are listed below from oldest to youngest.

Silurian to Devonian Humevale Siltstone

This unit is found underlying the south west portion of the site and comprises siltstone that has undergone contact metamorphism to produce hornfels as a result of baking from the adjacent igneous intrusion.

Late Devonian Warburton Granodiorite

An igneous intrusion covering a large part of the southern section of the site and forming the hills in this area.

Late Devonian Donna Buang Rhyodacite

A thick extrusive volcanic deposit which has formed the mountainous area north of Warburton.

Silurian to Carboniferous Felsic Dykes

A series of linear feeder dykes occurring in parts of the Donna Buang Rhyodacite which are very similar in composition.

Quaternary Colluvium and high level Alluvium

The deposits make up some of the lower slopes, larger scale landslips and high level river terraces adjacent to slopes.

Alluvium

This unit makes up the floodplains and lower terraces of the Yarra River and its tributaries.

3.2.5 Landslide susceptibility and risk

The current Yarra Ranges Council landslide inventory and Coffey report (ref: M2964/1-CF) have been used to assess the susceptibility and risk of landslides in the Warburton area.

The geographic distribution of existing landslides appears to reflect areas of sloping ground, but are markedly controlled by the presence of particular geological units. They all occur within the Donna Buang Rhyodacite, Felsic Dykes and Colluvium (derived from Rhyodacite and Felsic Dykes) present north of Warburton on the lower slopes and within the mountainous area. Except for soil creep, which has been observed in all units, there is currently no evidence that significant landslides occur in the Granodiorite and Humevale Siltstone units south of Warburton.

Information of historical landslides and instability suggest failures range from rock falls to rapid debris flows to very slow moving large landslides incorporating whole hillsides. Triggers for these have been associated with historical heavy rainfall events and other natural and manmade causes (such as artificial concentrations of water). It is noted that instability of cut and fill slopes has been observed in all geological units ranging from minor erosion to more substantial slope failures.

The susceptibility and associated risk of landslides occurring in the subject site will be controlled by a number of factors. The following risk categories are based on criteria for each critical factor summarised in the Coffey report (ref: M2964/1-CF).

High risk areas:

- Presence of known landslides, particularly on the northern slopes as these are likely to reactivate and move again in the future. An example is the large scale (>2 km x >2 km) Dee Road landslip complex north of Warburton within the Rhyodacite/Colluvium; or
- Areas with similar slope geometry and geological conditions to areas with known landslides. This would include steep slopes in the mountainous area north of Warburton; or
- Where the underlying geology is Donna Buang Rhyodacite or Felsic Dykes and natural slope angles are greater than 25° (50% slope grade)

Medium risk areas:

- Areas with natural slope angles between 11° and 22° (20% and 40% slope grade) and variable rock depth irrespective of underlying geology

Low risk areas:

- Natural slope angles are less than 11° (20% slope grade) and there is no evidence of natural slope instability

3.3 Geotechnical impact assessment

The following section assesses the geotechnical factors associated with landslide risk and susceptibility for the proposed trails and associated ancillary infrastructure associated with the Warburton Mountain Bike Park.

It highlights potential landslide hazards and numerically ranks each trail (one being the highest risk) based on the geotechnical factors identified within the trail location.

The assessment is based on the proposed trail plan dated 9 August 2019 as presented in Figures 2 to 8.

This assessment does not cover the full requirements of the Yarra Ranges Planning Scheme – Schedule to the Erosion Management Overlay (10/03/2016-C151). A geotechnical risk assessment in accordance with this EMO should be undertaken where ancillary infrastructure or earthworks greater than 0.6 m (cut or fill) are planned within areas covered by the EMO or in risk zones identified as part of this assessment.

The geotechnical factors evaluated for this assessment includes those described in the sections above, including:

- Slope grade/classes - The distribution of slope classes within the project area has been modelled from LiDAR data and regional DEM data and is shown in Figure 3
- Geology - determined based on the 1:250,000 Geological Survey of Victoria map of Warburton (1997) and is shown in Figure 5
- The current Yarra Ranges Council landslide inventory (http://www.mapimage.net/IntraMaps75/ApplicationEngine/Application.aspx?project=Yarra+Ranges&module=Landslide&configId=bf9bd338-12aa-43f2-95aa-a491de0b3a8d Accessed June 2019)
- Coffey report: Landslip Zoning of the Shire of Yarra Ranges (1999) (ref: M2964/1-CF)
- The Erosion Management Overlay (EMO) and high risk landslide susceptibility is shown in Figure 6

Table 3 (ancillary infrastructure such as visitor hub, bridges and trail heads), Table 4 and Table 5 (trail networks) summarise the results of the assessment, with text in **bold**, highlighting factors that contribute to high risk of landslide susceptibility.

Based on the geotechnical factors involved and the risk rating assigned, an indication of whether a full geotechnical risk assessment will be required for the trail is given. This is based on the geotechnical factors, plus the potential for deep cut/fill depending no slope grade and the typical sections provided by WT (see Section 2.2.1).

Table 3 Warburton Mountain Bike Park Ancillary Infrastructure Geotechnical Assessment

Ancillary Infrastructure	Geological conditions	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Recommendations
Warburton Mountain Bike Park Visitors Hub	Donna Buang Rhyodacite / Possible Colluvium	<20% / 21-40%	Site may be covered by EMO depending on location.	Evidence of minor instability	Poor ground conditions	Undertake geotechnical investigation to inform design of car park and facilities and to highlight potential geotechnical risks. Undertake geotechnical risk assessment in accordance with the Yarra Ranges Planning Scheme – Schedule to the Erosion Management Plan (10/03/2016-C151) where proposed infrastructure is covered by EMO.
Bridge 1A – Mayer Pedestrian Bridge	Donna Buang Rhyodacite	<20% (excluding river bank)	Not within the EMO or a recorded landslide.	Minor erosion features along Yarra River bank.	Shallow failures of uncontrolled fill associated with existing structures. Shallow river bank failures as a result of erosion. Poor foundation conditions.	Undertake ground investigation to inform bridge footing design and to highlight potential geotechnical risks.
Bridge 1B	Donna Buang Rhyodacite	<20% (excluding river bank)	The EMO covers the north site of the River Bank. A landslip occurred on an embankment near the suspension bridge ramp.	Minor erosion features along Yarra River bank.	Shallow river bank failures of uncontrolled fill associated with existing structures. Shallow failures as a result of erosion. Poor foundation conditions.	Undertake ground investigation to inform bridge footing design and to highlight potential geotechnical risks. Undertake a geotechnical risk assessment in accordance with the Yarra Ranges Planning Scheme – Schedule to the Erosion Management Plan (10/03/2016-C151).

Ancillary Infrastructure	Geological conditions	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Recommendations
Bridge 2 – Old Warburton Road Bridge	Humevale Siltstone	21-40%	Not within the EMO or a recorded landslide.	Minor erosion features associated with stream.	Shallow failures as a result of erosion.	Undertake ground investigation to inform bridge footing design and to highlight potential geotechnical risks.
Mt Tugwell Trail Head	Warburton Granodiorite	<20% / 21-40%	Not within the EMO or a recorded landslide.	No evidence of instability.	Slope instability of any proposed earthworks.	Undertake geotechnical investigation to inform design of car park and facilities and to highlight potential geotechnical risks.
Mt Donna Buang Trail Head	Donna Buang Rhyodacite	<20% / 21-40% (localised slopes >50%)	Not within the EMO or a recorded landslide.	Instability observed downslope of Donna Buang Summit Road	Slope instability of any proposed earthworks and where proposed works encroach existing steep slopes. Poor foundation conditions.	Undertake geotechnical investigation to inform design of car park and facilities and to highlight potential geotechnical risks.

Table 4 North trails geotechnical assessment

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
1	(70%) Donna Buang Rhyodacite (20%) Colluvium (middle of trail) (10%) Felsic Dyke	(45%) 21-40% (30%) <20% (15%) >50% (10%) 41-50%	Approximately 3 km of trail crosses existing Dee Road landslide complex (large scale debris flow) covered by the EMO.	Source of landslide material extends to ridge line traversed by Donna Buang Road where large scale back scarps observed. Displaced material covers large area upslope of trail route. Part of trail potentially traversing unrecorded landslide debris material.	Reactivation of debris flow material due to natural or artificial factors (heavy rainfall/earthworks/alteration of drainage pathways). Potential for development of future landslides where trail traverses slopes >50%.	1	Y
2	(85%) Donna Buang Rhyodacite (10%) Felsic Dyke (eastern end) (5%) Colluvium (western end)	(90%) 21-40% (5%) 40->50% (5%) <20%	Parts of the trail cross EMO and also are within areas of high susceptibility. Western end (~200 m) of trail passes through existing Dee Road landslide complex covered by the EMO.	Middle section (~700 m) and western end (~300 m) of trail traversing through potential unrecorded ancient debris flow.	Reactivation of debris flow material due to natural or artificial factors (heavy rainfall/earthworks/alteration of drainage pathways). Potential for development of small scale landslides in western portion of trail where slope grade >50%.	2	Y
3	(100%) Donna Buang Rhyodacite	(80%) 21-40% (20%) <20%	Northern half of trail covered by EMO.	Small scale erosion features associated with watercourses.	Small scale failures associated with alteration of drainage pathways.	7	N
4	(100%) Donna Buang Rhyodacite	(100%) 21-40%	Does not cross any recorded landslide or EMO.	Hummocky ground indicating possible landslide debris material.	Small scale failures associated with alteration of drainage pathways.	8	N

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
5	(95%) Donna Buang Rhyodacite (5%) Colluvium	(50%) 21-40% (20%) 41-50% (30%) >50%	70% of trail is within EMO	Potential back-scarps/landslide features following ridgeline.	Potential for small scale landslides developing where slope grade >50%. Reactivation of existing failures due to earthworks. Small scale failures associated with alteration of drainage pathways.	3	Y
6	(100%) Donna Buang Rhyodacite	(60%) 21-40% (20%) 41-50% (20%) >50%	Southern section slightly intersects EMO, does not interact with mapped landslides	No obvious back scarps or debris flow deposits.	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways.	15	P
7	(50%) Donna Buang Rhydacite (50%) Colluvium	(75%) 21-40% (10%) <20% (10%) 41-50% (5%) >50%	Does not cross any recorded landslide or EMO.	Hummocky ground indicating possible landslide debris material.	Small scale failures associated with alteration of drainage pathways.	9	N

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
8	(20%) Lake Mountain Rhyodacite (20%)Taggerty Subgroup (20%)Rubicon Rhyolite (30%) Felsic Dyke (10%) Colluvium (western end)	(20%) 21-40% (30%) 41-50% (50%) >50%	Does not cross any recorded landslide or EMO.	Hummocky ground indicating possible landslide debris material. No obvious landslide features but LiDAR resolution is poor in this area	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways.	16	P

(Text in bold highlights factors that contribute to high risk of landslide susceptibility)

(Geotechnical Assessment Required Key: Y=Yes, N=No, P=Possible, depending on design)

Table 5 South trails Geotechnical assessment

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
11	(40%) Humevale Siltstone (40%) Warburton Granodiorite **(20%) Felsic Dyke**	**(60%) >50%** (30%) 41-50% (10%) 21-40%	First ~20% of trail passes through EMO on lower, steep slopes above Yarra River. **Passes through small scale cut batter failure on Warburton Rail trail.**	Hummocky ground on lower slopes above Yarra River indicating possible past instability.	Reactivation of existing failures due to earthworks. Potential for development of future landslides where trail traverses slopes >50%. Small scale failures associated with alteration of drainage pathways.	4	**Y**
12	(100%) Humevale Siltstone	**(5%) >50%** (25%) 41-50% (70%) 21-40%	No EMO, no landslides	No obvious features	Small scale failures associated with alteration of drainage pathways. Potential for development of future landslides where trail traverses slopes >50%. Small scale failures associated with alteration of drainage pathways.	18	**N**
13	(100%) Humevale Siltstone	**(10%) >50%** (40%) 41-50% (50%) 21-40%	No EMO, no landslides	No obvious features	Small scale failures associated with alteration of drainage pathways. Small scale failures associated with alteration of drainage pathways. Potential for development of future landslides where trail traverses slopes >50%.	19	**N**

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
14	(100%) Humevale Siltstone	**(50%) >50%** (30%) 21-40% (10%) 41-50% (10%) <20%	Does not cross any recorded landslide or EMO	No obvious features of instability	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways.	20	**N**
15	(50%) Humevale Siltstone (50%) Warburton granodiorite	**(50%) >50%** (50%) 21-40%	Approx 5% of east trail crosses EMO	Slightly hummocky topography – possible ancient debris flow?	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways.	17	**P**
16	(30%) Humevale Siltstone (70%) Warburton granodiorite	(50%) 21-40% (50%) 41-50%	Approx 40% of trail crosses EMO in west	Slightly hummocky topography – possible ancient debris flow, possible back scarp features	Small scale failures associated with alteration of drainage pathways. Reactivation of existing failures due to earthworks.	21	**N**
17	(100%) Warburton granodiorite	**(30%) >50%** (30%) 21-40% (20%) 41-50% (20%) <20%00	Approx 30% of trail crosses EMO	Gully features, some possible signs of instability and old debris deposits	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways. Reactivation of existing failures due to earthworks.	10	**Y**

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
18	(100%) Warburton granodiorite	**(30%) >50%** (30%) 21-40% (20%) 41-50%	Approx 30% of trail crosses EMO	Gully features, some possible signs of instability and old debris deposits	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways. Reactivation of existing failures due to earthworks.	11	**Y**
19	(90%) Warburton granodiorite **(10%) Ythan Creek Rhyodacite**	**(30%) >50%** (30%) 21-40% (20%) 41-50% (20%) <20%	Approx 30% of trail crosses EMO	Gully features, some possible signs of instability and old debris deposits	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways. Reactivation of existing failures due to earthworks.	12	**Y**
20	(100%) Warburton granodiorite	**(30%) >50%** (30%) 21-40% (20%) 41-50% (20%) <20%	Approx 30% of trail crosses EMO	Gully features, some possible signs of instability and old debris deposits	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways. Reactivation of existing failures due to earthworks.	13	**Y**

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
21	(100%) Warburton granodiorite	**(30%) >50%** (40%) 21-40% (20%) 41-50% (10%) <20%	50% of trail crosses EMO	Some potential back scarp features on LiDAR	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways. Reactivation of existing failures due to earthworks.	14	**Y**
22	(100%) Warburton granodiorite	**(30%) >50%** (40%) 21-40% (20%) 41-50% (10%) <20%	50% of trail crosses EMO	Some potential back scarp features on LiDAR	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways. Reactivation of existing failures due to earthworks.	6	**Y**
23	(100%) Warburton granodiorite	**(50%) >50%** (20%) 21-40% (30%) 41-50%	60% of trail crosses EMO	Some potential back scarp features on LiDAR, possible erosion features by creeks	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways. Reactivation of existing failures due to earthworks.	5	**Y**
24	(100%) Warburton granodiorite	(20%) 21-40% (70%) 41-50% (10%) <20%	No interaction with EMO	No obvious features – appears to follow the Mt Bride road	Small scale failures associated with alteration of drainage pathways.	22	**N**

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
25	(50%) Humevale Siltstone (50%) Warburton Granodiorite	(40%) 21-40% (40%) <20% **(15%) >50%** (5%) 41-50%	Does not cross any recorded landslide or EMO	No evidence of instability	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways.	23	**N**
26	(100%) Humevale Siltstone	(70%) 21-40% (20%) 41-50% **(10%) >50%**	Does not cross any recorded landslide or EMO	No evidence of instability	Potential for small scale landslides developing where slope grade >50%. Small scale failures associated with alteration of drainage pathways.	24	**N**
27	(100%) Warburton Granodiorite	(50%) 21-40% (15%) <20% (15%) 41-50% **(20%) >50%**	Does not cross any recorded landslide or EMO	Minor evidence of instability associated with watercourses	Small scale failures associated with alteration of drainage pathways. Potential for small scale landslides developing where slope grade >50%.	25	**N**
28	(100%) Warburton Granodiorite	(50%) 21-40% (35%) <20% (10%) 41-50% **(5%) >50%**	Does not cross any recorded landslide or EMO	Minor evidence of instability associated with watercourses	Small scale failures associated with alteration of drainage pathways. Potential for small scale landslides developing where slope grade >50%.	26	**N**
29	(100%) Warburton Granodiorite	(50%) <20% (40%) 21-40% **(5%) >50%** (5%) 41-50%	Does not cross any recorded landslide or EMO	Small scale erosion features associated with watercourses	Small scale failures associated with alteration of drainage pathways. Potential for small scale landslides developing where slope grade >50%.	27	**N**

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
30	(100%) Warburton Granodiorite	(70%) 21-40% (20%) <20% (5%) 41-50% **(5%) >50%**	Does not cross any recorded landslide or EMO	Small scale erosion features associated with watercourses	Small scale failures associated with alteration of drainage pathways. Potential for small scale landslides developing where slope grade >50%.	28	**N**
31	(100%) Warburton Granodiorite	(100%) 21-40%	Does not cross any recorded landslide or EMO	No evidence of instability	Small scale failures associated with alteration of drainage pathways.	29	**N**
32	(100%) Warburton Granodiorite	(70%) 21-40% (20%) 41-50% **(10%) >50%**	Does not cross any recorded landslide or EMO	Small scale erosion features associated with watercourses	Small scale failures associated with alteration of drainage pathways. Potential for small scale landslides developing where slope grade >50%.	30	**N**
33	(100%) Warburton Granodiorite	(100%) 21-40%	Does not cross any recorded landslide or EMO	Small scale erosion features associated with watercourses.	Small scale failures associated with alteration of drainage pathways.	31	**N**
34	(100%) Warburton Granodiorite	(50%) 21-40% (35%) <20% (10%) 41-50% **(5%) >50%**	Does not cross any recorded landslide or EMO	Minor evidence of instability associated with watercourses	Small scale failures associated with alteration of drainage pathways. Potential for small scale landslides developing where slope grade >50%.	32	**N**
35	(100%) Warburton Granodiorite	(100%) 21-40%	Does not cross any recorded landslide or EMO	Minor evidence of instability associated with watercourses	Small scale failures associated with alteration of drainage pathways.	33	**N**

Trail number	Geological conditions ((%) of trail)	Terrain/Slope	Recorded landslides/EMO	Landform features (from LiDAR)	Hazards/Risk considerations	Risk ranking	Geotechnical Assessment Required (Y/N/P)
36	(100%) Warburton Granodiorite	(100%) <20%	Does not cross any recorded landslide or EMO	No evidence of instability	Small scale failures associated with alteration of drainage pathways	34	**N**

(Text in bold highlights factors that contribute to high risk of landslide susceptibility)

(Geotechnical Assessment Required Key: Y=Yes, N=No, P=Possible, depending on design)

3.4 Preliminary assessment of trail network

The World Trail proposed trail network provides a range of options for potential end users, while maximising those trail classes most attractive to visitors, and locating trails within slopes that will favour their long term sustainability.

To better assess the proposed trail design and construction as a result of the variable ground conditions along the alignment, GHD refer to the International Mountain Bicycling Association Standards (IMBA) (IMBA 2004[1]). GHD has assumed the World Trail design of the network and the associated final construction plan will adopt these standards.

These standards are considered world's best practice in the design, construction and management of mountain bike trails and considered an appropriate assessment tool in respect to determining the ability of the land and trail system to sustain the proposed development and potential impact on the local ground conditions.

As outlined in Section 2.2.1 the exact alignment to be taken within the ground-truthed corridor is determined during construction. Therefore, this refinement, often during construction enables key aspects associated with the IMBA Standards to mitigate trail risks to be applied. In particular the following essential elements have been considered in the preliminary alignment and are understood to be further applied during refinement of the trail plan, detailed design and during construction (CEMP):

- Trail grade must not exceed half the sideslope which the trail is traversing. For example on a 10% (5.7 degrees) slope the trail gradient should not exceed 5% (2.8 degrees).
- Generally an average of <10% trail (<5.7 degree) grade is most sustainable.
- The maximum grade of trail (over sections of more than three metres) generally should not exceed 15-20% (8-11 degrees).
- Trails should be built with grade reversal, rising and dropping to allow water to drain and outlet off the trail. Intervals between drain outlets depend on the soil material and slope but for trails under 15 % (<8 degrees) in higher erodibility soils spacing should not exceed 20 m.
- Trail crossfall drainage to the downhill side of approximately three degrees.

As part of the preliminary assessment, GHD assumes World Trail will apply specific trail design and final construction controls in accordance with the IMBA standard, detailed design stage drawings, CEMP and other approved protocols, such as the Warburton MBT Ecological Protocols (dated 18 October 2018). This approach will not only allow for a refinement of the preferred trail coordinator, manage environmental and water quality risks, but also reduce initial construction and ongoing maintenance costs for the land manager.

In relation to the proposed design and the IMBA standards, the following general observations are made in relation to the local setting and proposed trail design and controls:

- 0-10% - On gentle side slopes below 10% it can actually be more difficult to design a sustainable trail as it is difficult to achieve the IMBA Half Rule.
- 11-25% - The ideal side slope for MTB trails is probably 10-25%. Small deviations in the trail to the left and right create deep and functional grade reversals. Water flowing across the surface sheds across the trail.

[1] International Mountain Bicycling Association (IMBA) (2004) Trail Solutions: IMBA's Guide to Building Sweet Single Track. Published by the IMBA, Boulder Colorado

- 26 - 50% - As the side slope exceeds 25% it becomes harder to build on, often requiring retaining walls on the lower edge (depends on soils and vegetation). Often the issue is not so much whether we can safely and sustainably build on such slopes, but the exposure that it creates for the rider, which may not be suitable on easier trails.

4. Surface water assessment

4.1 Relevant legislation

This section provides an overview of the key legislation and policy documents which form the regulatory framework for surface water. These consist of:

- *Environment Protection and Biodiversity Conservation Act 1999* (CWlth) (EPBC Act)
- *Flora and Fauna Guarantee Act 1988* (Vic) (FFG Act)
- *Water Act 1989* (Vic)
- *Environment Protection Act 1970* (Vic)
- State Environment Protection Policy (Waters)
- *Heritage Rivers Act 1992* (Vic)
- *Yarra River Protection (Wilip-gin Birrarung murron) Act 2017* (Vic)
- *Safe Drinking Water Act 2003* (Vic)

4.1.1 Environment Protection and Biodiversity Conservation Act 1999 (CWlth)

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) promotes the conservation of biodiversity by providing protection for threatened species, threatened ecological communities, migratory and marine species and other protected matters. The Australian Government Department of the Environment and Energy (DoEE) administers the EPBC Act. Two fish species, listed under the Act, which have the potential to inhabit waterways in the vicinity of the proposed development include:

- Australian Grayling *(Prototroctes maraena)* Vulnerable under EPBC Act
- Macquarie Perch (*Macquaria australasica*) Endangered under EPBC Act

4.1.2 Flora and Fauna Guarantee Act 1988 (Vic)

The *Flora and Fauna Guarantee Act 1988* (FFG Act) is the key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes. The FFG Act seeks to put in place preventative management mechanisms to ensure no biota or ecological communities become extinct within Victoria, and to ensure that the processes that threaten biodiversity are identified and addressed. The FFG Act is far broader than 'endangered species' legislation, covering ecological communities; potentially threatening processes; community involvement in conservation; and a strategic approach to biodiversity conservation and sustainable use. Two species listed under the FFG Act have the potential to inhabit waterways in the vicinity of the proposed development:

- Australian Grayling *(Prototroctes maraena)*
- Macquarie Perch (*Macquaria australasica*)

Threatening processes to surface water quality, which are listed under the FFG Act, that are potentially applicable to the project include those listed below:

- Alteration to the natural flow regimes of rivers and streams
- Input of toxic substances into Victorian rivers and streams
- Degradation of native riparian vegetation along Victorian rivers and streams
- Increase in sediment input into Victorian rivers and streams due to human activities
- Invasion of native vegetation by 'environmental weeds'
- Invasion of native vegetation by Blackberry *Rubus fruticosus L. agg*

4.1.3 Water Act 1989 (Vic)

The Victorian *Water Act 1989* provides legislative framework for the allocation and management of water. A licence is required to construct works on a waterway identified under section 67 of the Water Act. The proposed development will involve construction of bridges and crossings over waterways. Consequently, the development will require approval from Melbourne Water.

4.1.4 Environment Protection Act 1970 (Vic) and State Environmental Protection Policy (Waters)

The *Environment Protection Act 1970* empowers the Environment Protection Authority Victoria (EPA Victoria) to implement regulations, maintain State Environment Protection Policies and protect the environment from pollution and the management of wastes.

The *Environmental Protection Act (1970)* allowed for the establishment of the *State Environmental Protection Policy (Waters) (SEPP Waters)*, which applies to all surface waters, estuarine and marine waters and groundwaters across the State (Vic. Gov. 2018). The SEPP (Waters) aims to provide a coordinated approach for the protection and, where necessary, rehabilitation of the health of Victoria's water environments. The SEPP (Waters) describes the uses and values of the environment that the community want to protect (these are referred to as 'beneficial uses') and define the quality of the environment required to protect these.

The beneficial uses that are to be protected in terms of aquatic ecology within the project site include water dependant ecosystems, human consumption, agriculture & irrigation, human consumption of aquatic foods, water-based recreation, traditional owner cultural values and cultural and spiritual values. Further information on the beneficial uses to be protected at the project site is provided in Table 6.

Impacts to water quality must not exceed water quality objectives specified to protect beneficial uses, unless extensive modification or natural variation precludes this attainment. In such situations the background level becomes the objective. Relevant clauses of this policy must be adhered to. The following clauses (with a brief description of relevant aspects) are applicable to the project.

Clause 33 – Surface water management and works

- Melbourne Water must ensure that public access to water supply catchments is restricted

Clause 40 – Management of instream works

- A person undertaking works in or adjacent to surface waters must minimise risks to beneficial uses
- Minimise unnatural erosion, sediment re-suspension and other risks to aquatic habitat
- Ensure that existing and new in situ structures do not pose a barrier to fish movement

Clause 42 - Construction activities

- Minimise soil erosion, land disturbance and discharge of sediment and other pollutants to surface waters
- Where construction activities impinge on surface waters, construction managers need to monitor affected surface waters to assess whether beneficial uses are being protected

Clause 45 – Native vegetation protection and rehabilitation

- Minimise the removal of and rehabilitate native vegetation within or adjacent to surface waters

4.1.5 Heritage Rivers Act 1992 (Vic)

The *Heritage Rivers Act 1992* identifies 18 Heritage River Areas in Victoria, including the Yarra River. The Act protects public lands in specific parts of rivers and river catchment areas which have significant recreation, nature conservation, scenic or cultural heritage attributes. The Act prohibits some land and water uses in heritage river areas, including constructing artificial barriers and structures that impedes the passage of water fauna.

The Heritage Rivers Act does not apply to the Yarra River tributaries that the project may intersect as the proposed river crossings are not within the Yarra River Heritage Area. However, the Yarra River itself would fall within the Yarra River Heritage Area.

4.1.6 Yarra River Protection (Wilip-gin Birrarung murron) Act 2017 (Vic)

The *Yarra River Protection (Wilip-gin Birrarung murron) Act 2017* provides for the development and implementation of the Yarra Strategic Plan for the river's management and protection. The Act also sets out environmental, social, cultural, recreational and management principles which public entities must regard when performing functions or duties in relation to Yarra River land and land 1 km from the river's edge. The Act also established the Birrarung Council, an independent body to provide advice to the government on protection and improvement of Yarra River land and to advocate for protection and preservation of the Yarra River.

As of 12/6/19, the Yarra Strategic Plan draft is under development. It will be released in mid-2019 and is likely to have implications for the proposed bike park. YRC should stay informed of the Yarra Strategic Plan draft. It is recommended that the design of the proposed track comply with the environmental, social, cultural, recreational and management principles set out in the Act. It is also recommend that YRC consult with Birrarung Council.

4.1.7 The Safe Drinking Water Act 2003 (Vic)

The *Safe Drinking Water Act 2003* requires water suppliers to ensure that they drinking water they supply complies with quality standards and requires water suppliers to manage risks in relating to drinking water and some other types of non-potable water. The Coranderrk catchment north of the site is a closed water supply catchment. It is also recognised that the Yarra River itself is harvested at Yering Gorge for urban water and thus constitutes a water supply catchment.

4.2 Beneficial uses and values of the Yarra River tributaries near the proposed track site

A list of beneficial uses to be protected in a waterway are defined by the *Environment Protection Act 1970* (Vic) – and listed in the SEPP (Waters) (2018). The beneficial uses are listed in Table 6.

Table 6 Beneficial uses and values of the Yarra River and its tributaries near the proposed mountain bike track

Beneficial uses	Note	Is beneficial use present in the Yarra
Water dependant ecosystems	Melbourne Water Corporation (2018) measured ecosystem values in the Upper Yarra River (Rural) Sub-catchment as part of the Co-Designed Catchment Program for the Yarra Catchment. The catchment scored high for platypus and very high for macroinvertebrates. Fish as well as birds scored moderate.	✓
Human consumption (after appropriate treatment)	Melbourne Water harvests water from the mid Yarra River, downstream of Millgrove. Melbourne Water also harvests water from the Maroondah Reservoir water supply catchment.	✓
Agriculture & Irrigation	Aerial imagery show that water is extracted for irrigation and watering livestock on the Yarra and the tributaries.	✓
Aquaculture	Inactive trout farm downstream of Warburton which is licensed to extract water from the Yarra River.	✓
Human consumption of aquatic foods	Anglers may eat the fish they catch	✓
Industrial and commercial	Several restaurants, cafes and bed and breakfasts are located on the banks of the Yarra in Millgrove.	✓
Water-based recreation (primary contact)	The Upper Yarra River is used for fishing, canoeing, kayaking and swimming. The tracks along the Yarra River are visited by bushwalks and bird watchers.	✓
Water-based recreation (secondary contact)		✓
Water-based recreation (aesthetic enjoyment)		✓
Traditional Owner cultural values	The Yarra River (Birrarung) is of great importance to the Woi-wurrung people, as stated in the Yarra River Protection (Wilip-gin Birrarung murron) Act 2017 Many of the tributaries are located within mapped areas of Aboriginal Cultural Heritage Sensitivity.	✓
Cultural and spiritual values	Cultural events (e.g. Warburton River Folk Festival).	✓

4.3 Surface water quality

Water quality parameters from two stream gauges near the proposed mountain bike trail were compared against the environmental quality objectives listed in the SEPP (Waters). When environmental quality objectives are not met, this indicates that beneficial uses are not being protected.

For objectives that are not described by SEPP (Waters), values are derived from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). The 95% ecosystem protection level of ANZECC (2000) was adopted, as defined by SEPP (Waters).

Water quality data is available for two sites near the proposed stream crossings:

- Yarra River at McKenzie-King Drive, Millgrove (Site ID: YAYAR0855)
- McMahons Creek at Woods Point Road, McMahons Creek (Site ID: YAMCM0059)

The Yarra River at Millgrove gauge is located approximately 2.5 km downstream from the proposed development. The site is affected by urban and agricultural runoff in the catchment upstream of the gauge. Both sites are located in the *Uplands A* segment (largely unmodified), as defined in SEPP (Waters). Flood level mapping indicates that the River Trail track is subject to inundation but that the main trail network is not (Figure 7).

The McMahons Creek at Woods Point Road gauge is further upstream (approx. 17 km) from the proposed development. The gauge is situated in a forested catchment and water quality conditions are likely to be similar to the proposed stream crossings.

The different types of parameters and count of all available data for the Yarra River and McMahons Creek are presented in Table 7. Results show there to be 6987 data for the two gauges. This data extends as far back as 1975 for some parameters at the Yarra River. There are well over 200 data points for most key parameters in general chemistry, nutrients, metals and microbiology.

An overview of data in comparison to guideline values (including both SEPP and ANZECC) are presented in Table 7. Results are highlighted by colour – green essentially means compliant and red means non-compliant, with a sliding scale in between. Turbidity is the parameter most likely to be impacted by the proposed mountain bike trail. Data indicates turbidity is compliant at both sites. Parameters of highest non-compliance are copper and zinc. To a lesser extent, phosphate, chromium and lead are also non-compliant.

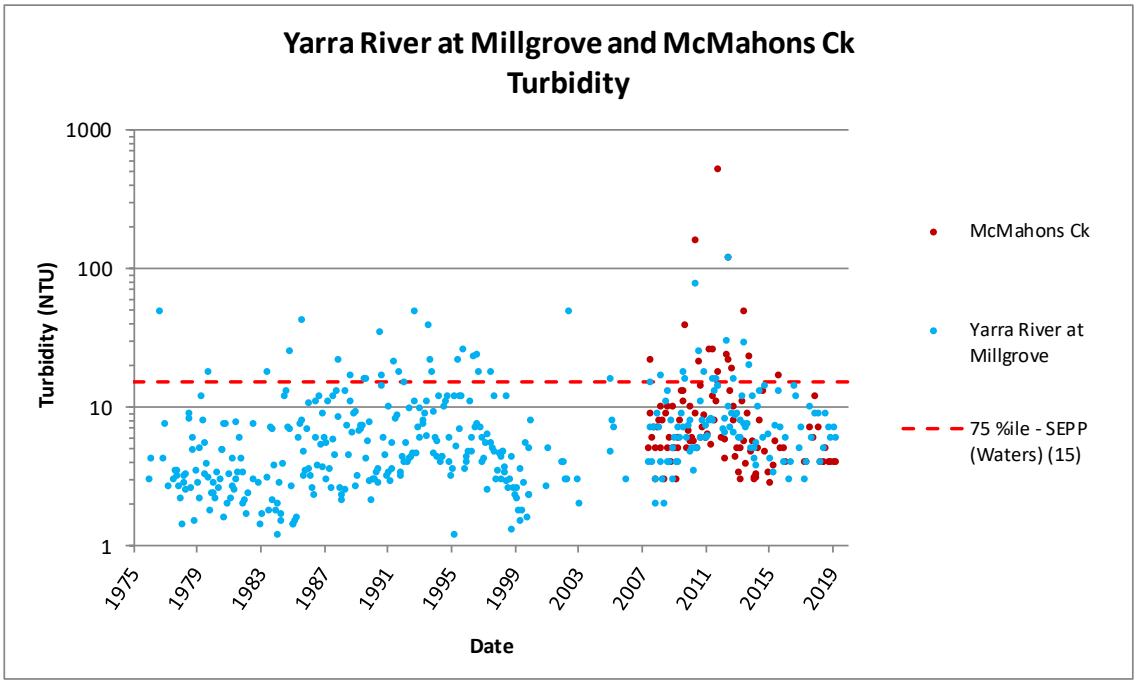
Table 7 Count of water quality data for the Yarra River and McMahons Creek

Group	Parameter	Unit	McMahons Ck	Yarra River at Millgrove
General Phys-Chem	Colour	PCU	0	108
	Dissolved Oxygen (%)	% sat	106	131
	Dissolved Oxygen (mg/L)	mg/L	106	227
	Electrical Conductivity	µS/cm	106	401
	pH	pH units	106	392
	Suspended Solids	mg/L	106	239
	Temperature	°C	106	402
	Turbidity	NTU	106	398
Nutrients	Nitrogen - Ammonia as N	mg/L	106	131
	Nitrogen - Nitrate as N	mg/L	106	131
	Nitrogen - Nitrite as N	mg/L	0	131
	Nitrogen - NOx	mg/L	108	108
	Nitrogen - Total	mg/L	31	166
	Nitrogen - Total Kjeldahl	mg/L	106	239
	Phosphorus - Total	mg/L	106	239
	Phosphorus - PO4 Filtered as P	mg/L	106	239
Metals	Arsenic	mg/L	106	131
	Cadmium	mg/L	106	131
	Chromium	mg/L	106	131
	Copper	mg/L	106	131
	Lead	mg/L	106	131
	Nickel	mg/L	106	131
	Zinc	mg/L	106	131
Microbiology	E. coli	orgs/100 mL	106	131
	Total		**2259**	**4730**

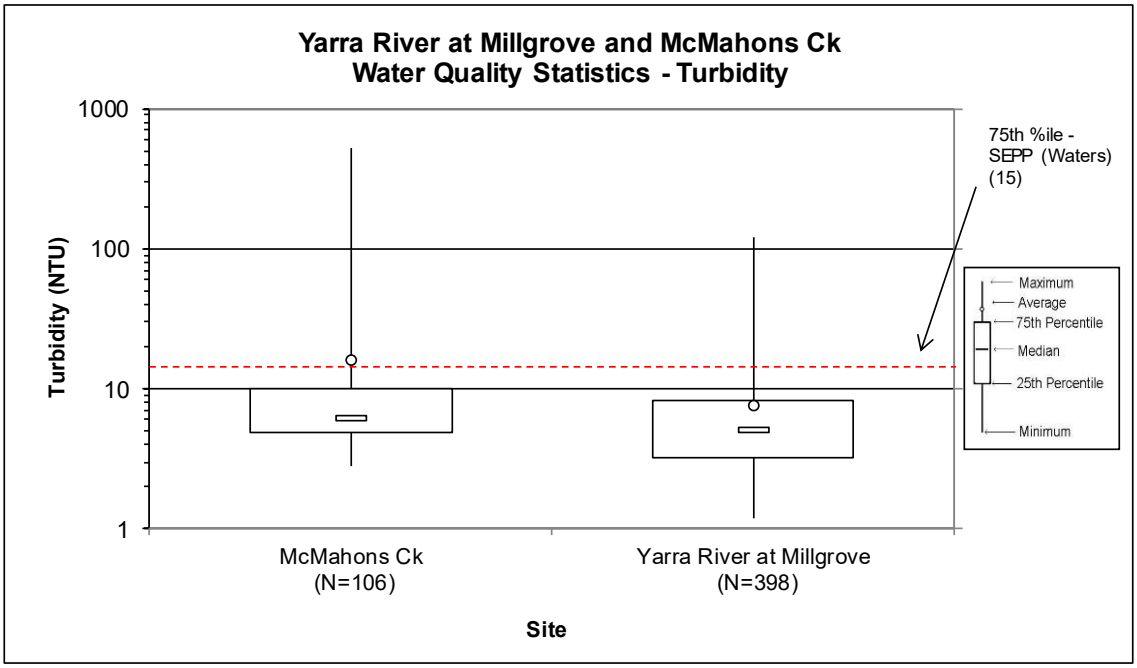
Table 8 Water quality data for the Yarra River and McMahons Creek – proportion of data not complying with guidelines

Parameter	Unit	Guideline			ANZECC or SEPP	McMahons Ck	Yarra River at Millgrove
		Max	75th %ile	25th %ile			
Parameters with percent of data not meeting guideline value							
Nitrogen - Ammonia as N	mg/L	0.9			ANZECC	0%	0%
Nitrogen - Nitrate as N	mg/L	7.2			ANZECC	0%	0%
Phosphorus - PO4 Filtered as P	mg/L	0.015			ANZECC	1%	9%
Arsenic	mg/L	0.024			ANZECC	0%	0%
Cadmium	mg/L	0.0002			ANZECC	0%	0%
Chromium	mg/L	0.001			ANZECC	8%	6%
Copper	mg/L	0.0014			ANZECC	24%	27%
Lead	mg/L	0.0034			ANZECC	10%	1%
Nickel	mg/L	0.011			ANZECC	0%	0%
Zinc	mg/L	0.008			ANZECC	22%	13%
Parameters meeting guideline (with yes / no criteria)							
Dissolved Oxygen (%)	% sat	130		≥ 80	SEPP	Yes	Yes
Electrical Conductivity	µS/cm		≤ 100		SEPP	Yes	Yes
pH	pH units		≤ 7.6	≥ 6.4	SEPP	Yes	Yes
Turbidity	NTU		≤ 15		SEPP	Yes	Yes
Nitrogen - Total	mg/L		≤ 0.9		SEPP	Yes	Yes
Phosphorus - Total	mg/L		≤ 0.035		SEPP	Yes	Yes

Data for turbidity along and SEPP guidelines is presented in Plot 1. Statistics of all available turbidity data is presented in Plot 2. Results show the 75th percentiles of the turbidity at McMahons Creek and the Yarra River at Millgrove (10 and 8.2 NTU respectively) are well below the SEPP guideline (15 NTU).



Plot 1 Long-term turbidity data – Yarra River and McMahons Creek



Plot 2 Summary statistics– Yarra River and McMahons Creek turbidity data

4.4 Sensitive water receptors

4.4.1 Aquatic Ecology values

The project site is located in Melbourne Water's Yarra River Upper (Rural) Sub-catchment (Melbourne Water, 2018). The key aquatic values within this sub-catchment include fish and platypus and macroinvertebrates (Melbourne Water, 2018). The current status of the native fish community is considered to be 'high', meaning that 'most native freshwater species recorded in the catchment are likely to be present'. Platypus are rated 'high' and also likely to be found in the waterways within the sub-catchment.

The presence of small-bodied native fish in the Little Yarra River and Don River catchments include Ornate Galaxias *Galaxias ornatus*, Southern Pygmy Perch *Nannoperca australis*, River Blackfish *Gadopsis marmoratus*, Short-Finned Eel *Anguilla australis*, Australian Smelt *Retropinna semoni*, Short-Headed Lamprey *Mordacia mordax* and Pouched Lamprey *Geotria australis* and Spiny Crayfish (Euastacus sp.) (Melbourne Water, 2012). The presence of these species can therefore be considered likely in both the Yarra River and smaller tributaries, where water is present.

Current status of the macroinvertebrate community is provided in Section 4.4.3.

4.4.2 Threatened aquatic species

Two *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and *Flora and Fauna Guarantee Act 1988* (FFG Act) fish are considered to potentially inhabit the Yarra River sub-catchment (Melbourne Water, 2018). A brief summary of life cycle requirements for each species is provided in the following section:

- Australian Grayling *(Prototroctes maraena)* Vulnerable under EPBC Act and Listed under FFG Act
- Macquarie Perch (*Macquaria australasica*) Endangered under EPBC Act and Listed under FFG Act

Australian Grayling

The Australian Grayling is an amphidromous fish that migrates between fresh and salt water. Most of its life is spent in freshwater but adults undertake annual migrations downstream towards the upper limit of estuaries to spawn during autumn (April to June), before moving back upstream. Spawning is initiated by increased river flow and decreased water temperatures (DELWP 2015). The eggs are demersal and are thought to settle in gravel interstices. Larvae are buoyant, positively phototropic and actively swim towards the water surface (Berra 1982; Bacher and O'Brien, 1989) and are swept out to sea where they mature. Juvenile Grayling spend between six and 10 months within coastal waters before returning to the freshwater reaches as juveniles between October and December. Adults are commonly found to be 170- 190 mm but may reach lengths of 330 mm (Berra, 1982, Backhouse *et al.*, 2008). They are distributed widely across Victoria - from the Genoa system in the east to the Hopkins system in the west and known to inhabit the Yarra River.

Macquarie Perch

Macquarie Perch are found in rivers in the cool upper reaches of the Murray-Darling system, Victoria, the ACT and man-made lakes and reservoirs (Bray and Thompson, 2018; Commonwealth of Australia, 2017). Populations have declined in Victoria, and they are now restricted to a small number of fragmented populations mostly in cool, rocky, fast flowing streams in relatively undisturbed upland catchments, such as King Parrot Creek in the Goulburn Broken Catchment in northern Victoria (Bray and Thompson, 2018). However, a self-sustaining population exists in the Yarra River from fish translocated in the 1920s (Bray and Thompson, 2018) and this is reported as potentially the most secure population in Australia (Douglas 2002, cited in Ryan et al. 2003). The species inhabit cool, clear freshwaters of rivers with deep holes and shallow riffles, lakes and reservoirs (Bray and Thompson, 2018). In rivers they prefer areas with aquatic vegetation, as well as large boulders, woody debris and overhanging banks (Cadwallader & Eden 1979). Brumley *et al.* (1987) found that habitat areas often consisted of a pool (usually 15 – 30 m long and at least 1.5 m deep) upstream of fast-flowing broken water.

Summary

The presence of native fish and platypus is obviously habitat (i.e. water) driven and the Yarra River, rather than the tributaries, is most likely to support a range of native fish and platypus. Both EPBC Act listed species (Australian Grayling and Macquarie Perch) are likely to inhabit the Yarra River but the likelihood of their occurrence in the tributaries of the Yarra River is considered low, based on habitat requirements for each species.

4.4.3 Biological indicators - Macroinvertebrates

Aquatic macroinvertebrates provide an integrative measure that respond to the effects of multiple physical and chemical stressors acting together and provide measures of longer term impacts and responses of environmental condition. SEPP (Waters) use biological index objectives that, when not met, may indicate that beneficial uses are potentially at risk. A summary of these indices and objectives for the *Uplands A* region that the project sits in are is provided in Table 9. Macroinvertebrates are also a key component of the aquatic ecosystem, providing ecosystem services and as a food source for other fauna. They are also one of Melbourne Waters key values (Melbourne Water, 2018).

Table 9 Summary of biological indices and SEPP (Waters) objectives

Biological Index	Purpose	Scale	Edge objective	Riffle objective
Number of families	Family diversity considered to represent ecological health of a stream	Healthy ecosystems generally have more families.	17	19
SIGNAL-2	Refined SIGNAL pollution sensitivity scores	One (pollution tolerant community) to 10 (pollution sensitive community)	4.5	5.6
EPT	The pollution sensitive insect orders of Ephemeroptera, Plecoptera and Trichoptera provide an indication of stream disturbance	Undisturbed streams generally have more EPT families	6	8

Macroinvertebrate data from the Yarra River and tributaries in the vicinity of the proposed mountain bike project were obtained from Melbourne Water and key indices were calculated to provide an assessment against SEPP (Waters) objectives. The following sites were used as the basis for characterising sensitive water receptors:

- Cement Creek (two sites: 2001-2013):
  - Cement Creek at Eighteen Road (CMT0008)
  - Cement Creek at Cement Creek Road (CMT0018)
- Dee River (one site: 2001 & 2002)
  - Dee River at Dee Rd (DEE0006)

- Yarra River (58 samples from five sites – 1999-2012)
  - Yarra River upstream of Big Pat's Creek, Warburton Hwy (YAR0753)
  - Yarra River @ Giffords Rd, Warburton (YAR0760)
  - Yarra River @ Mac Sparks Oval, Warburton (YAR0800)
  - Yarra River @ The Grange 3185 Warburton Hwy, Warburton (YAR0831)
  - Yarra River @ Dee Rd Flow Gauge (YAR0852)

Summary biological index results are provided in Table 10. Results indicate that, on average, the majority of biological index results met SEPP (Waters) objectives, with the exception of edge habitat in Cement Creek. This indicates that the Yarra River and tributaries in the vicinity of the proposed project site are high value ecosystems, supporting a diverse range of pollution-sensitive taxa.

Table 10 Mean (±SD) biological index results – Yarra River and tributaries. Green cells indicate compliance with SEPP (Waters). Red cells indicate non-compliance

Site	Number of families		EPT		SIGNAL2	
	Edge	Riffle	Edge	Riffle	Edge	Riffle
Yarra River						
YAR0753	31±5	29±5	12±2	13±2	5.5±0.2	6.1±0.3
YAR0760	22±5	25±5	10±3	11±2	5.1±0.2	6.1±0.4
YAR0800	19±6	19±4	8±3	9±2	5.0±0.5	6.0±0.3
YAR0831	20±3	22±3	8±2	9±1	5.0±0.4	5.9±0.3
YAR0852	28±5	25±5	10±2	10±2	4.8±0.4	5.6±0.5
Cement Creek						
CMT0008	**14±4**	21±4	7±2	11±2	6.0±0.4	6.9±0.4
CMT0018	21±5	21±4	10±3	11±2	6.2±0.5	6.8±0.2
Dee River						
DEE0006	n/a	22±4	n/a	12±1	n/a	7.0±0.3

4.4.4 Index of Stream Condition

The Yarra River was last assessed using the Index of Stream Condition (ISC) approach in 2012. The ISC is a benchmarking process that provides information on five key aspects of river condition: hydrology, streamside zone, physical form, water quality and aquatic life. This information is then combined to give an overall measure of environmental condition.

The third Index of Stream Condition Report – DEPI (2012) showed that the Yarra River at Millgrove was assessed to be in 'Moderate' condition. The river scored highly in hydrology, streamside zone and water quality but moderately in physical form. Aquatic life was not assessed.

4.5 Surface water impact assessment

4.5.1 Methods

The surface water impact assessment has used a number of criteria to assign level of risk at each crossing point. These include:

- Soil type at each crossing
- Slope at each crossing
- Stream order at each crossing (Strahler method)
- Catchment area upstream at each crossing (km^2)

In total, 164 crossing points were identified, with preliminary crossing locations identified by World Trail outlined in Figure 8). It is acknowledged that field assessments have been previously been carried out at some of these locations during the initial trail design process. Our preliminary assessment is based on the Melbourne Water designated stream network, which has meant that a greater number of waterway crossings have been identified, which should be considered during any further trail design refinement, detailed design and CEMP. Further field investigations may reduce the total number of crossings.

Of the crossings identified, the majority (113) were classified as Stream Order 1, 33 crossings intersected Stream Order 2, 16 crossings intersected Stream Order 3. This indicates that the majority of crossings intersect small headwater sections of the stream network – with Stream Order 1 being a waterway with no tributaries. An assessment of flow at each of these crossings was not carried out during this assessment as the majority of these tributaries are not gauged. However, Stream Order 1 streams have the potential to be either ephemeral or intermittent in nature and may only flow after heavy rainfall. That said, the fact that they are located in the headwaters of catchments means that any impacts at these points have the potential to lead to downstream impacts on sensitive water receptors (aquatic flora and fauna) and other downstream beneficial uses if mitigation measures are not of high efficacy. As such, the risk rating for each crossing places emphasis on the low order (1-3) stream crossings as lowering the risk at these locations is considered of importance. Stream order 4&5 remain important but, by their nature, are likely to require larger bridge crossings to allow for bike users to cross.

The majority of the stream crossings are located in areas of native vegetation. Excluding the River Trail section of the trail the average native vegetation cover at each crossing was 99%. As such, the use of native vegetation was not included to allow for calculation of the risk rating at each crossing. However, the potential risk of clearing native vegetation in terms of surface water quality impacts will be discussed in the following sections.

Soil type and slope (%) at each crossing point were used as criteria to assess the potential for erosion at crossings as soil type combined with surrounding landform/slope are key factors that determine erosion capacity. An increase in the potential for erosion in the vicinity of waterway crossings may lead to increased waterway sedimentation and impacts on downstream beneficial uses and aquatic values.

The criteria used to calculate risk at each of the crossings is provided in Table 11.

Descriptions of soil/landform characteristics are provided in Table 2.

Table 11 Surface water impact assessment risk criteria

Inherent risk (no mitigation)	Criteria
Very High	Melbourne Water Supply catchment
High (almost certain likelihood of erosion or restricted aquatic fauna passage)	Stream order at crossing (1,2,3) MRI with hillslopes greater than 20% OR Dee – all drainage lines OR Res – hillslopes >30% OR Mmy - >15% OR Sev - >20%
Medium (increased likelihood of erosion or restricted aquatic fauna passage)	Stream order at crossing (4,5) Don with hillslopes >8% OR Dee – all drainage lines OR Res – hillslopes >30% OR MmY >15% OR Sev – hillslopes 5-19% Stream order at crossing (1,2,3) Don with hillslopes >8% OR Sib <30% OR Res <30% OR MRI <20%
Low (low likelihood of increased erosion, no impact on aquatic fauna passage)	Stream order at crossing (4,5) MRI with hillslopes <20% OR Don with hillslopes <8% OR Res – hillslopes <30% OR Mmy - <15% OR Sev -<5% Stream order at crossing (1,2,3) AND Don with hillslopes <8%

4.5.2 Results

Waterway crossing risk assessment

It is understood that trail construction will follow the preliminary World Trail methodology (as summarised in section 2.2), which specifies controls to protect water quality and will be updated in the project's detailed design drawings, CEMP and other protocols such as the Warburton MBD Ecological Protocols dated 18 October 2019.

The results from this preliminary desktop assessment have identified that 114 crossings may pose a high risk to downstream water quality (with 49 rated medium risk and one crossing rated low risk). It should be stressed that these ratings are preliminary inherent risks (based on location, soil type and stream order) without any mitigation measures in place.

The waterway crossing assessment indicates that the majority of crossings are located within areas susceptible to erosion, with the grade of the current trail network in the vicinity of the waterway crossings likely to lead to sediment input to waterways if no mitigation measures are put in place.

Based on the proposed waterway crossing construction method all waterway crossings are constructed as dry tyre crossings utilising elevated structures or bridges.

Water Supply Protection Areas and Drinking Water catchments

Based on the Melbourne Water supplied survey of the Mt Donna Buang ridgeline (Figure 7) a small section (116 metres) of Trail 1 crossed into the Watts River catchment, in the vicinity of Coranderrk Creek. Although Coranderrk Creek does not flow into Maroondah Reservoir, it is recommended that the location of the proposed track be moved to outside the water supply catchment.

Based on the updated trail plan (see details in Appendix A) the proposed track has been moved outside the water supply catchment area.

Trail 13 falls within Little Yarra Water Supply Protection Area and Trail 1 intersects the Don River Water Supply Protection Area (Melbourne Water, 2012). The purpose of the Streamflow Management Plans prepared for these catchments is to manage catchments that are considered to be under flow stress. The plans provide environmental flow recommendations and licence conditions to protect the environment and to allow for local diverters to extract water from these systems. The proposed development is not likely to impact on provision of flows to these catchments. Without mitigation the project has the potential to increase sediment input to waterways, which may impact beneficial uses. However, following the proposed waterway crossing construction method, where all waterway crossings are constructed as dry tyre crossings utilising elevated structures or bridges, will render the risk low.

Native vegetation

The majority of the track network traverses largely intact areas of native vegetation, which provides buffering for the stream network to reduce run-off during rain events. The clearing of native vegetation has the potential to reduce the resilience of the forested areas in providing this ecosystem service as the trail network will increase the areas of exposed soil.

In addition, increased activity within these forested areas also has the potential to spread *Phytophthora cinnamomi*, a plant pathogen that has the potential to further threaten native vegetation and exacerbate the impacts of native vegetation clearing.

4.5.3 Mitigation measures

The key potential impacts that must be addressed during construction and operation of the proposed development include:

- Increased sedimentation
- Restriction of aquatic fauna passage
- Input of toxic substances (e.g. fuel or oil during construction) to waterways
- Increased weed infestation
- Spread of *Phytophthora cinnamomi* pathogen

The following preliminary mitigation measures are recommended, incorporating those specified by Melbourne Water (18 April 2019):

- Meet standards of Melbourne Water's Constructed Crossing Guidelines for new crossings (Melbourne Water, 2011), Shared Pathway Guidelines (Melbourne Water, 2009) and DELWP guidelines (O'Connor et al., 2017). Noting that:
  - Proposed bridge crossings over waterways should not increase flood levels or flow velocities and should not present significant flow obstruction in any flood event. This will usually necessitate clear spanning of waterways.
  - The underside of a 'pedestrian' bridge should be set at or above the 1 in 10 year ARI flood level and should not result in an increase up to and including the 1 in 100 year ARI level
  - Bridge abutments must have a minimum offset of five metres from the top of bank or be outside the slipline, whichever is greater, or unless otherwise agreed by Melbourne Water. The setback distance may vary due to the creek bank profile and condition.
  - Any culvert crossings should make allowance for fish migration through any barrier. Recessed culverts, which enable a build-up of natural substrate, enable greater fish passage than perched culverts. Culvert crossing pipe sizing must meet the 1 in 10 Average Recurrence Interval (ARI).
- Prepare an Environmental Management Plan that includes:
  - Hygiene Protocols for both construction and operation phases to minimise spread of weeds and Phytophthora
  - An ongoing operational plan detailing the maintenance regime to be applied to the trails to allow for potential erosion and other impacts outlined to be managed
  - Regular inspection of erosion and sediment control measures, particularly following heavy rain, to maintain ongoing functionality
  - Siting of stockpiles at least 20 metres from waterways
  - No refuelling of equipment within 20 metres of waterways
  - Construct adequate bunds for fuel/hazardous chemicals

4.5.4 Residual risk

The key consideration in assessing risks to surface water (and thereby downstream beneficial uses) is to avoid or minimise erosion/sedimentation at waterway crossing points. The initial risk assessment indicates that a large number of crossings can be considered high risk without mitigation measures put in place due to their location in the upper catchment and/or surrounding landform. Proposed crossing locations (Figure 8) and the proposed "dry wheel" methodology is likely to mitigate risks at a number of the locations identified or in general at all water crossings.

An approach to lower the risk at the identified crossing points will need to include site assessments of all crossing points and as described in the detailed design and associated CEMP and other protocols. To that end:

- If site assessments lead to the recommendation of elevated structures or bridges (completed as per World Trail and Melbourne Water specifications) over high or medium risk crossings, the risk to waterway values is likely to be reduced to low if mitigation measures provided in Section 4.5.3 are followed
- Existing crossings (including road crossings) will be considered low risk

5. Recommendations

5.1 Geotechnical

The following recommendations should be considered as part of future design and construction associated with the Warburton Mountain Bike Park to manage geotechnical related risks.

- A revised construction management plan should be prepared to better define the specific management and construction controls across the trail network and related ancillary infrastructure components. As identified in the current Master Plan for the site trail, construction should be completed in accordance with the IMBA standards (IMBA 2004) which identify the erosion control requirements that should be included to reduce long term maintenance needs.
- Undertake geotechnical assessments (including Landslip Risk Assessment) in accordance with the Yarra Ranges Planning Scheme – Schedule to the Erosion Management Overlay (10/03/2016-C151) where proposed earthworks greater than 0.6 m (cut or fill) and ancillary infrastructure are covered by the EMO and areas identified as higher risk as presented in Figure 6. This assessment should include a visual assessment of all the high risk areas identified in Section 3.3 and on Figure 6 to identify presence and assess the risk of potential geotechnical hazards.
- From the preliminary geotechnical risk assessments in Tables 4 and 5, the following trails are likely to require full geotechnical risk assessment: Trails 1, 2, 5, 11, 17, 18, 19, 20, 21, 22 and 23.
- Trails 6, 8 and 15 may require a full geotechnical risk assessment, this will depend on the detailed design of the trails. Some features may require ground truthing prior to deciding on a full assessment for these trail routes.
- It is noted that routes for trails 9 and 10 have not been provided and therefore have not been assessed as part of the preliminary risk assessment.

As part of the risk assessment, the following preliminary measures are recommended to minimise shallow slope failure hazards adjacent to the slope trail:

- Manage surface drainage during construction. Control and redirect water runoff from the trails to prevent it from flowing onto the slope uncontrolled.
- Construct armouring where a shallow failure has been observed.
- Implement a trail construction and management plan and report any observed failure along the trail slopes for further assessment (both during and post construction).

As part of the risk assessment, the following measures are recommended to minimise rock fall hazards:

- Manage surface drainage (as above)
- Remove any loose or disturbed boulders in trail earthworks
- Report any rock fall incidents to a geotechnical engineer for further assessment
- Prior to finalising each trail ensure potential rock fall risks are removed from the trail

Geotechnical investigations should be undertaken to inform design and any potential geotechnical risks at the following proposed developments:

- Main trail head/visitor hub
- Bridges – three large bridge locations
- Elevated structures/bridges – any waterway crossings which require confirmation of ground conditions to inform structural engineering design and construction requirements
- Mt Tugwell trail head
- Mt Donna Buang trail head

The following is recommended to manage general erosion and geotechnical related risks:

- Clearly identify and assess all known landslide areas to ensure the most appropriate design and construction techniques are implemented, in particular drainage.
- Assess local soil conditions to ensure the most appropriate design and construction techniques and drainage intervals are incorporated for the different soil types.
- Construct full benched trail where possible or assessed. Reinforce downslope of trail where partial bench is constructed, always providing an outslope to ensure water runoff.
- Angle batter sufficiently to reduce erosion and blend with the existing side slope.
- Make use of elevated structures and bridges at stream crossings to avoid erosion.
- To ensure effective drainage off the trails employ IMBA guidelines such as grade reversals, trail outslope of 5% promoting water sheet flow across trail, rolling grade dips, and knicks.

Stream crossings and related structures need to consider the following key geotechnical considerations:

- Engineering designs prepared by a qualified engineer prior to any works commencing on structures.
- Structures must be designed to cope with peak flows for the catchment.
- Approaches to stream crossings should as much as possible be at right angles to the watercourse and minimise the length of track within the immediate area.
- Overburden from cuttings in stream side reserves must be deposited on uphill side of cuttings and where possible outside the immediate area.
- Crossings should minimise disturbance to drainage lines, wet soaks and stream banks and provide a solid carriageway.
- Works near waterways should be scheduled appropriately. For example, works should be timed to coincide with periods of low flow and completed quickly. Works should be stopped if conditions are not suitable, such as during and after heavy rain.

5.2 Surface water

In addition to the recommendations provided in Section 5.1 the following should be considered:

The aquatic environment in the waterways in the vicinity of the proposed development are considered in good to excellent condition, largely meeting SEPP (Waters) water and environmental quality objectives. In addition, it is likely that two threatened fish species have the potential to inhabit the Yarra River. As such, the proposed development must allow for protection of these sensitive water receptors. To that end the project must:

- Meet standards of Melbourne Water's Constructed Crossing Guidelines for new crossings (Melbourne Water, 2011), Shared Pathway Guidelines (Melbourne Water, 2009) and DELWP guidelines (O'Connor et al., 2017). Noting that:
  - Ensure that all new crossings must allow for unrestricted passage for aquatic fauna and low flows.
  - Proposed bridge crossings over waterways should not increase flood levels or flow velocities and should not present significant flow obstruction in any flood event. This will usually necessitate clear spanning of waterways.
  - The underside of a 'pedestrian' bridge should be set at or above the 1 in 10 year ARI flood level and should not result in an increase up to and including the 1 in 100 year ARI level.
  - Bridge abutments must have a minimum offset of five metres from the top of bank or be outside the slipline, whichever is greater, or unless otherwise agreed by Melbourne Water. The setback distance may vary due to the creek bank profile and condition.
  - Any culvert crossings should make allowance for fish migration through any barrier. Recessed culverts, which enable a build-up of natural substrate, enable greater fish passage than perched culverts. Culvert crossing pipe sizing must meet the 1 in 10 Average Recurrence Interval (ARI).
- Meet SEPP (Waters) water quality objectives in tributaries that will be crossed by the trail network by minimising erosion risk.
- Minimise native vegetation removal where possible.
- Prepare an Environmental Management Plan that includes:
  - Hygiene Protocols for both construction and operation phases to minimise spread of weeds and *Phytophthora*
  - An ongoing operational plan detailing the maintenance regime to be applied to the trails to allow for potential erosion and other impacts outlined to be managed
  - Regular inspection of erosion and sediment control measures, particularly following heavy rain, to maintain ongoing functionality
  - Siting of stockpiles at least 20 metres from waterways
  - No refuelling of equipment within 20 metres of waterways
  - Construct adequate bunds for fuel/hazardous chemicals
- In any Environment Effect Statement referral consider impacts on aquatic fauna.
- An approach to lower the risk at the identified crossing points will need to include ground-truthing of all crossing points either during detailed design or at construction. Selection of approved dry tyre crossing infrastructure or alternative method would be based on approved treatment methods detailed in the Construction Environment Management Plan (CEMP), detailed design drawings and approved project protocols.

6. References

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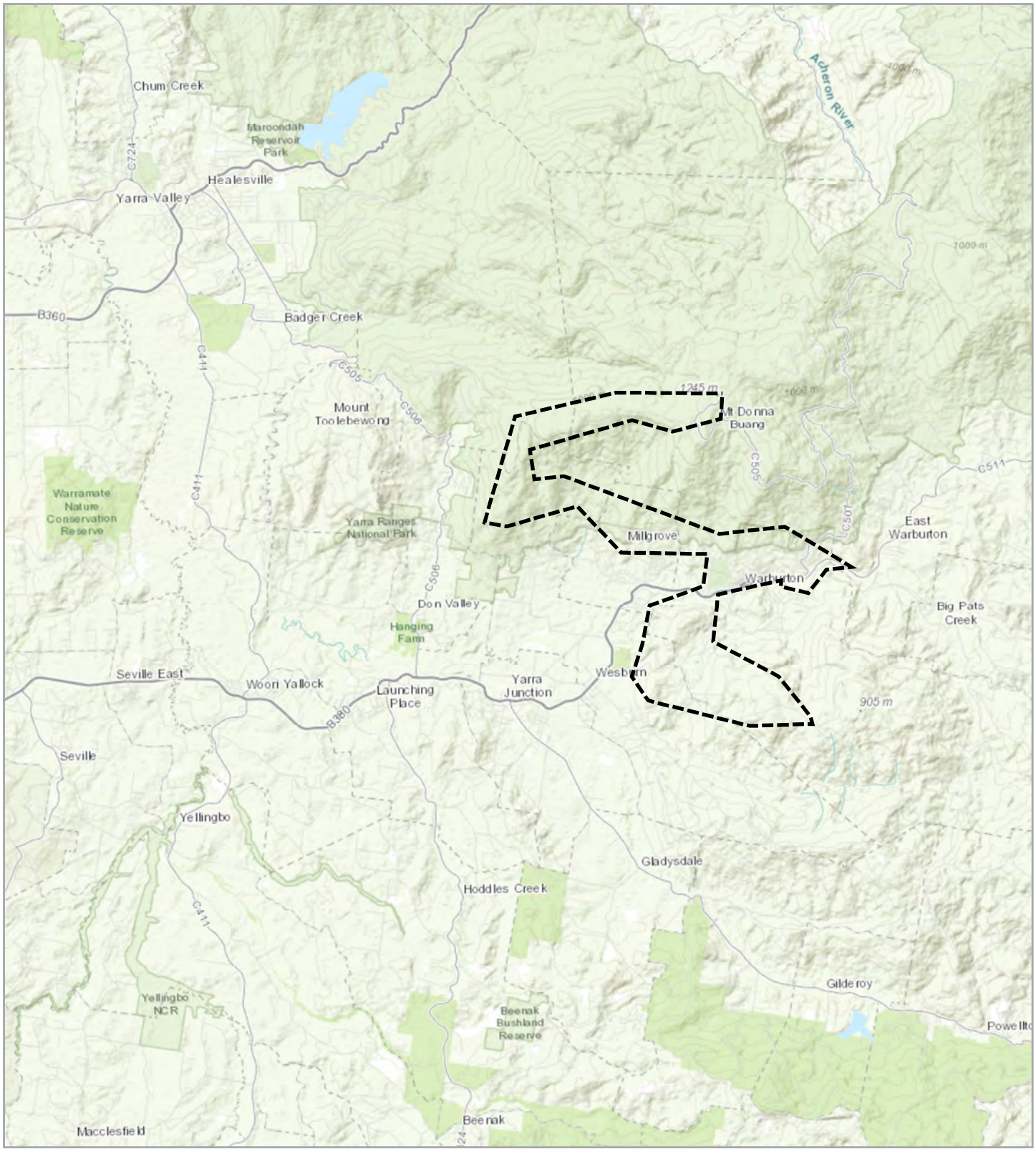
Figures



Legend

Trail Area

Paper Size ISO A4

0 1 2 3 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Warburton Mountain Bike Destination Location

Project No. 31-37322
Revision No. A
Date 04/12/2019

Figure 1

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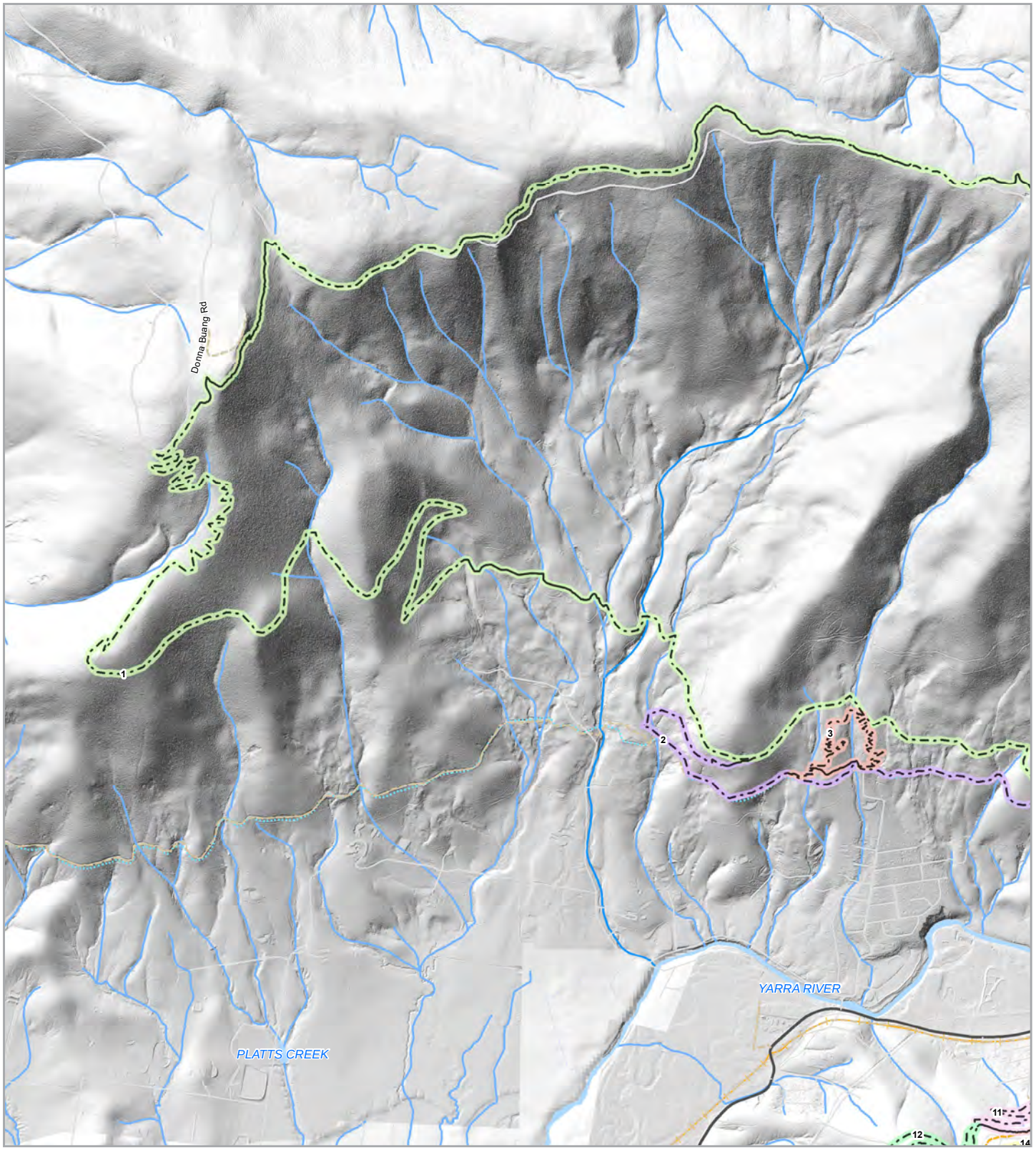

Legend

Trail Type

- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream

- Channel
- Drain/Channel/Other

Rail

- Rail trail

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Trail Network Plan
with Hillshade 40 LiDAR Model

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 2

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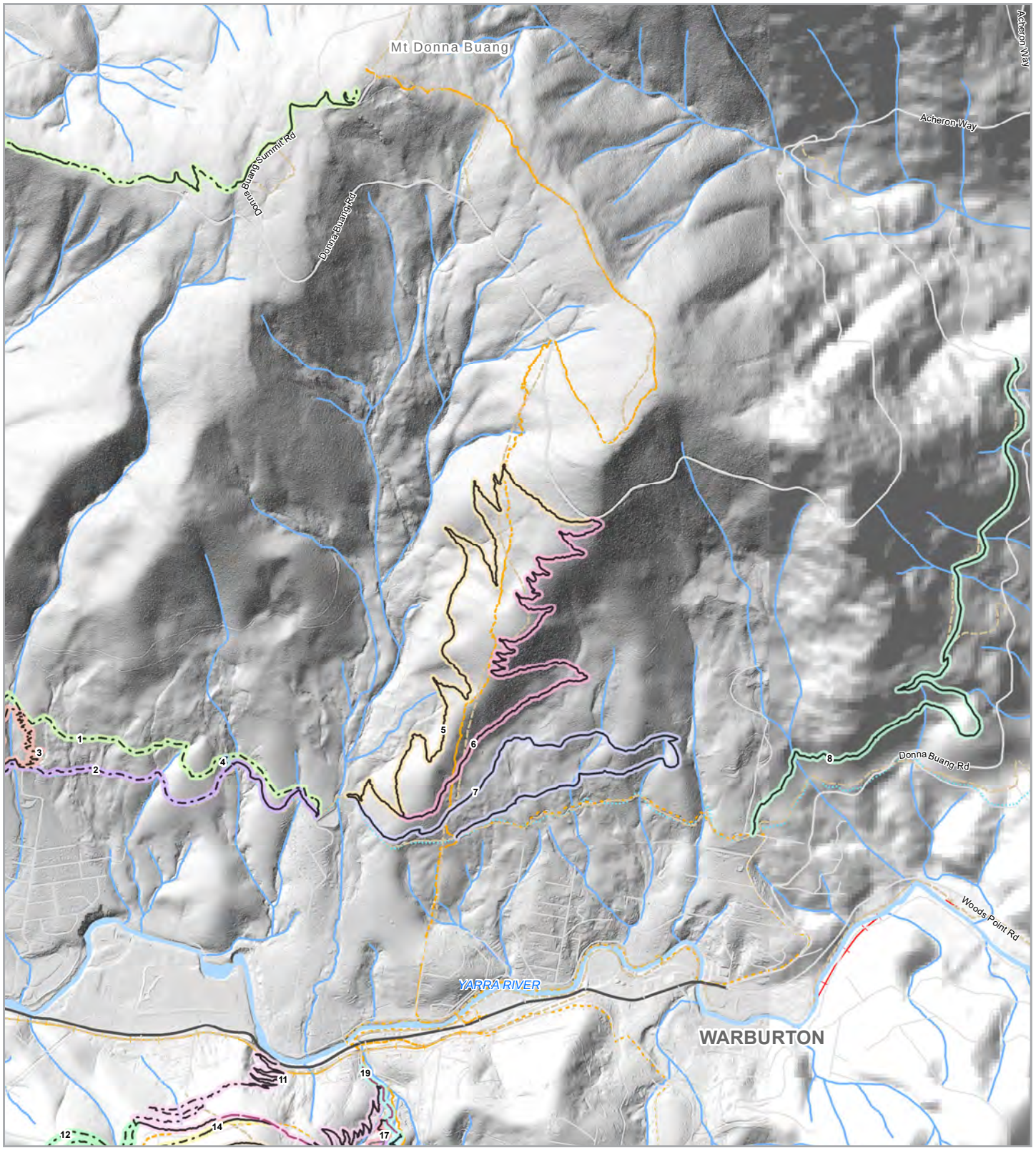

Legend

Trail Type

- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream

- Channel

Rail

- Rail dismantled
- Rail trail

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Trail Network Plan
with Hillshade 40 LiDAR Model

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 2

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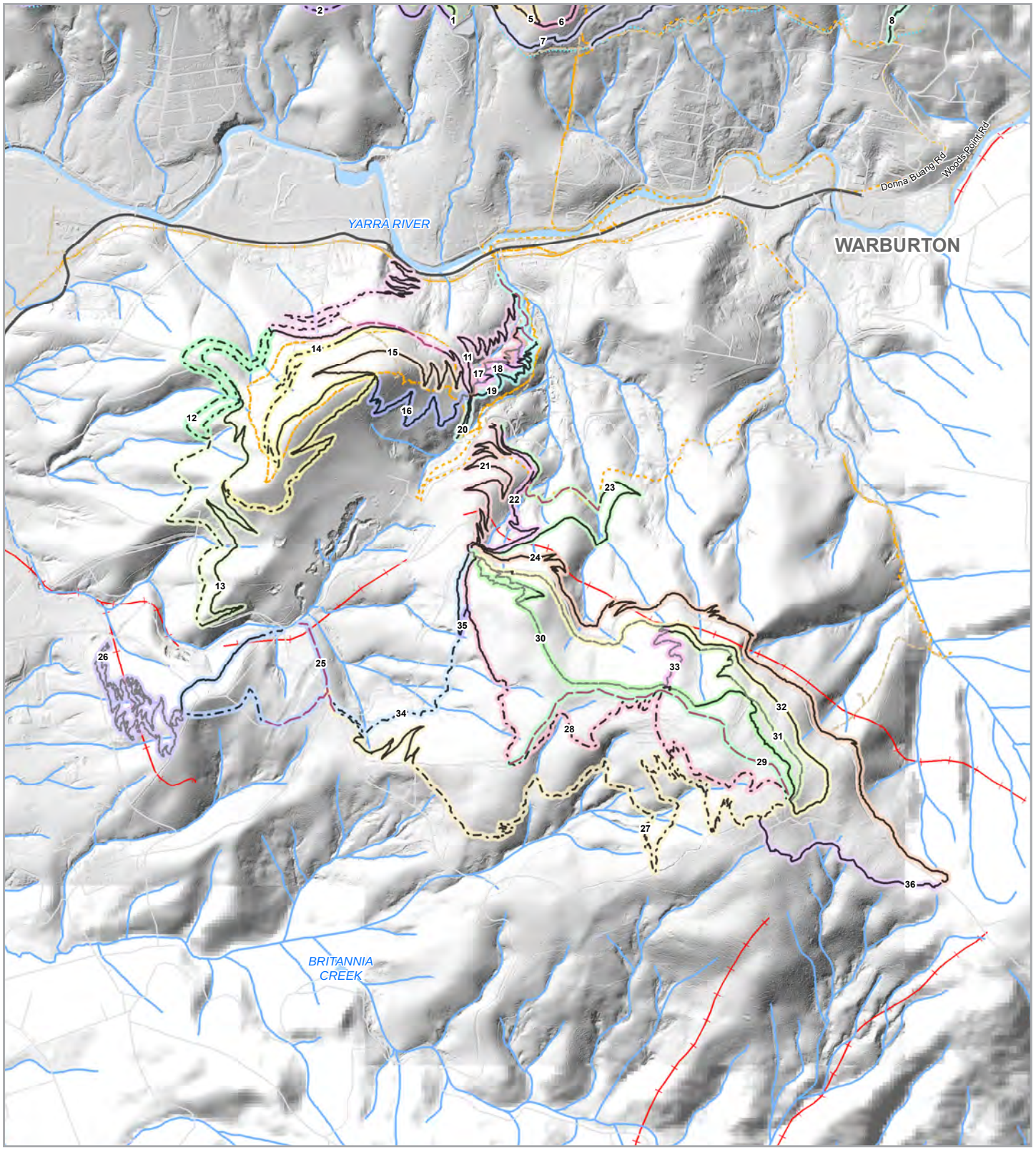

Legend

Trail Type

- WT Alignment
- Cox Alignment
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- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream

- Channel
- Drain/Channel/Other

Rail

- Rail dismantled
- Rail trail

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Trail Network Plan
with Hillshade 40 LiDAR Model

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 2

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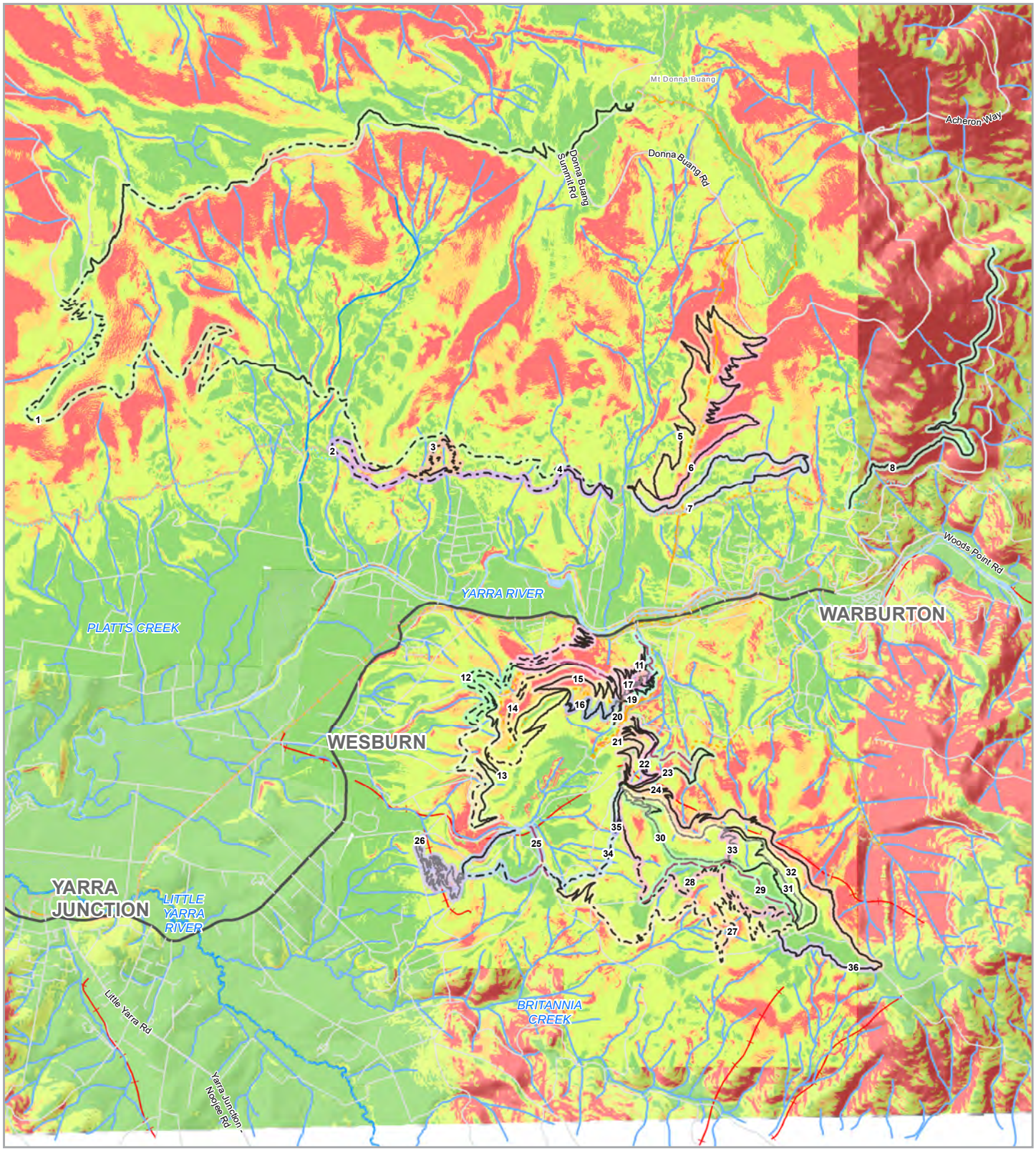

Legend

Trail Type

- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream

- Channel
- Drain/Channel/Other

Rail

- Rail dismantled
- Rail trail

Slope 20

Percentage Slope

- < 20
- 21 - 40
- 41 - 50
- > 50

Paper Size ISO A4

0 0.4 0.8 1.2 1.6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Slope Model

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 3

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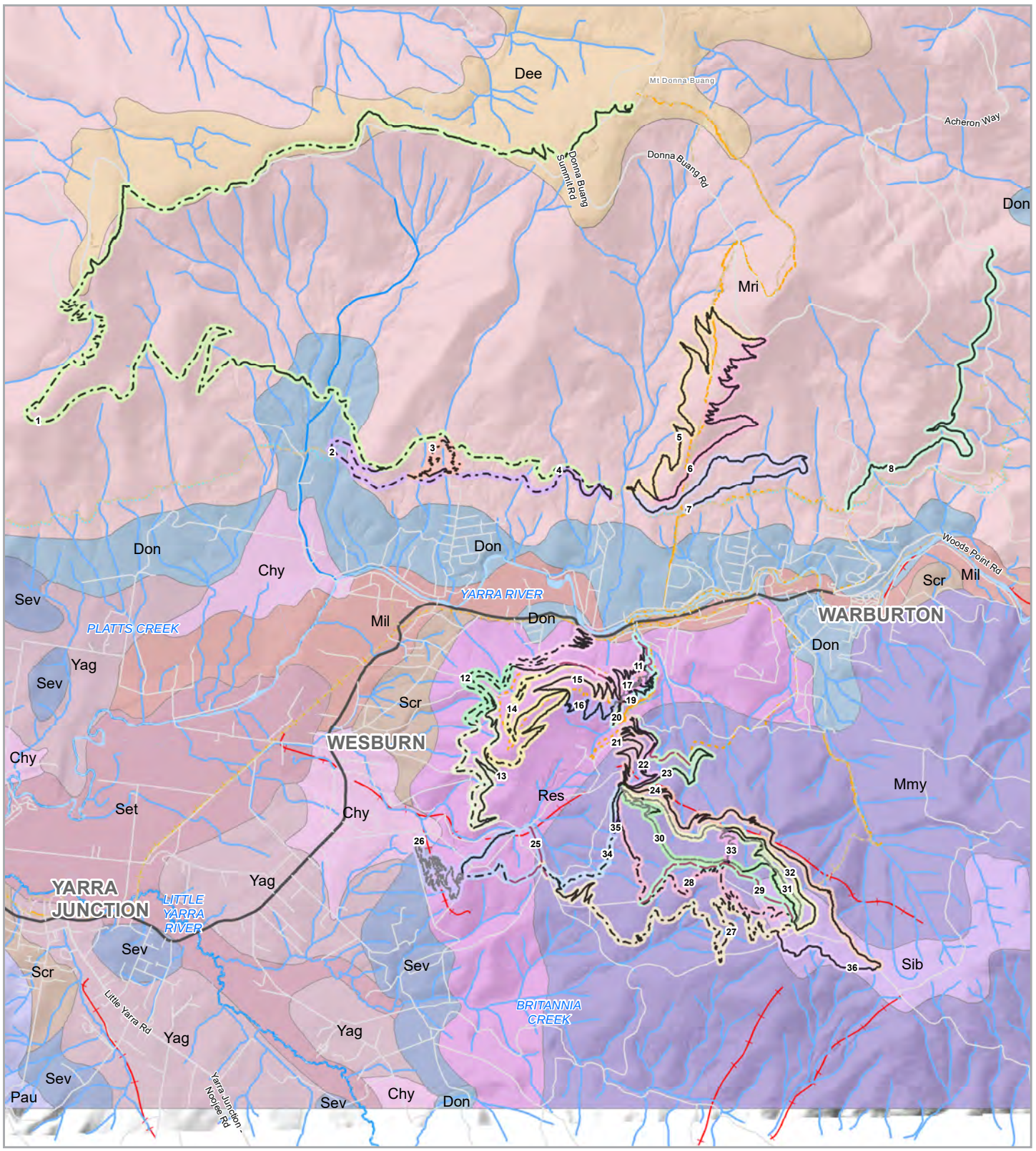

Legend

Trail Type
- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream

- Channel
- Drain/Channel/Other

Rail
- Rail dismantled
- Rail trail

Soils

LU_CODE
- UpperYarra_Chy
- UpperYarra_Dee
- UpperYarra_Don
- UpperYarra_Mil
- UpperYarra_Mmy
- UpperYarra_Mri
- UpperYarra_Pau
- UpperYarra_Res
- UpperYarra_Scr
- UpperYarra_Set
- UpperYarra_Sev
- UpperYarra_Sib
- UpperYarra_Yag

Paper Size ISO A4

0 0.4 0.8 1.2 1.6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Soil and Landform Map

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 4

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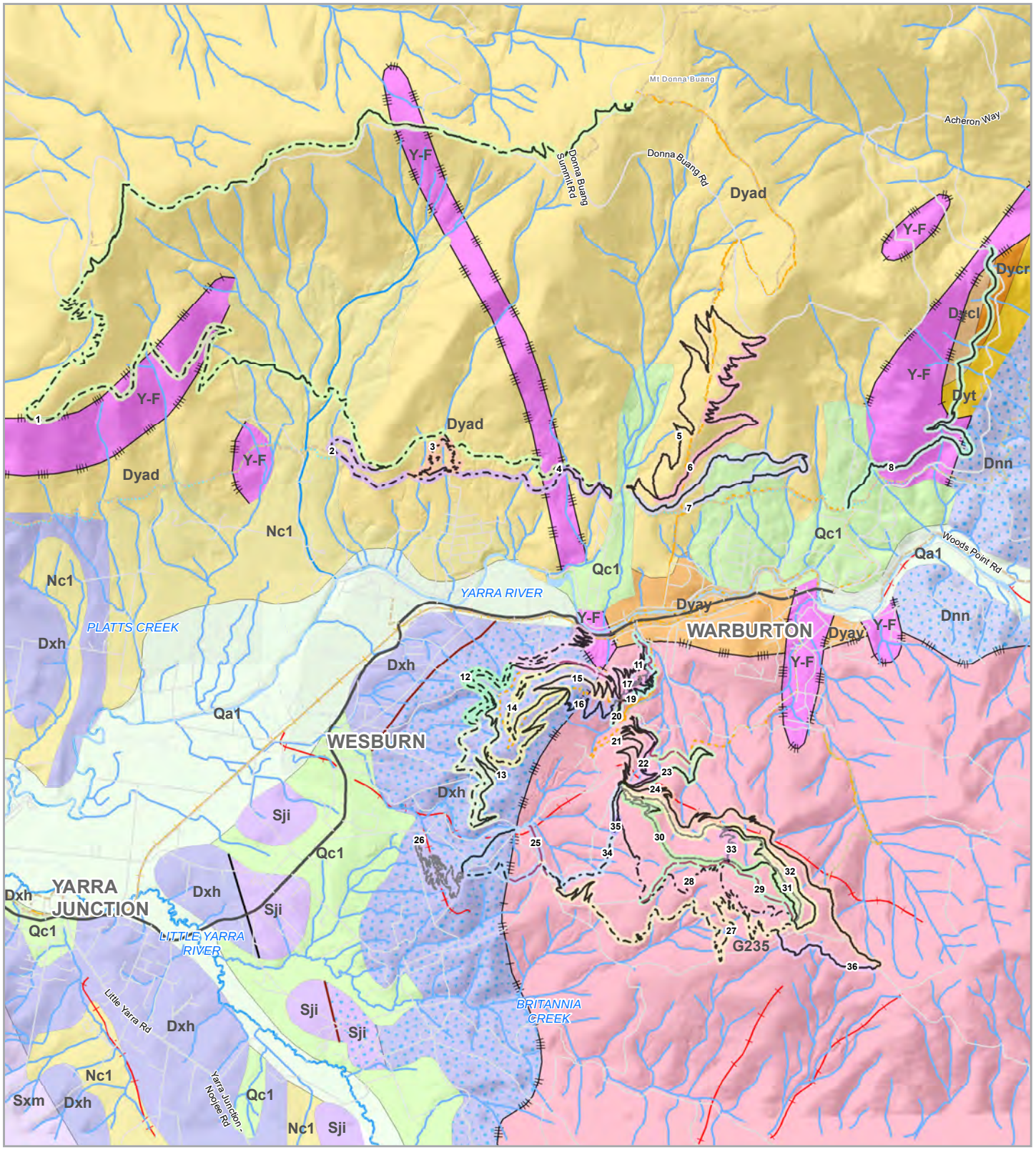

Legend

Trail Type
- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream
- Channel
- Drain/Channel/Other

Rail
- Rail dismantled
- Rail trail

Geological structure 250k
- <all other values>

TYPE
- conformity
- faulted contact
- geological unit boundary
- intrusive contact
- nonconformity
- unconformity

Geological unit 250k

Geographic Feature ID
- Dnn
- Dxh
- Dxh
- Dyad
- Dyay
- Dycl
- Dycr
- Dyt
- G235
- Nc1
- Qa1
- Qc1
- Sji
- Sji
- Sxm
- Y-F

Paper Size ISO A4

0 0.4 0.8 1.2 1.6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Project No. 31-37322
Revision No. B
Date 04/12/2019

Geology

Figure 5

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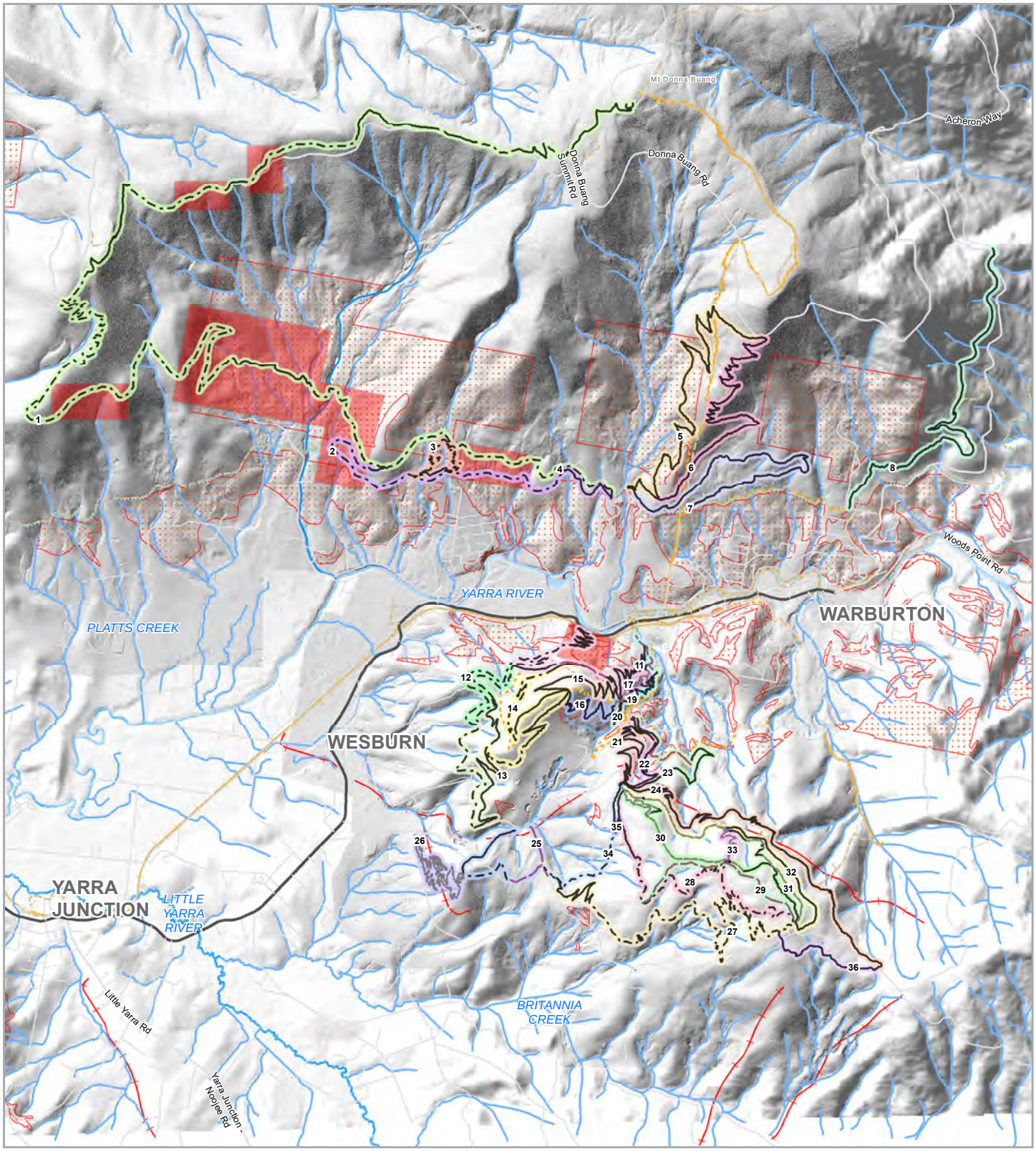

Legend

Trail Type

- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks
- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream
- Channel
- Drain/Channel/Other

Rail

- Rail dismantled
- Rail trail
- High Risk Landslide Susceptibility
- Erosion Management

Paper Size ISO A4

0 0.4 0.8 1.2 1.6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Landslide Susceptibility and High Risk Zones

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 6

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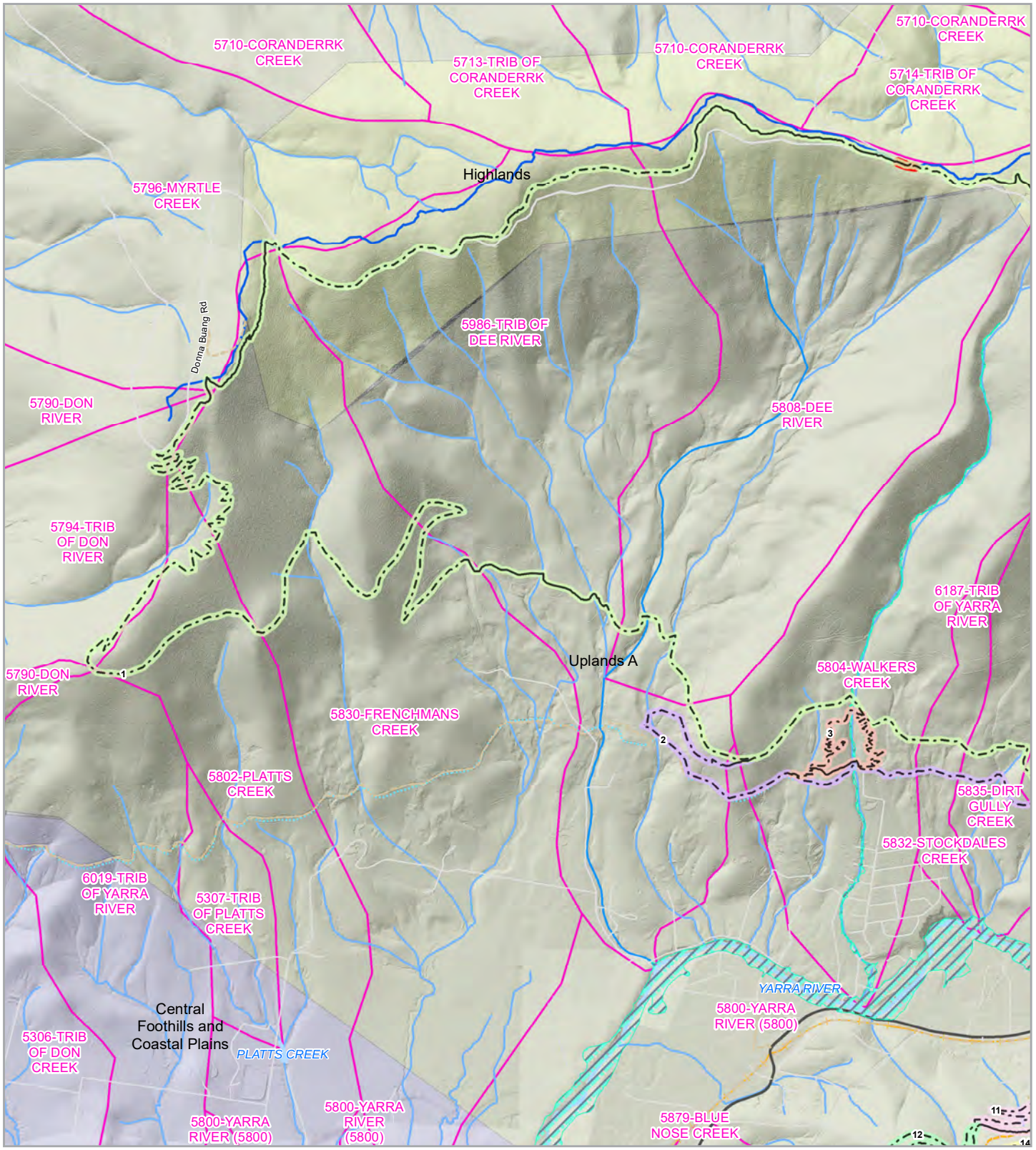

Legend

Trail Type
- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream

- Channel
- Drain/Channel/Other

Rail
- Rail trail
- Land Subject to Inundation

SEPP(Waters)

SurfWater
- Central Foothills and Coastal Plains
- Highlands
- Uplands A
- Melbourne Water Catchments
- Coranderrk Creek Catchment Ridge

- Trail in Drinking Water Catchment

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Flood and Water Catchments

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 7

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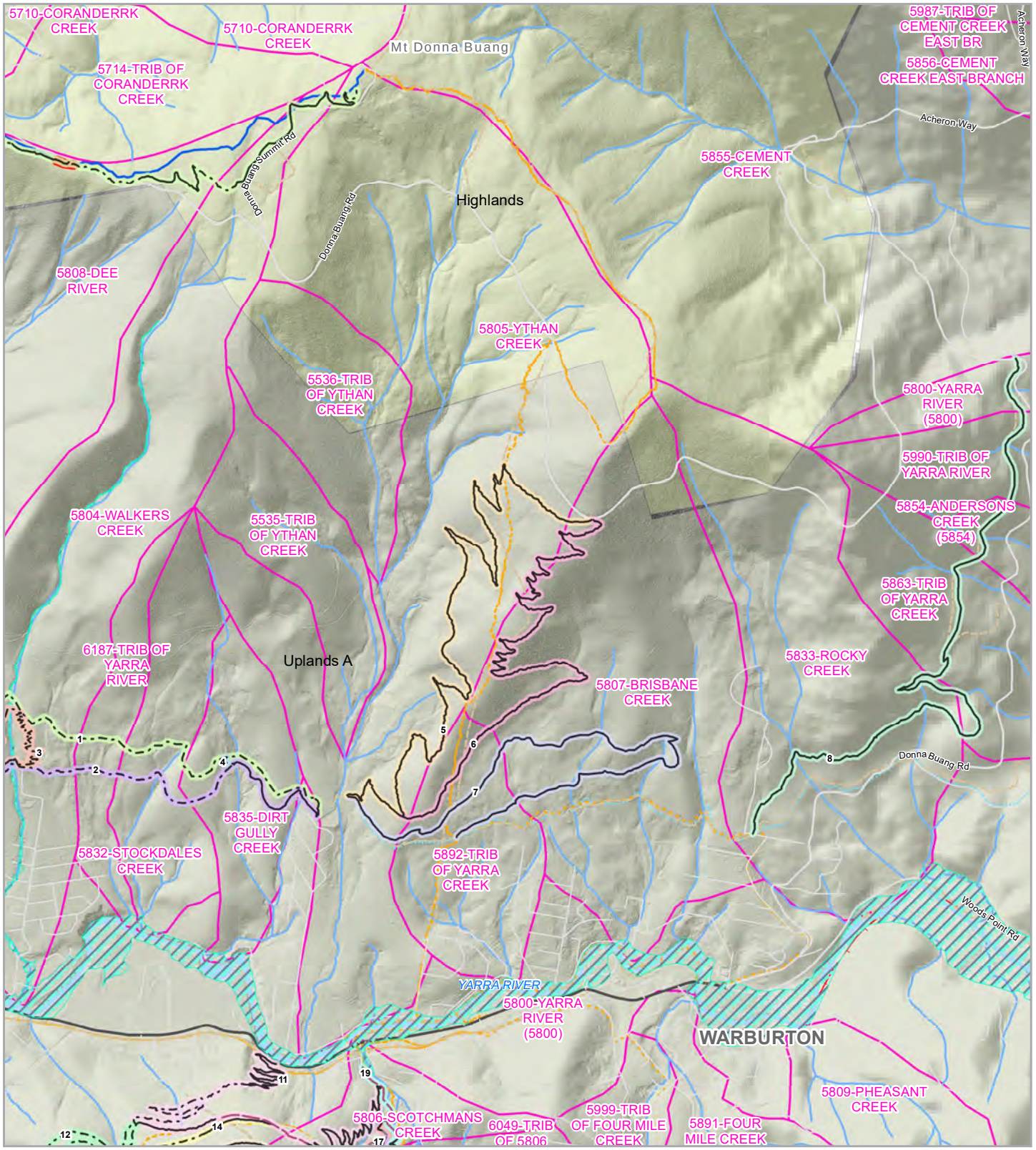

Legend

Trail Type
- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream

- Channel

Rail
- Rail dismantled
- Rail trail
- Land Subject to Inundation

SEPP(Waters)

SurfWater
- Highlands
- Uplands A
- Melbourne Water Catchments
- Coranderrk Creek Catchment Ridge
- Trail in Drinking Water Catchment

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Flood and Water Catchments

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 7

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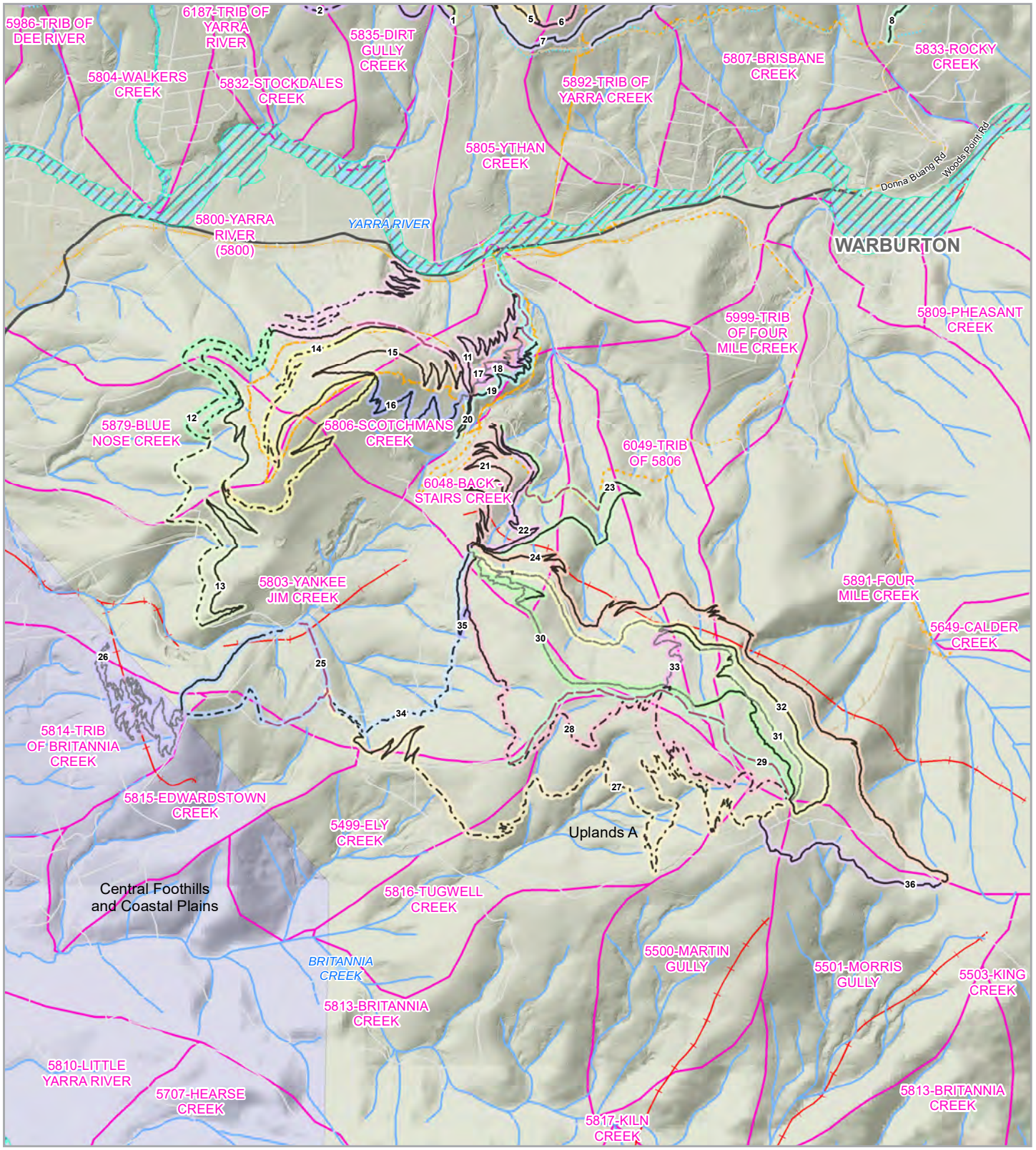

Legend

Trail Type

- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Walking Tracks

- Highway
- Arterial
- Collector
- Tracks
- Watercourse
- River
- Stream

- Channel
- Drain/Channel/Other

Rail

- Rail dismantled
- Rail trail
- Land Subject to Inundation

SEPP(Waters)

SurfWater

- Central Foothills and Coastal Plains
- Uplands A
- Melbourne Water Catchments
- Coranderrk Creek Catchment Ridge
- Trail in Drinking Water Catchment

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Flood and Water Catchments

Project No. 31-37322
Revision No. B
Date 04/12/2019

Figure 7

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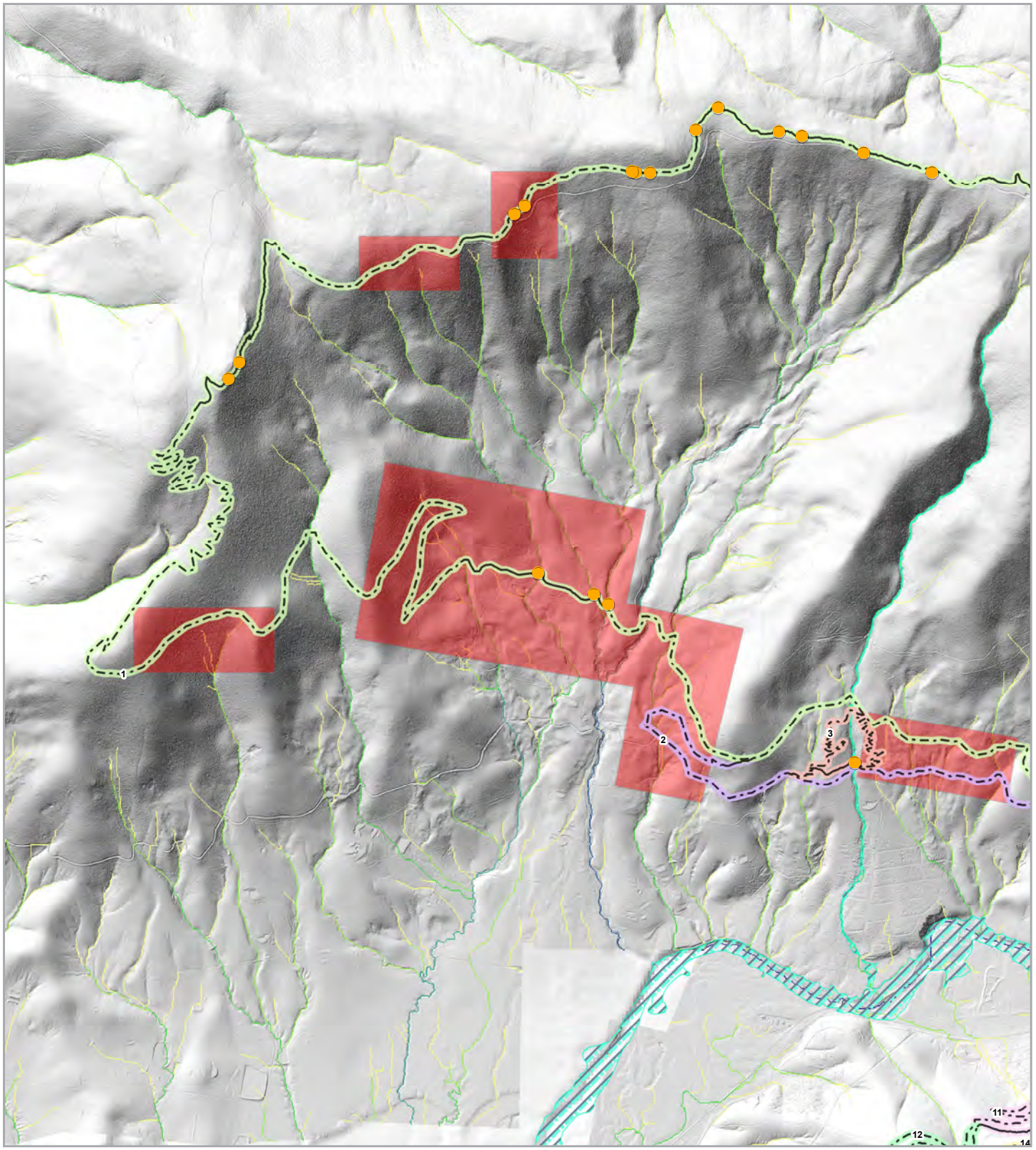

Legend

Trail Type

- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Identified Crossing Locations (World Trail August 2019)

Stream Order

Order (Strahler)

- 1
- 2
- 3
- 4
- 5
- 6

- Land Subject to Inundation
- High Risk Landslide Susceptibility

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Surface Water Risk Locations

Project No. 31-37322
Revision No. C
Date 04/12/2019

Figure 8

N:\AU\Melbourne\Projects\31\37322\GIS\Maps\Working\3137322_KBM_A4P_2.mxd
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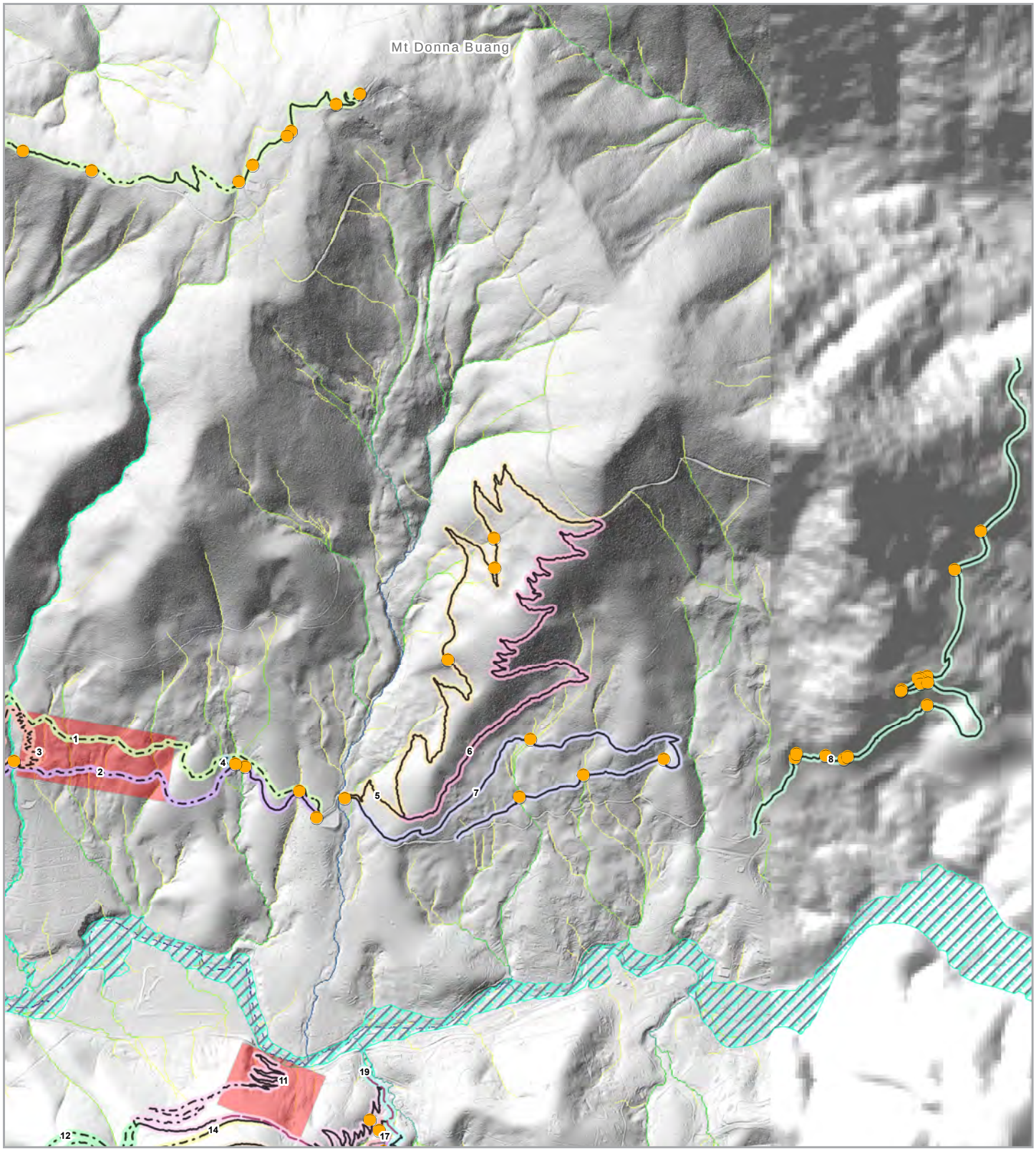

Legend

Trail Type

- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Identified Crossing Locations (World Trail August 2019)

Stream Order

Order (Strahler)

- 1
- 2
- 3
- 4
- 5
- 6

- Land Subject to Inundation
- High Risk Landslide Susceptibility

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

N

GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Surface Water Risk Locations

Project No. 31-37322
Revision No. C
Date 04/12/2019

Figure 8

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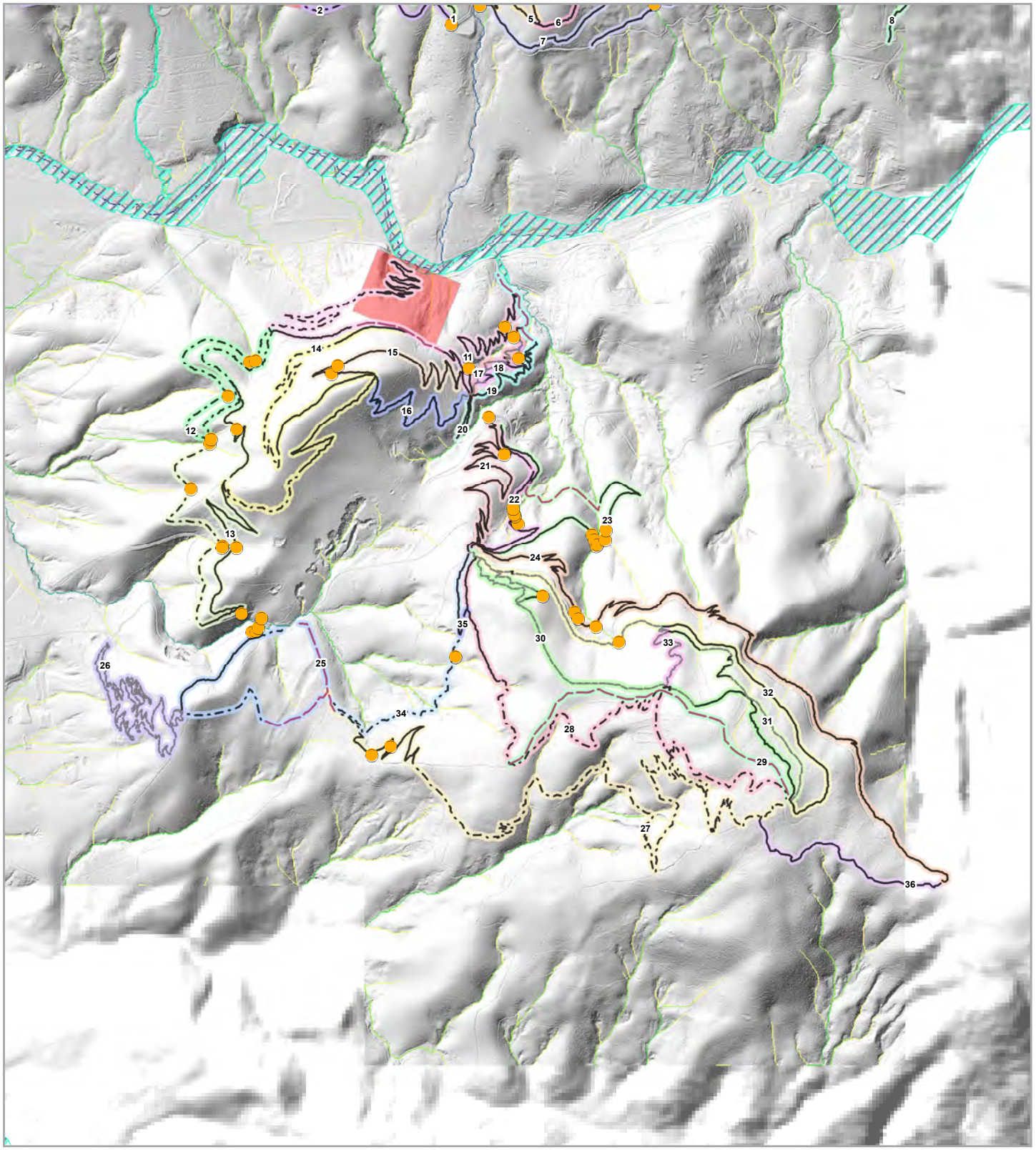

Legend

Trail Type

- WT Alignment
- Cox Alignment
- Existing MTB trail
- Existing Vehicle Track
- To be closed
- Identified Crossing Locations (World Trail August 2019)

Stream Order

Order (Strahler)

- 1
- 2
- 3
- 4
- 5
- 6

- Land Subject to Inundation
- High Risk Landslide Susceptibility

Paper Size ISO A4

0 0.2 0.4 0.6 0.8

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA94 MGA zone 55

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GHD

Yarra Ranges Council
Warburton Mountain Bike Destination

Surface Water Risk Locations

Project No. 31-37322
Revision No. C
Date 04/12/2019

Figure 8

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Print date: 04 Dec 2019 - 17:34

Data source: DELWP, VicMap, 2019; GHD, 2019 Created by: tworth

Appendices

Appendix A – Trail Plan (dated 29 November 2019)

Trail ID	Trail Length (m)	General Notes	Trail Style	Proposed Trail Difficulty Rating	TDRS Average Trail Gradient	Calculated Average Trail Gradient	Trail Number in Previous Version
1	27939	Droppa K - Descends from top of MDB to golf course.	XC / Wilderness	Intermediate	10% or less	8.76%	1
2	5730	Undulating trail running parallel to O'Shannassy Aqueduct linking to Dee Rd car park and then to Droppa K.	XC	Intermediate	10% or less		2
3	3257	Loop trail located between trail 1 and 2.	XC	Intermediate	10% or less		3
4	116	Short link between trail 1 and 2.	XC	Intermediate	10% or less		4
5	7076	Gravity trail from MDB Rd down to O'Shannassy Aqueduct.	Gravity	Intermediate/Difficult	15% or less		5
6	5946	Gravity trail from MDB Rd down to O'Shannassy Aqueduct.	Gravity	Difficult	Not specified		6
7	5068	Loop trail, starting and finishing on O'Shannassy Aqueduct.	XC	Easy	7% or less		7
8	6189	Easy descending trail from MDB Rd down to O'Shannassy Aqueduct.	XC / Gravity	Easy	7% or less		8
9	2488	Loop trail located on private property (Eco Lodge) above golf course.	XC / Gravity	Easy	7% or less		9
11	7321	First loop on Mt Little Joe.	XC	Easy	7% or less		11
12	3585	Second loop on Mt Little Joe.	XC	Easy	7% or less		12
13	5694	Third loop on Mt Little Joe.	XC	Easy	7% or less		13
14	5973	Loop to summit of Mt Little Joe.	XC	Easy/ Intermediate	7% or less		14
15	2432	Descending trail on the north/east face of Mt Little Joe.	Gravity	Intermediate	10% or less		15
16	1962	Descending trail on the east face of Mt Little Joe.	Gravity	Difficult	Not specified		16
17	3299	Climbing link from old Warburton Chalet into trail network.	XC	Easy	7% or less		New trail ground truthed in October

Trail ID	Trail Length (m)	General Notes	Trail Style	Proposed Trail Difficulty Rating	TDRS Average Trail Gradient	Calculated Average Trail Gradient	Trail Number in Previous Version
18	1021	Descending trail through Backstairs corridor.	XC / Gravity	Intermediate	10% or less		17
19	1009	Descending trail through Backstairs corridor.	XC / Gravity	Intermediate	10% or less		18
20	1810	Descending trail through Backstairs corridor.	XC / Gravity	Difficult	Not specified		19
21	638	Access linkage between Backstairs trail junction and vehicle track.	XC	Easy	7% or less		20
22	3533	Climbing linkage from Old Warburton Rd crossing up to Edwardstwon Rd.	XC	Intermediate	10% or less		21
23	1651	Descending trail from Edwardstown Rd to Old Warburton Rd crossing.	Gravity	Intermediate	10% or less		22
24	3352	Descending trail from Edwardstown Rd to Old Warburton Rd crossing.	Gravity	Easy	7% or less		23
25	2945	Linkage from Old Warburton Rd to Hey Hey My My.	XC	Intermediate	10% or less		25
26	6522	Existing MTB trail - Hey Hey My My	XC	Intermediate	10% or less		26
27	9759	Main climbing trail to summit of Mt Tugwell.	XC	Intermediate	10% or less		27
28	5875	XC style descending trail from summit of Mt Tugwell.	XC / Gravity	Intermediate	10% or less		28
29	2638	A-line style jump track using top portion of Cemetery Track.	Gravity	Difficult	Not specified		29
30	3823	Gravity descent from summit of Mt Tugwell using mix of new and existing MTB trails (Top Track).	Gravity	Difficult	Not specified		30
31	736	Alternate end section on 30.	Gravity	Difficult	Not specified		30 (formerly combined with 30)

Trail ID	Trail Length (m)	General Notes	Trail Style	Proposed Trail Difficulty Rating	TDRS Average Trail Gradient	Calculated Average Trail Gradient	Trail Number in Previous Version
32	2110	Gravity descent from summit of Mt Tugwell using mix of new and existing MTB trails.	Gravity	Difficult	Not specified		31
33	4136	Gravity descent from summit of Mt Tugwell using mix of new and existing MTB trails (Matt's Track).	Gravity	Intermediate	10% or less		32
34	816	Linkage trail between 30 and 32.	Gravity	Difficult	Not specified		33
35	2163	Linkage from Edwardstown Rd into Mineshaft Hill area.	XC	Intermediate	10% or less		34
36	189	Linkage between trails 28 and 35.	XC / Gravity	Intermediate	10% or less		35
37	528	Linkage between trails 27 and 35.	XC	Intermediate	10% or less		37
38	1767	Linkage between summit of Mt Tugwell and Tugwell trailhead.	XC	Intermediate	10% or less		36
39	6676	Long climbing trail, from Edwardstown Rd to Mt Tugwell trailhead, parallel below Mt Bride Rd.	XC	Easy/ Intermediate	7% or less		24
40	1404	Link trail between 40 and 42.	XC	Easy	7% or less		New trail ground truthed in October
41	7405	Descending trail below Mt Bride Rd.	XC / Gravity	Easy	7% or less		New trail ground truthed in October
42	8491	Long descending trail from Tugwell trailhead wrapping around onto Mt Bride.	XC / Gravity	Easy/ Intermediate	7% or less		New trail ground truthed in October
43	2304	Gentle descending trail into Wesburn Rec Reserve. Uses portion of old tramway.	XC	Easy	7% or less		New trail ground truthed in October
44	3140	Climbing trail out of Wesburn Rec Reserve.	XC	Easy	7% or less		New trail ground truthed in October
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3137322-26871/https://projects.ghd.com/oc/Victoria3/warburtonmtbdestinat/Delivery/Documents/3137322-REP-0_Warburton MTB Preliminary Surface Water and Geotech Assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	S.Harrow G.Jones R.Hayes K.Jelly-Butterworth	D.May G.Jones		B.George		06/12/2019

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