Environmental & Social Consultants

BASELINE RIPARIAN CONDITION REPORT (2022)

Martins Creek Quarry

FINAL

June 2022

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Martins Creek Quarry

FINAL

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Daracon

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Report No.	3957C/R23
Date:	June 2022

This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Acknowledgement of Country

Umwelt would like to acknowledge the traditional custodians of the country on which we work and pay respect to their cultural heritage, beliefs, and continuing relationship with the land. We pay our respect to the Elders – past, present, and future.

Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
FINAL	Darren Lyon	16 June 2022	Barbara Crossley	17 June 2022

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1.0 Introduction

1.1 Background

The Martins Creek Quarry (the quarry) is licensed by Buttai Gravel Pty Ltd, which is part of the Daracon Group (hereafter referred to as Daracon). The quarry is an existing hard rock quarry situated within the Dungog Local Government Area (LGA), approximately 7 kilometres (km) north of Paterson and 28 km north of Maitland, New South Wales (NSW) (refer to **Figure 1.1**).

In response to the Biodiversity Conservation Division (BCD) recommendations and advice in relation to the Martins Creek Quarry project (SSD-6612), Daracon has committed to undertaking baseline riparian condition monitoring for the streams receiving discharges from licenced discharge points (LDP) 6 and LDP 8 for the reaches extending 200 m downstream from the discharge locations as well as upstream unimpacted stream sections.

The streams receiving discharges from the quarry water management system (WMS), via environment protection licence (EPL) 1378 LDP 6 and LDP 8, have been subject to the altered flow regime associated with controlled discharges for approximately 9 years.

Baseline riparian condition monitoring has been undertaken for the streams receiving discharges from LDP 6 and LDP 8 for the reaches extending 200 m downstream from the discharge locations as well as upstream unimpacted stream sections. The watercourses are shown on Figure 1.2 and a catchment overview is provided in **Section 2.0**. Reaches 1, 2, and 5 were used as upstream unimpacted stream sections and reaches 3 and 4 are the downstream reaches. This report includes an assessment of waterway character and condition to identify historical channel change and propensity for future morphological impact.

1.2 Purpose of this Report

The purpose of this baseline riparian condition report is to:

- provide an overview of the catchments
- outline the assessment methodology
- document the results of riparian condition monitoring undertaken on 6 May 2022
- assess the upstream and downstream baseline condition of these watercourses
- provide recommendations for ongoing monitoring
- provide recommendations for future management of unstable channel reaches.

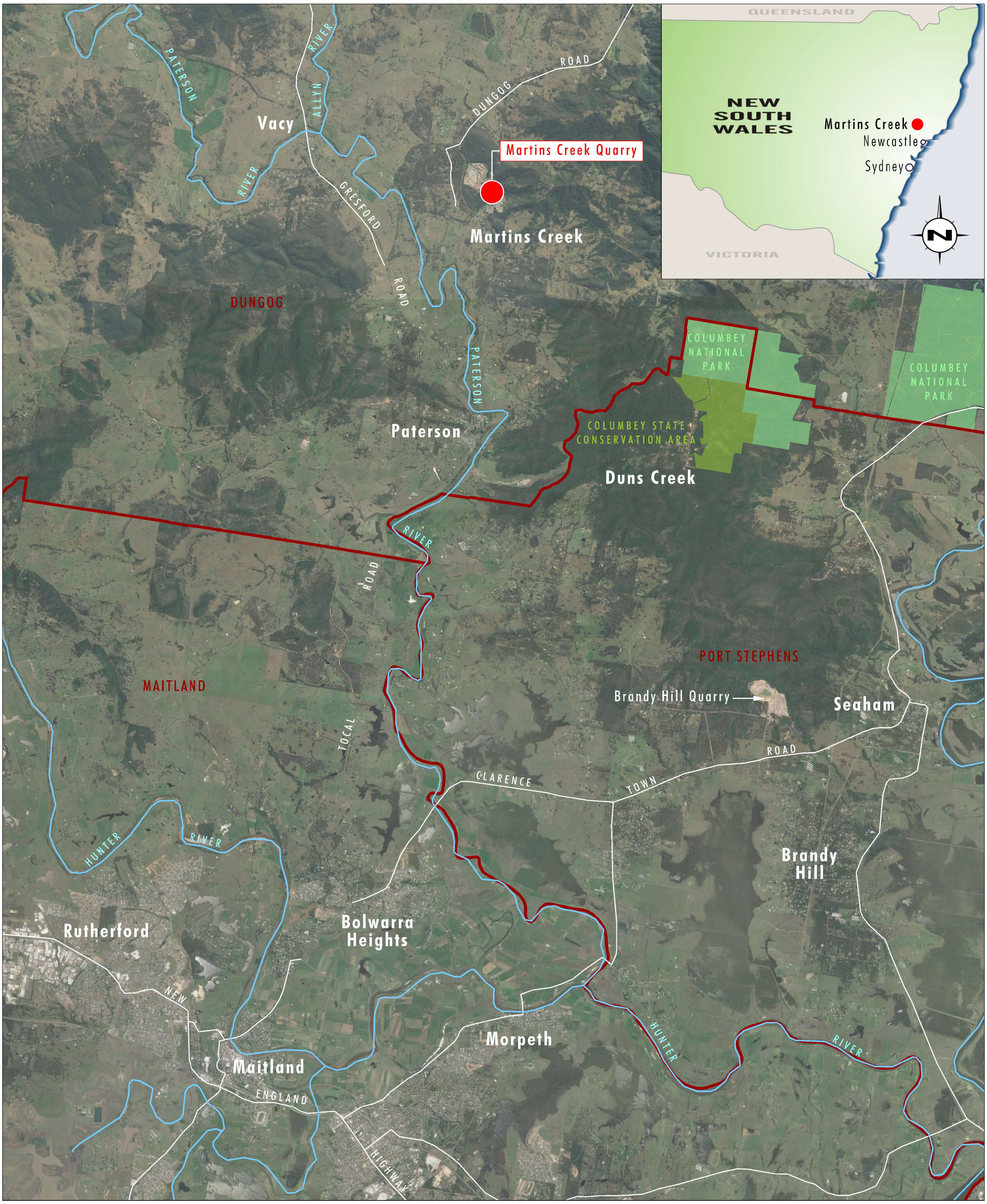

Image Source: Google Earth (2016)
Data Source: LPI (2019),
NSW National Parks and Wildlife Service (NPWS) Estate (Jan 2018)

Legend

- Martins Creek Quarry
- Local Government Area Boundary

FIGURE 1.1

Locality Plan

Image Source: Google Earth (Aug 2018)
Data Source: Daracon (2020), CANRI

0 100 250 500m
1:10 000

Legend

- Project Area
- Proposed Disturbance Area
- Riparian Monitoring Reaches
- Drainage Line
- Culverts
- Water Quality Monitoring Locations

FIGURE 1.2

Watercourses

File Name (A4): R23/3957_254.dgn
20201029 10.26

2.0 Catchment Overview

Baseline riparian condition monitoring has been undertaken for the streams receiving discharges from LDP 6 and LDP 8 for the reaches extending 200 m downstream from the discharge locations as well as upstream unimpacted stream sections. The following reaches were selected for the monitoring (as shown on **Figure 2.1**):

- Reach 1 and 2 are unimpacted stream sections upstream of LDP 6 representative of "natural" or pre-quarry, and are both heavily vegetated, undisturbed catchments. They are upstream of an access road culvert near the confluence.
- Reach 3 is downstream of LDP 6. The reach is located just downstream of the confluence of Reach 1 and 2, and only has a minor additional catchment area including the contributing quarry area.
- Reach 4 is downstream of LDP 8. The majority of the upstream catchment area consists of the quarry area.
- Reach 5 is an unimpacted stream section representative of "natural" or pre-quarry as a comparison to Reach 4. It is downstream of a rail culvert and the upstream catchment area is heavily vegetated and undisturbed.

Catchments were delineated from LiDAR data flown in 2013 available from Geosciences Australia. The catchments and topography are shown on **Figure 2.1.** The respective catchment areas are provided in **Table 2.1**. The natural catchment areas for reaches 3 and 4 are modified as a result of the quarry extents.

Long sections from LiDAR data of the monitoring reaches are provided in **Figure 2.2** and average stream slopes are included in **Table 2.1**. Due to heavy vegetation, the LiDAR may not accurately represent discrete bed levels along the entire reaches. However, the average long section profile plots are representative of the approximate gradients of the stream profiles. Local gradients over shorter stream lengths will vary, particularly with presence of local pool/riffle type sequences, however, these are difficult to identify with the quality of the topographic data.

Reach 1 and 2 are the steeper upper catchment reaches with slopes of approximately 0.05 to 0.06 m/m. The lower 50 m of Reach 1 around the confluence is slightly flatter at 0.04 m/m transitioning into Reach 3. Reaches 4 and 5 have similar gradients are similar in terms of the general location around mid-catchment between the upper slopes and confluence with the Paterson River.

Table 2.1 Catchment Areas and Stream Slopes

Catchment	Total Catchment Area (ha)	Average Stream Slope (m/m)
Reach 1	46.4	0.06
Reach 2	42	0.05
Reach 3	121.5	0.03
Reach 4	42.4	0.03
Reach 5	24.3	0.03

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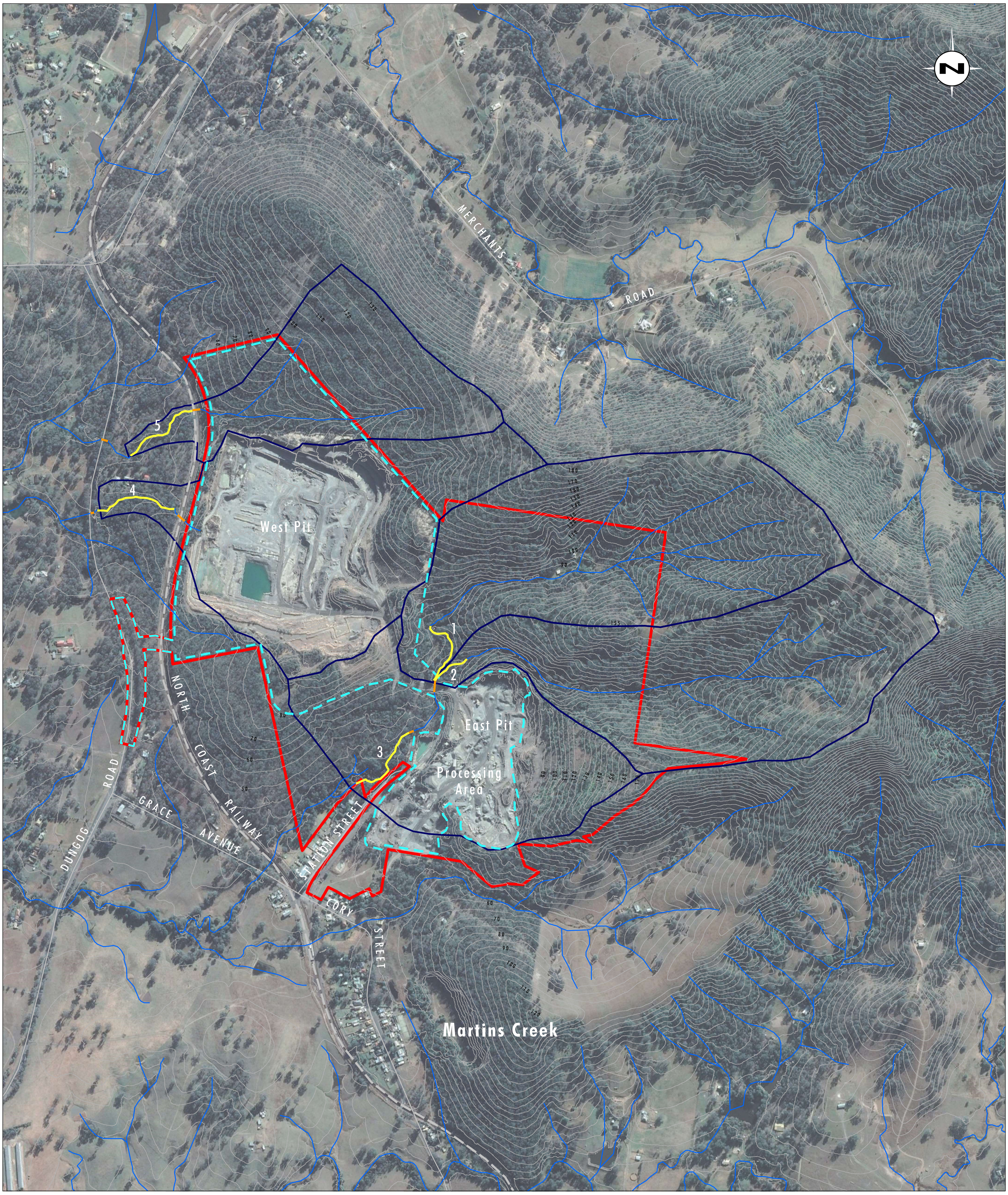

Image Source: Google Earth (Aug 2018)
Data Source: Daracon (2020), CANRI

0 250 500 750m
1:15 000

Legend

- Project Area
- Proposed Disturbance Area
- Catchment area
- Contours 5m
- Riparian Monitoring Reaches
- Drainage Line
- Culverts
- Water Quality Monitoring Locations

FIGURE 2.1

Catchments and Topography

File Name (A4): R23/3957_258.dgn
20150309 9.47

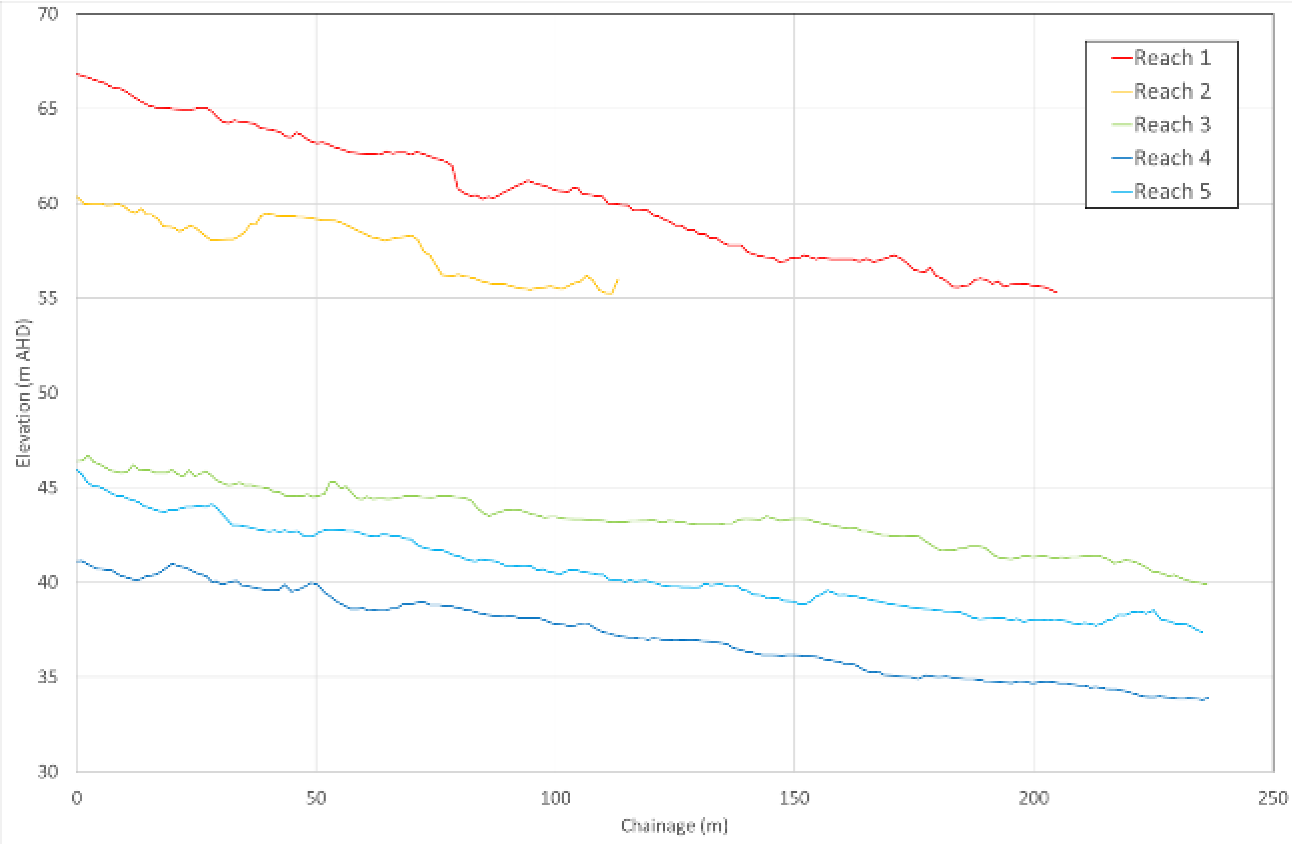

Figure 2.2 **Stream Profiles**

3.0 Riparian Condition Assessment

3.1 Methodology

The riparian condition assessment methodology was derived from the CSIRO Ecosystem Function Analysis – Ephemeral Stream Assessment Guidelines (CSIRO Guidelines) (CSIRO, n.d.). There are four main classes of indicators identified in the CSIRO Guidelines, including:

- the type and condition of the vegetation present, if any
- the shape and profile of the drainage line and type and condition of materials on the drainage line floor
- the nature of the drainage line wall materials
- the nature of the stream bank bordering flats and/or slopes and regulation of lateral flow into drainage lines.

These four main classes of indicators are assessed using eight visual indicators described in **Table 3.1** to **Table 3.8**. Each indicator was scored using the CSIRO Guidelines. The sum of the eight scores produces an activity rating expressed as a percentage of the maximum possible score. As per the CSIRO Guidelines, the activity rating is used to classify monitoring points, ranging from 'very active' for scores less than 50% to 'very stable' for scores greater than 80% according to **Table 3.9**.

Table 3.1 A.1: Vegetation on Drainage Line Floor (CSIRO, n.d.)

Rating	Description
1	Little or no vegetation growing on drainage line floor
2	Any vegetation present is annual or short-lived: partial burial of plants by recently deposited sediment evident.
3	Dense perennial plant cover, similar to vegetation on floodplain/riparian zone: characteristic wetland species composition: no observable plant burial by sediment.

Table 3.2 A.2: Vegetation on Drainage Line Walls (CSIRO, n.d.)

Rating	Description
1	Little or no vegetation growing on drainage line walls.
2	Any vegetation present is annual or short-lived: partial burial of plants by recently deposited sediment evident.
3	Dense perennial plant cover, similar vegetation on floodplain/riparian zone: characteristic wetland species composition: no observable plant burial by sediment.

Table 3.3 B.1: Shape and Aspect Ratio of Drainage Line Cross-Section (CSIRO, n.d.)

Rating	Description
1	Very actively eroding: caving, mass wasting and/or tunnelling present: depth >> width (aspect ratio high)
2	Actively eroding: slight undercutting, near vertical walls, alluvial fans also eroding: depth = width
3	Potentially stabilising: side walls become rounded and crusted alluvial fan at foot of side walls: width > depth
4	Stabilising: wall angles less than 65°, small inactive alluvial fan at foot of side walls: width > depth

Rating	Description
5	Stable: gently sloping walls, generally low, "S" shaped bed/bank continuum: width >> depth (aspect ratio very low)

Table 3.4 B.2: Longitudinal Morphology of Drainage Line (CSIRO, n.d.)

Rating	Description
1	Currently incising bed in pre-existing loose sediment; faceted lower wall/bed profile (benches), scour holes in bed. Morphology implies high flow rates and erosion.
2	Flat, continuous, loose sediment with signs of recent/frequent movement
3	Flat with a cohesive fine textured "soil-like" bed
4	Non-cascading pools or ponds, with non-slaking, non-dispersive clay base, implying low energy flow

Table 3.5 B.3: Particle Size of Materials on Drainage Line Floor - Material Available for Erosion (CSIRO, n.d.)

Rating	Description
1	Material on floor is similar or smaller in particle size and/or density than material on the walls (e.g. unconsolidated fine sand deposits)
2	Material on floor is slightly larger in particle size and/or denser (more consolidated) than material on walls (e.g. well sorted gravel)
3	Material on floor is much larger in particle size and/or denser than material on walls: surface armouring (e.g. cobbles, competent country rock)

Table 3.6 C.1: Nature of Drainage Line Wall Materials (CSIRO, n.d.)

Rating	Description
1	Dispersive material is exposed for greater than 1 metre of wall height
2	Materials that slake rapidly, or disperse are exposed on greater than 0.3 metres and less than 1 metre of vertical wall height (the sum of multiple layers if present)
3	Materials that slake and/or disperse are exposed on less than 0.3 metres of wall height
4	Materials that do not slake or disperse are exposed on wall surface

Table 3.7 D.1: Shape of Stream-bordering Flats and/or Slopes (CSIRO, n.d.)

Rating	Description
1	Very steep slope, > 30° creating high velocity flows
2	Steep bank, 10-30°, permitting moderate to high velocity flows
3	Moderately sloped bank, 5-10°
4	Gently sloped bank/floodplain, laterally extensive, < 5°
5	Woodland with dense litter: very low, diffuse inflow rate

Table 3.8 D.2: Nature of Lateral Flow Regulation into Drainage Line (CSIRO, n.d.)

Rating	Description
1	Side arm channel inflow: very high inflow rates
2	Bare bank, laterally extensive
3	Sparse grassland/woodland with bare soil bank lip: moderate flow rate, some highly focused inflow locations

Rating	Description
4	Dense grassland: low inflow rate, mostly diffuse
5	Woodland with dense litter: very low, diffuse inflow rate

Table 3.9 Classification of Different Drainage Line States (CSIRO, n.d.)

Activity Rating (%)	Classification	Description of Classification
80+	Very Stable	Drainage line is very stable and likely to be in original form. It is able to withstand all flow velocities that have previously occurred in this area and only minimal monitoring is required, predominantly after high flow events, to ensure condition does not deteriorate.
70-80	Stable	Drainage line is stable. It is important to assess this zone in relation to the other classifications and define whether this zone is moving from potentially stabilising to a more stable form or if it is deteriorating from a very stable form. The nature of this relationship will identify the type of monitoring required.
60-69	Potentially Stabilising	Drainage line is potentially stabilising. Ongoing monitoring is required while rehabilitation works are not needed in the immediate future.
50-59	Active	Drainage line is actively eroding and remedial actions are required. It is important to classify if erosion is caused primarily by upstream flows, lateral flows or unstable wall materials so that appropriate rehabilitation can be carried out.
< 50	Very Active	Drainage line is very actively eroding and immediate remedial actions are required. It is important to classify if erosion is caused primarily by upstream flows, lateral flows or unstable wall materials so that appropriate rehabilitation can be carried out.

In addition to the above assessment, the main causes of gully erosion were also considered at each monitoring point. Gully erosion can be caused by (i) high flow rates from upstream, (ii) high lateral flow rates, and (iii) exposure of unstable side wall materials that slake and/or disperse.

3.2 Results

Results for each of the eight visual indicators assessed according to the CSIRO Guidelines are presented in **Appendix A**. Activity ratings for each monitoring point are presented in **Table 3.10** and **Table 3.11**. A selection of representative photos of the reaches are included in **Sections 3.2.1** and **3.2.2**, with locations of the photos shown on **Figure 3.1** and **Figure 3.2**.

In order to appreciate the catchment conditions at the time the monitoring, rainfall conditions in the months preceding the monitoring were compared to the long-term average rainfalls. The nearest rainfall gauge to the area of interest is the Gostwyck Bridge – Paterson River gauge (ID 631349). Monthly rainfall at Gostwyck Bridge – Paterson River gauge for the period 2017 to 2022 is presented in **Appendix B** and shows that rainfall for the four months prior to monitoring (January to April 2022 inclusive) totals 638.5 mm, equal to 167% of the sum of mean monthly rainfall for January to April (inclusive) of 382.4 mm.

Higher than average rainfall suggests wet soil conditions in the catchment. Wet soil conditions can decrease infiltration losses for rainfall events and increase rainfall runoff volumes, resulting in more and higher energy flows in watercourses. These higher flows caused by wet conditions can increase the activity of erosion and sediment transport processes, and therefore the likelihood of change to channel stability at the monitoring points. Wet soil conditions may also have a positive impact on vegetative growth that can have a stabilising impact on channels.

In association with the channel stability assessment and the photographic record, some general observations from the site inspection are noted below:

- All of the reaches appeared generally stable with no significant deterioration of bed and bank condition. Some limited localised bank erosion, specifically around Monitoring Location 3.6 was observed. The scale and nature of the erosion do not represent any significant risk of further extensive degradation, however, would be a key location for ongoing monitoring. Heavy rainfall across the catchment in recent months is the potential cause of this localised erosion. It is noted that LDP 6 discharged approximately 31 and 25 megalitres (ML) for the first four months of 2021 and 2022 respectively. These discharges would provide only a relatively minor additional flow to the natural flow generated across the full catchment from the rainfall conditions experienced.

- All reaches had considerable rock and gravel bed material and established vegetation contributing to the overall general stability of the bed and banks.

- There is a channel bifurcation at the downstream end of Reach 3 and correspond to Monitoring Locations 3.7 and 3.8. These locations are off the main alignment of the monitoring reach and also pick up some additional catchment area from the north west.

- An example of fallen vegetation across the channel was noted in Reach 5 (Monitoring Location 5-3). These types of instances can impede streamflow and create local vortices initiating streambank erosion. In-stream snags (woody debris) along the watercourse should be monitored for influence on local stream stability.

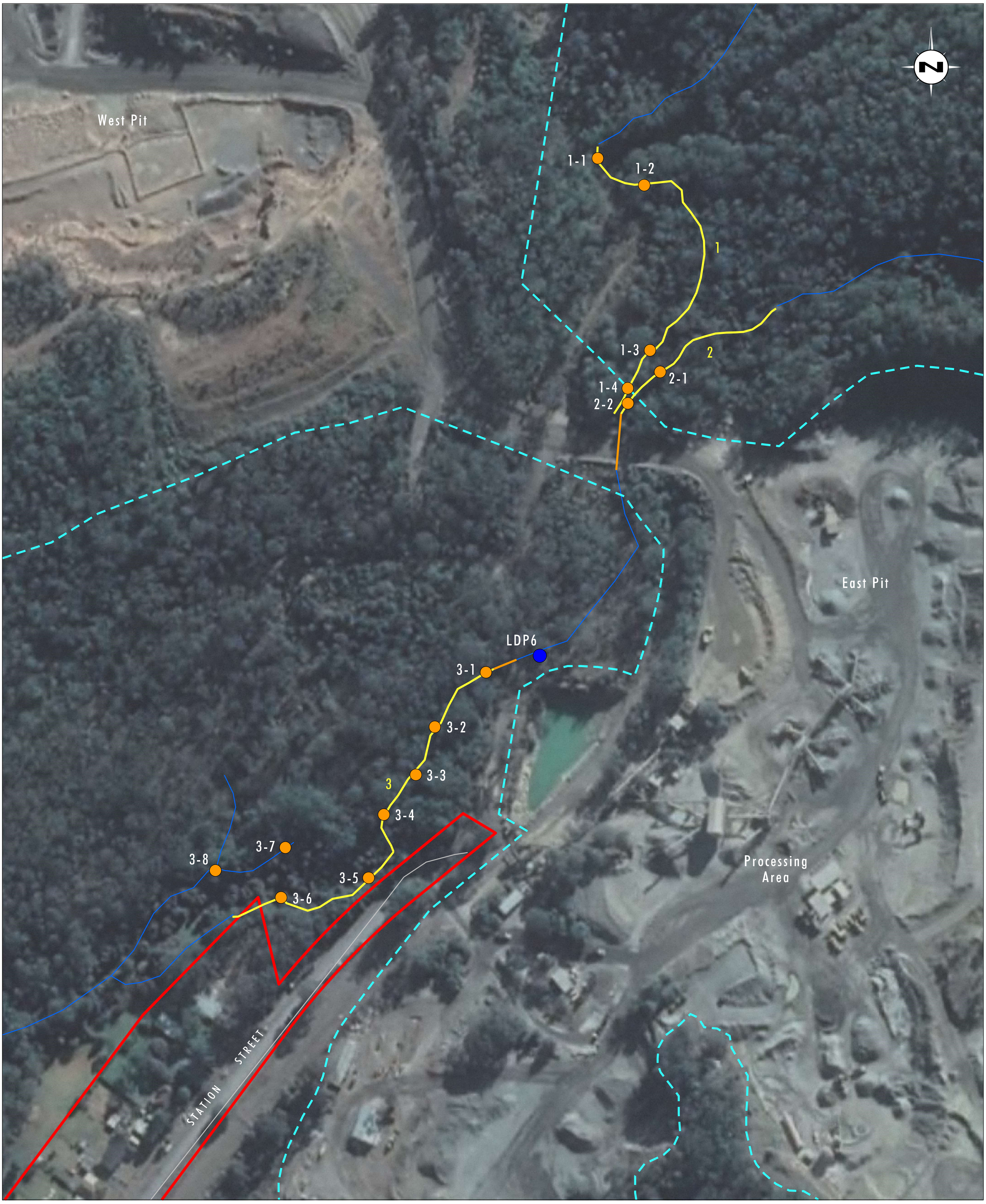

Image Source: Google Earth (Aug 2018)
Data Source: Daracon (2020), CANRI

0 50 100 150m
1:3 000

Legend
- Project Area
- Proposed Disturbance Area
- Riparian Monitoring Reaches
- Monitoring Photo Location
- Water Quality Monitoring Locations
- Drainage Line
- Culverts

FIGURE 3.1
Monitoring Photo Locations

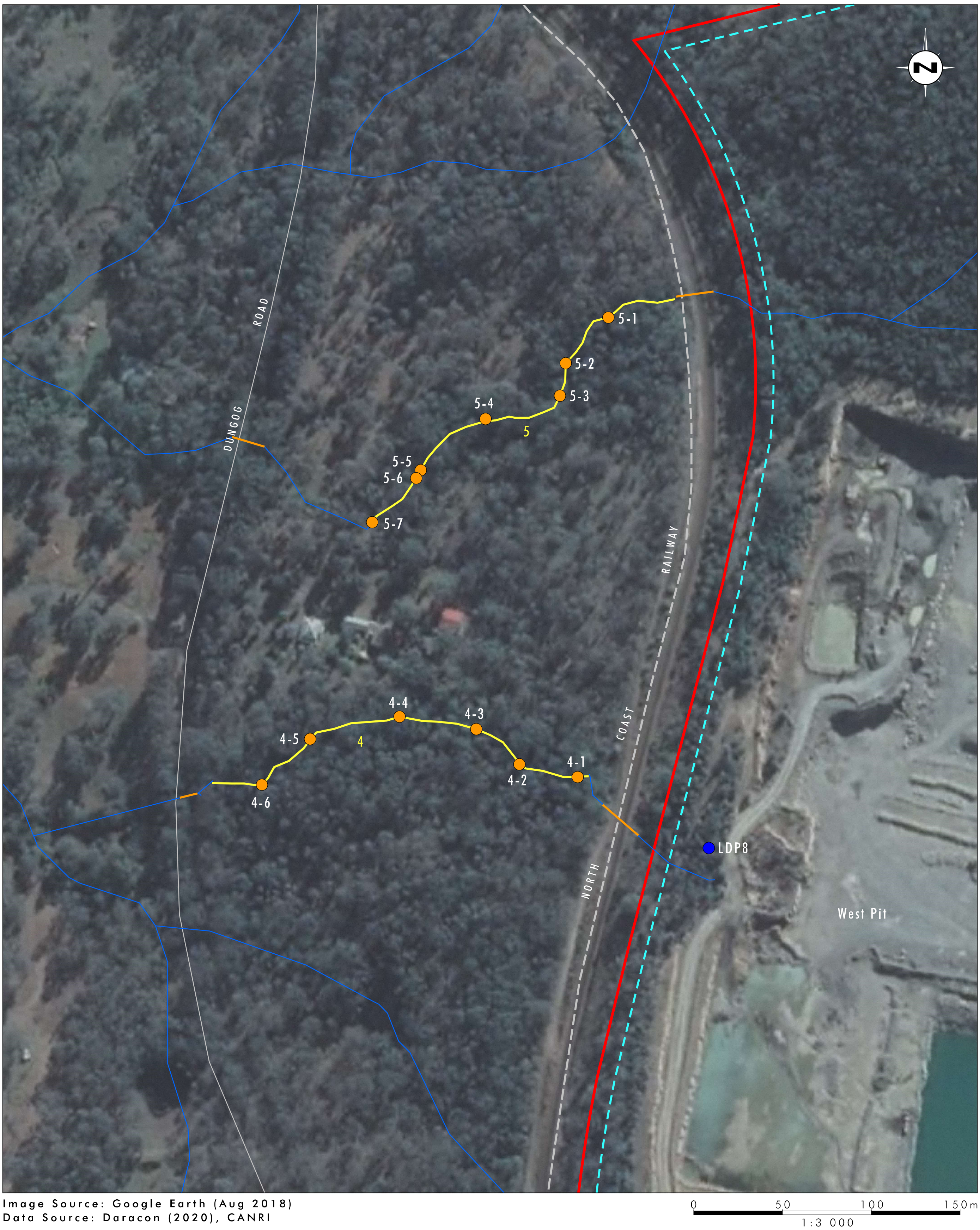

Image Source: Google Earth (Aug 2018)
Data Source: Daracon (2020), CANRI

Legend

- Project Area
- Proposed Disturbance Area
- Riparian Monitoring Reaches
- Monitoring Photo Location
- Water Quality Monitoring Locations
- Drainage Line
- Cuvlerts

FIGURE 3.2

Monitoring Photo Locations

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3.2.1 Upstream Unimpacted Stream Reaches

Reach 1, 2 and 5 represent the reference reaches as upstream unimpacted catchments and have been used as proxy baseline areas to represent riparian condition prior to the previous expansion of quarry operation.

The surveyed reaches were observed to be wet during the monitoring which followed rainfall. Bed armouring and bedrock controls was found on each reach, along with stabilising vegetation. There was dense vegetation and leaf litter present along the areas bordering the watercourse. Some bank undercuts were also observed. The results of the channel stability assessment for Reach 1, 2 and 5 are provided in **Table 3.10**. The activity ratings for Reaches 1, 2, and 5 have been classified as 'stable' or 'very stable'.

Table 3.10 Channel Stability Assessment – Reach 1, 2 and 5 (Upstream Unimpacted Stream Reaches)

Monitoring Point	Latitude (degrees)	Longitude (degrees)	Activity Rating (%)	Comments
1-1	-32.5508	151.6221	75	Approximately 20 m downstream of railway line
1-2	-32.5509	151.6223	78	
1-3	-32.5517	151.6224	78	
1-4	-32.5519	151.6222	78	
2-1	-32.5519	151.6224	78	
2-2	-32.5520	151.6222	78	
5-1	-32.5454	151.6148	91	Approximately 40 m downstream of railway line
5-2	-32.5456	151.6146	88	
5-3	-32.5458	151.6145	88	Fallen tree and debris.
5-4	-32.5459	151.6141	88	
5-5	-32.5462	151.6137	88	
5-6	-32.5462	151.6136	88	
5-7	-32.5464	151.6134	88	
Classification				
80+	Very Stable			
70-80	Stable			
60-69	Potentially Stabilising			
50-59	Active			
<50	Very Active			

Photo 3.1 Reach 1 – Monitoring Location 1-1. Looking Upstream.

Photo 3.2 Reach 1 – Monitoring Location 1-2. Looking Downstream.

Photo 3.3 Reach 1 – Monitoring Location 1-3. Looking Upstream.

Photo 3.4 Reach 1 – Monitoring Location 1-4. Looking Upstream.

Photo 3.5 Reach 2 – Monitoring Location 2-1. Looking Upstream.

Photo 3.6 Reach 2 – Monitoring Location 2-2. Looking Upstream.

Photo 3.7 Reach 5 – Monitoring Location 5-1. Looking Upstream.

Photo 3.8 Reach 5 – Monitoring Location 5-2. Looking Upstream.

Photo 3.9 Reach 5 – Monitoring Location 5-3. Looking towards Western bank. Flow from Right to Left.

Photo 3.10 Reach 5 – Monitoring Location 5-4. Looking Upstream.

Photo 3.11 Reach 5 – Monitoring Location 5-5. Looking Upstream.

Photo 3.12 Reach 5 – Monitoring Location 5-6. Looking Upstream.

Photo 3.13 Reach 5 – Monitoring Location 5-7. Looking Downstream.

3.2.2 Downstream Reaches

Reach 3 and 4 are streams receiving discharges from LDP 6 and LDP 8 respectively with the monitoring extending a minimum of 200 m downstream of the discharge points. The results of the channel stability assessment are provided in **Table 3.11**.

In general, Reach 3 was classified as 'stable', however an area of localised erosion and scour with bank undercutting was evident on Reach 3 (ID 3-6) and has been classified as 'potentially stabilising'. The erosion and bank undercutting at this location is likely a result of the flows generated from the natural catchment from recent and persistent wet weather as discussed in **Section 3.2**, rather than a result of quarry produced flow.

The activity ratings for each monitoring point for Reach 4 have been classified as 'very stable'.

Table 3.11 Channel Stability Assessment – Reach 3 and 4

Location ID	Latitude (degrees)	Longitude (degrees)	Activity Rating (%)	Comments
3-1	-32.5533	151.6214	81	Immediately downstream of LDP 6
3-2	-32.5536	151.6211	75	50m downstream of LDP 6
3-3	-32.5539	151.6209	78	80m downstream of LDP 6
3-4	-32.5541	151.6207	72	110m downstream of LDP 6
3-5	-32.5543	151.6205	78	150m downstream of LDP 6
3-6	-32.5544	151.6202	69	210m downstream of LDP 6
3-7[1]	-32.5542	151.6202	72	On bifurcated flow path approx. 25m north of Reach 3. [1]
3-8[1]	-32.5544	151.6197	72	On bifurcated flow path approx. 25m north of Reach 3. [1]
4-1	-32.5477	151.6146	81	100m downstream of LDP 8, approximately 20m downstream of railway line.
4-2	-32.5476	151.6142	81	130m downstream of LDP 8
4-3	-32.5475	151.6140	81	160m downstream of LDP 8
4-4	-32.5474	151.6135	81	210m downstream of LDP 8
4-5	-32.5475	151.6130	81	260m downstream of LDP 8
4-6	-32.5478	151.6127	81	290m downstream of LDP 8
Classification				
80+	Very Stable			
70-80	Stable			
60-69	Potentially Stabilising			
50-59	Active			
<50	Very Active			

Note: 1. Locations 3-7 and 3-8 are on a bifurcated flow path. The flow peels off from approximately Location 3-4 towards both Location 3-5 and Point 3-7. Location 3-8 receives additional flows from the north.

Photo 3.14 Reach 3 – Location 3-1. At LDP 6, Looking Upstream at Discharge Point Pool.

Photo 3.15 Reach 3 – Location 3-1. At LDP 6, Looking Downstream.

Photo 3.16 Reach 3 – Location 3-2. Looking Upstream.

Photo 3.17 Reach 3 – Location 3-3. Looking Upstream.

Photo 3.18 Reach 3 – Location 3-4. Looking Downstream Towards Eastern Bank.

Photo 3.19 Reach 3 – Location 3-5. Looking Upstream.

Photo 3.20 Reach 3 – Location 3-6. Looking Downstream at Eastern Bank.

Photo 3.21 Reach 3 – Location 3-6. Looking Downstream.

Photo 3.22 Reach 3 – Location 3-6 (Approximately 10m South). Looking Downstream.

Photo 3.23 Reach 3 – Location 3-7. Looking Upstream.

Photo 3.24 Reach 3 – Location 3-8. Looking Downstream.

Photo 3.25 Reach 4 – Location 4-1. Looking Downstream.

Photo 3.26 Reach 4 – Location 4-2. Looking Downstream.

Photo 3.27 Reach 4 – Location 4-3. Looking Downstream.

Photo 3.28 Reach 4 – Location 4-4. Looking Downstream.

Photo 3.29 Reach 4 – Location 4-5. Looking Downstream.

Photo 3.30 Reach 4 – Location 4-6. Looking Downstream.

4.0 Recommendations for Proposed Monitoring and Management

The condition assessment of the reaches downstream of LDP 6 and LDP 8 does not indicate any requirement for any immediate remediation works. As noted, the reaches are considered in a generally stable condition at present.

Routine monitoring is proposed to ensure regular assessment of stream condition, identification of active stream degradation and remedial works to arrest / rehabilitate affected reaches. The recommendations for future monitoring and management are outlined below:

- Areas of ‘potentially stabilising’ erosion, on Reach 3 may be monitored on a 6-monthly interval by Daracon, or following significant local catchment rainfall events (providing streamflow response for 50% to 100% bank full condition) until demonstrated as stable, with annual monitoring undertaken by a specialist.
- If monitoring indicates that areas of erosion are becoming less stable, the requirement for remedial works should be reviewed with consideration of the mechanism of the damage (e.g. high streamflow) and relative contribution from the quarry operation.
- Annual channel stability monitoring should be undertaken by a specialist to ensure that any further erosion can be identified and addressed and that any rehabilitation activities are successful.

Ongoing riparian condition monitoring requirements will be included in the Water Management Plan (WMP) for the operations, should the Project be approved, including trigger levels for investigating any potentially adverse impacts.

5.0 Conclusions and Recommendations

A channel stability monitoring program was initiated to address DPIE recommendations and advice in relation to the Martins Creek Quarry project (SSD-6612) in December 2021. The monitoring included visual inspection of nominated reaches including unimpacted reference reaches and reaches immediately downstream of LDP 6 and LDP 8. A channel stability rating analysis was undertaken based on the site observations.

The general observations from the site inspections and assessment include:

- Monitoring reaches are generally stable with only isolated instances of minor bank erosion.
- No indications of recent or significant bed lowering.
- Typically well-established vegetation coverage on banks and adequate bedload material (rock and gravel typical).
- The causes of the minor erosion are likely due high rainfall and flow events which have occurred recently in the local catchments.
- Once slaking and/or dispersive materials have been exposed in a watercourse, erosive flow events can cause the area of exposed material to increase exponentially, creating a positive feedback loop that will continue until the erosive energy is reduced or physical limits to erosion are reached, e.g. removal of material back to bedrock.
- Recent weather conditions may have also positively impacted the growth of stabilising vegetation.

The recommendations for future monitoring and management are detailed below. It is recommended that:

- Areas of 'potentially stabilising' erosion, on Reach 3 are to be monitored by Daracon on a 6-monthly interval, or following significant local catchment rainfall events until demonstrated as stable, with annual monitoring undertaken by a specialist.
- If monitoring indicates that areas of erosion are becoming less stable, the requirement for remedial works should be reviewed with consideration of the mechanism of the damage (e.g. high streamflow) and relative contribution from the quarry operation.
- Annual channel stability monitoring should be undertaken by a specialist following any remedial works to ensure that any further erosion can be identified and addressed and that any rehabilitation activities are successful.

6.0 References

BOM (2022). Monthly Rainfall Data – Gostwyck Bridge (Paterson River). http://www.bom.gov.au/climate/data/

CSIRO, no published date (n.d.) - Ecosystem Function Analysis – Ephemeral Stream Assessment Guidelines.

APPENDIX A

Assessment Results

Ephemeral Stream Field Assessment
Results Analysis

Site Name: **Martins Creek Quarry**

		Site Name: Martins Creek Quarry	1-1	1-2	1-3	1-4	2-1	2-2	5-1	5-2	5-3	5-4	5-5	5-6	5-7
		Observer: MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM
		Date: 6/5/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022
Activity Rating			Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating
Vegetation	**A.1**	On D/L floor (1-3)	1	1	1	1	1	1	2	3	1	1	1	1	1
	A.2	On D/L Wall (1-3)	2	2	2	2	2	2	2	3	3	3	3	3	3
Profile of Drainage Line	**B.1**	Shape of X-Section (1-5)	2	3	3	3	3	3	5	5	5	5	5	5	5
	B.2	Longitudinal Morphology (1-4)	4	4	4	4	4	4	4	4	4	4	4	4	4
	B.3	Type of Materials on Floor (1-3)	3	3	3	3	3	3	3	2	3	3	3	3	3
Drainage Line Wall Materials	**C.1**	Nature of Materials (1-4)	3	3	3	3	3	3	4	3	4	4	4	4	4
Bank Edge	**D.1**	Nature of Shape (1-5)	5	5	5	5	5	5	5	4	4	4	4	4	4
	D.2	Lateral Flow Regulation (1-5)	4	4	4	4	4	4	4	4	4	4	4	4	4
Activity Score (total of above)			24	25	25	25	25	25	29	28	28	28	28	28	28
Activity Score (%)			75%	78%	78%	78%	78%	78%	91%	88%	88%	88%	88%	88%	88%
Classification			Stable	Stable	Stable	Stable	Stable	Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable
Other Questions and Notes:															
Is the gully erosion caused by high flow rates from upstream? (i.e. Banks are well vegetated suggesting diffuse lateral flow rates but currently incising bed suggests higher flows from upstream).			No	No	No	No	No	No	No	No	No	No	No	No	No
Is the gully erosion predominantly caused by high lateral flow rates? (i.e. Are banks poorly vegetated and side arms are developing suggesting inflow is sourced laterally from catchment and is not necessarily a problem upstream).			No	No	No	No	No	No	No	No	No	No	No	No	No
Is the gully erosion predominantly due to initial exposure of slaking and/or dispersive materials which continue to erode when exposed to low and high flow events? (i.e. Banks are well vegetated, drainage line bed is continuous and not further eroding but headwall gully erosion continues unabated).			No	No	No	No	No	No	No	No	No	No	No	No	No
General Notes			Some evidence of bank erosion. Ponded water. Bed rock armouring.			Ponded water. Bedrock controls.					fallen tree, debris				

Ephemeral Stream Field Assessment
Results Analysis

Site Name: Martins Creek Quarry

			3-1	3-2	3-3	3-4	3-5	3-6	3-7	3-8	4-1	4-2	4-3	4-4	4-5	4-6
		Site Name: Martins Creek Quarry														
		Observer: MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM	MM
		Date: 6/5/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022	6/05/2022
Activity Rating			Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating
Vegetation	**A.1**	On D/L floor (1-3)	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	A.2	On D/L Wall (1-3)	3	2	2	2	2	2	2	2	2	2	2	2	2	2
Profile of Drainage Line	**B.1**	Shape of X-Section (1-5)	4	5	5	3	5	2	4	4	5	5	5	5	5	5
	B.2	Longitudinal Morphology (1-4)	4	3	3	3	3	3	3	3	3	3	3	3	3	3
	B.3	Type of Materials on Floor (1-3)	3	1	2	2	2	2	2	2	3	3	3	3	3	3
Drainage Line Wall Materials	**C.1**	Nature of Materials (1-4)	3	4	4	4	4	4	3	3	3	3	3	3	3	3
Bank Edge	**D.1**	Nature of Shape (1-5)	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	D.2	Lateral Flow Regulation (1-5)	4	4	4	4	4	4	4	4	5	5	5	5	5	5
Activity Score (total of above)			26	24	25	23	25	22	23	23	26	26	26	26	26	26
Activity Score (%)			81%	75%	78%	72%	78%	69%	72%	72%	81%	81%	81%	81%	81%	81%
Classification			Very Stable	Stable	Stable	Stable	Stable	Potentially Stabilising	Stable	Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable	Very Stable
Other Questions and Notes:																
Is the gully erosion caused by high flow rates from upstream? (i.e. Banks are well vegetated suggesting diffuse lateral flow rates but currently incising bed suggests higher flows from upstream).			No	No	No	No	No	No	No	No	No	No	No	No	No	No
Is the gully erosion predominantly caused by high lateral flow rates? (i.e. Are banks poorly vegetated and side arms are developing suggesting inflow is sourced laterally from catchment and is not necessarily a problem upstream).			No	No	No	No	No	No	No	No	No	No	No	No	No	No
Is the gully erosion predominantly due to initial exposure of slaking and/or dispersive materials which continue to erode when exposed to low and high flow events? (i.e. Banks are well vegetated, drainage line bed is continuous and not further eroding but headwall gully erosion continues unabated).			No	No	No	No	No	No	No	No	No	No	No	No	No	No
General Notes								Undercutting Up to 1m wall height. Root masses on banks. Erosion likely due to wet season.								

APPENDIX B

Monthly Rainfall Data

Table B.1 Monthly Rainfall (mm) at Gostwyck Bridge (Paterson River) for 2017 – 2022 (Source: BOM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2017	44	81	204.5	59.5	9.5	123.5	2	6	16	79.5	21	38.5	685
2018	6.5	95.5	150	34.5	5.5	134	2	0	18	144.5	61	84.5	736
2019	7.5	46.5	140.5	17	28.5	59	11.5	39	84.5	13	15.5	0.5	463
2020	51	121.5	105	36	56.5	48	112.5	26	44.5	168	22	168.5	959.5
2021	137	138	289	24.5	40	52	36	34	44	64	300.5	65	1224
2022	74.5	122.5	347.5	94	-	-	-	-	-	-	-	-	-

Table B.2 Summary Statistics for monthly and annual rainfall (mm) at Gostwyck Bridge (Paterson River) Meteorological Station for the Years 1929 – 2022 (Source: BOM)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
10th %ile	5.9	29.7	13.4	18.8	6.6	22.0	2.0	0.0	4.7	10.0	20.9	6.4	472.0
Mean	67.9	103.3	116.9	94.3	33.1	91.0	28.4	24.9	44.1	56.3	90.8	66.3	846.8
90th %ile	137.1	186.3	221.4	229.6	72.1	145.6	62.0	66.2	99.3	123.3	194.4	137.7	1191.0

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