IN THE ENVIRONMENT COURT

CHRISTCHURCH REGISTRY

I MUA I TE KOOTI TAIAO O AOTEAROA

ENV-2017-CHC-090

Under	**the Resource Management Act 1991**
In the matter	**of an appeal pursuant to section 120 of the Act**
Between	**THE ROYAL FOREST AND BIRD PROTECTION SOCIETY OF NEW ZEALAND INCORPORATED** **Appellant**
And	**WEST COAST REGIONAL COUNCIL AND BULLER DISTRICT COUNCIL** **Respondents**
And	**STEVENSON MINING LIMITED** **Applicant**

REVISED AND UPDATED STATEMENT OF EVIDENCE OF ROBYN CATHERINE SIMCOCK FOR STEVENSON MINING

20 August 2021

NATURAL RESOURCES LAW LIMITED

Solicitor: M R Christensen
s 9(2)(a)

PO Box 6643
Upper Riccarton
CHRISTCHURCH 8442

Tel s 9(2)(a)

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QUALIFICATIONS AND EXPERIENCE

Introduction

1 My full name is Robyn Catherine Simcock.

2 I hold the degrees of Bachelor of Horticultural Science (First class honours, 1986) and Doctor of Philosophy in Soil Science/Land Rehabilitation (1993), both from Massey University.

3 I am an ecologist and soil scientist with Manaaki Whenua Landcare Research Ltd, for whom I have worked since 1995.

4 My research and consultancy have specialised in rehabilitation and amelioration strategies for sites where whole ecosystems (i.e. plants and soils) are impacted. The impacts may be from mining, road construction, or urban development. The rehabilitation involves salvaging or creating new 'root zones' and landscapes that support the desired ecosystems, ecosystem functions and specified management regimes.

Experience with mining and edge affected ecosystems

5 I have researched and consulted in the field of mine rehabilitation since completing a thesis on rehabilitation of aggregate mines in 1993 developing optimum rehabilitation profiles for soils of contrasting drainage status. In 1995 I joined Manaaki Whenua – Landcare Research (MWLR) to assist researchers studying mine rehabilitation methods at the Giles Creek opencast coal mine where Dr Craig Ross. This included trials of different root zones, establishment of nursery-raised beech, and direct vegetation transfer with pakihi vegetation in 1996/97. In 2013/14 I joined a collaborative research programme, the Centre for Mine Environmental Research (CMER), contributing to a closure-focused mine environment life-cycle guide which was published in 2018. Three volumes cover epithermal gold mines, mesothermal gold mines and coal mines.[1] This involved reviewing rehabilitation at mine sites throughout New Zealand, with a focus on identifying effective rehabilitation techniques, and best practice rehabilitation and closure.

[1] https://www.cmer.nz/publications/2018/MELG_Coal_PAFV1.3.pdf

6 In 2014 I prepared ‘Guidelines for mine rehabilitation in Westland’ with Dr Craig Ross for the West Coast Regional Council. In 2017 we summarised mine rehabilitation research and practice across New Zealand as a chapter in an international book on rehabilitation practice ‘Spoil to Soil’[2] (Appendix 2).

7 I am currently the rehabilitation peer reviewer of Waihi Mine(s) for Waikato Regional Council. In a consultant’s capacity I have reviewed rehabilitation of pasture areas at Macraes gold mine in Otago (NZ’s largest active gold mine), and rehabilitation to pasture, plantation forestry and native forests at the Huntly-Rotowaro coal mines of Waikato. I have co-supervised post-graduate students in land rehabilitation and provided lectures to students in mine and road rehabilitation at the University of Auckland.

8 My MWLR research and consultancy have included developing rehabilitation and management practices for physically impacted ecosystems along transport corridors for Waka Kotahi – NZ Transport Agency and Auckland Motorways. I contributed to the national 2014 NZTA Landscape Guidelines (I had co-authored the 2006 guide), and have technically reviewed rehabilitation plans and maintenance practices for new and existing highways including ecologically sensitive sites such as Waipoua Forest Sanctuary. I currently lead a project for Waka Kotahi-NZTA reviewing and characterising the edge effects of roads, and a project for Ministry of Primary Industries reviewing practices that extend the planting season for nursery-grown native trees. The latter project included remeasuring areas rehabilitated with native forest species at Wangaloa Mine, Otago Coast (~18 years after planting with Dr Cathy Rufaut), at Globe-Progress Mine, Reefton (1–14 years after planting with Dr David Norton), and at Tui Mine, Waikato (1–6 years after planting and direct transfer).

9 I have presented evidence in Council hearings and before the Environment Court on behalf of Solid Energy NZ for the Cypress, Mt Augustus, and Mt William proposals. These proposals impacted coal measures ecosystems on the Buller coal plateaus and were linked to specific rehabilitation trials at Stockton mine

[2] Extracts of the chapter concerning native ecosystem rehabilitation.

between 1997 and 2011 in which new rehabilitation methods were tested. As I discuss in my evidence, these trials involved seeding, direct transfer,[3] and planting nursery-raised or wilding plants of a range of plants from coal measures, red tussock wetlands, herbfields, and shrublands. With Dr Ross and others, I helped develop seeding and hydroseeding methods for native moss, herb and vascular plant species at Stockton and Strongman, including on haul road batters.

Experience in soil physics/hydrology

10 My post-graduate research investigated the effects of compaction and soil degradation on soils and the impact on plant growth. I have continued this research in soil physical properties as they influence hydrology and moisture assessment and links to plant evapotranspiration and plant stress.[4] I applied this research in a collaborative programme with NZ Forest Research Institute (now Scion) that modelled water balance and contribution of soil physical and chemical factors to productivity of plantation species in mid 2000s.[5] From 2008 I applied understanding of soil moisture to assist stormwater engineers understand the performance of green infrastructure, in particular a) to understand impacts of degradation of earthworked natural soils on soil water storage and b) to design root zones that optimise stormwater retention.[6] A core

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[3] Direct transfer is the movement of intact vegetated sods, or root plates of trees with attached seedlings and underlying soils, their transport in a single layer, and placement on areas requiring rehabilitation. Internationally known as turf, sod, or community translocation (Bullock 1998, Trueman *et al.* 2011). The term has been adapted to include transfer of weathered boulders with attached vegetation (Rodgers et al. 2011).

[4] Voyde E, Fassman E, Simcock R, Wells J. 2010. Quantifying evapotranspiration rates for New Zealand green roofs. Journal of Hydrologic Engineering 15(6): 395–403.

[5]Watt MS, Kiyvyra AL, Clinton PW, Coker G, Parfitt RL, Simcock R, Dando J, Davis MR, Schoenholtz SH. 2008. Modelling water balance in fertilised and unfertilised *Cupressus lusitanica* and *Pinus radiata* grown across an environmental gradient. Forest Ecology and Management 255(3–4): 1104–1112 and Watt M, Davis M, Clinton P, Coker G, Ross C, Dando J, Parfitt R, and Simcock R. 2008. Identification of key soil indicators influencing plantation productivity and sustainability across a national trial series in New Zealand. Forest Ecology and Management 256 (1-2):180-190.

[6]Fassman EA, Simcock R Wang S. 2013. Media specification for stormwater bioretention devices. Auckland Council Technical Report TR2013/11, Fassman Beck E, Simcock R 2013. Living roofs review and design recommendations for stormwater management. TR2013/020, and Fassman-Beck E, Wang S,

paper on moisture measurements won an American Society of Civil Engineers award.[7]

11 In summary, I consider my experience with mining over the last 20 years at the Stockton Mine and other mines in a wide range of environments has allowed me to understand what rehabilitation outcomes are practically possible, over what timeframes, and the impacts of changing conditions and priorities on rehabilitation outcomes.

My role with this project

12 I have been involved with this Te Kuha proposal since 2013. I have visited the proposed mine footprint, including the alignment of the access road, on three occasions. Throughout my involvement, I have worked to ensure the ongoing and final rehabilitation is integral to the mine plan and is consistent with specific landscape and individual species outcomes. This has involved working iteratively with Dr Bramley on ecology, Mr Rough on landscape and visual matters, and with Ms Rock, Ms Brewster, and others on planning and design of the mine and access road and its rehabilitation, on the draft management plans for species and habitat enhancement, and on draft consent conditions to underpin the proposed rehabilitation outcomes. I helped identify sites suitable for field work by technical experts on bryophytes, ponds, and earthworms.[8]

13 I was the author of the section on rehabilitation in the technical report attached to AEE (Appendix 10 (Vegetation and Fauna)), I contributed to the S92 response Appendix C (Mitchel Partnerships 2017) and to the draft Te Kuha Biodiversity Management Plan, and I am the primary author of the draft Te Kuha Rehabilitation Management Plan.

Simcock R, Liu R. 2015. Assessing the effects of bioretention's engineered media composition and compaction on hydraulic conductivity and water holding capacity. Journal of Sustainable Water in the Built Environment.

[7] American Society of Civil Engineers, 2014 EWRI Wesley W Horner Award for contribution to engineering science with Dr E Fassman. The paper: Fassman E, Simcock R. 2012. Moisture measurements as performance criteria for extensive living roof substrates. Journal of Environmental Engineering 138 (8):841-851.

[8] Sites at Stockton used in the paper 'Boyer and Wratten 2011'.

SCOPE OF EVIDENCE

The purpose of my evidence

14 My evidence describes the objectives for rehabilitated areas at Te Kuha and the methods proposed (and required by conditions) to ensure those outcomes are achieved. It includes how success in meeting the objectives will be measured at 'closure' of the mine, and the main risks and factors that influence the achievability of rehabilitation. Specifically, my evidence addresses:

(a) A description of the project with respect to areas requiring rehabilitation;

(b) Key features of rehabilitation at Te Kuha that influence the planned outcomes, including soils;

(c) How rehabilitation differs from restoration;

(d) The measures that avoid and minimise adverse effects;

(e) Rehabilitation objectives and outcomes – how overall success is determined;

(f) The rehabilitation methods proposed to deliver the outcomes;

(g) How the risks to achieving the rehabilitation outcomes are to be managed;

(h) Closure criteria for terrestrial rehabilitation – defining short-term success (10 years post initial revegetation);

(i) Relevant objectives and policies in statutory planning documents.

Matters considered in preparing my evidence

15 In preparing this evidence I have reviewed:

(a) The reports and draft statements of evidence of other experts giving evidence and providing information relevant to my area of expertise, including:

(i) Dr Graham Ussher and Mr Chris Glasson on behalf of Buller District Council; and

(ii) Dr Gary Bramley, Dr John Craig, Dr Craig Ross, Mr Richard Toft, Mr Peter Rough, and Ms Rock on behalf of the applicant; and

(b) the rehabilitation evidence presented for the Escarpment Mine in 2012 and the Environment Court's decision on that appeal.

16 This is an updated and revised statement of primary evidence from my original statement of evidence dated 4 May 2018. In this revised evidence, I have also considered:

(a) The statements of evidence filed by all ecologists for the appellant and for the Director-General of Conservation and by Mr Stephen Brown on landscape issues in May 2018;

(b) The expert ecology conferencing that occurred in June 2018 (I participated in the conferencing on rehabilitation), including agreements on amended conditions, as reflected in the four Joint Witness Statements (JWS); and

17 Throughout my evidence I refer to the Rehabilitation JWS and Dr Lloyd's evidence from March 2018. The Rehabilitation JWS in particular sets out the similarities and differences in both approach and detail between myself and expert witnesses for Forest & Bird and the Director-General, and those issues on which we do not agree.

18 In Appendix 1 to my evidence, I have included a summary of other sites with known rehabilitation histories, photographs, and where available, summary data, to assist the Court understand and assess the rehabilitation methods proposed and their anticipated outcomes at Te Kuha. Sites include areas at Stockton, Strongman, and Globe-Progress Mines. I refer to this information throughout this evidence. Appendix 2 to my evidence is a short overview of rehabilitation in New Zealand that I also reference, as it draws together broader information, including giving the background to the mine sites referred to in this evidence.

19 When I refer to draft conditions in this evidence, I am referring to the draft set of conditions dated 23 July 2021. This draft is revised and updated from the conditions that I considered in my earlier

statement of evidence dated 4 May 2018 and at the rehabilitation expert conferencing in June 2018. The present draft dated 23 July 2021 includes changes resulting from:

(a) agreements reflected in the Rehabilitation Joint Witness Statement dated 19 June 2018 (Rehabilitation JWS); and

(b) success of monitoring practices at Globe-Progress Mine as it nears rehabilitation closure; one of very few large mines in native ecosystems to be reaching closure.

20 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. This evidence has been prepared in accordance with it and I agree to comply with it. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

PROJECT OVERVIEW

21 The project is described in Ms Brewster's evidence, with her Figure 2 providing an indicative overview of the project.

22 The maximum area of disturbance allows some flexibility. Flexibility is required in all mining operations to both optimise resource extraction and rehabilitation outcomes. Poor rehabilitation outcomes occur when mine footprints are severely constrained as slopes of overburden are typically over-steepened. The actual footprint should be smaller, in part because not all the area within the footprint is to be cleared. A key rehabilitation priority has been to ensure opportunities to minimise the footprint and ecological impacts within the consented area are prioritised, identified and actioned throughout the road construction and mining process. For example, high value ecosystems have been mapped so 'moveable' components of mining, such as soil stockpiles, can be placed on lowest-value ecosystems and/or ecosystems with best rehabilitation outcomes.

23 An access road will run from a coal load-out site situated on KiwiRail land at Te Kuha, near the Buller River to the mine site, about 9 km. The average footprint width of the mine access road used in the calculations is 35 m; this includes a typical road

running width of 7 m, i.e. a single truck lane, but with passing bays allowing two trucks to pass about every kilometre. The footprint width considers water tables, bunds and the area required for cuts and fills. Soil and overburden stockpiles will also be located along the road and are additional to the 35 m.

24 The mine is planned to produce coal over a 16-year period with some rehabilitation carried out progressively during these 16 years. Most of the rehabilitation occurs once the mining void is backfilled to near-original topography. This is planned to be two years after completion of coal extraction. At this stage, the road will be rehabilitated from a ~7 m running width to a ~3 m running width to enable light vehicle access to allow maintenance. A 10-year period is anticipated to complete rehabilitation to the specified 'closure' condition. When the following agreed period of weed and pest control is completed, Department of Conservation staff have indicated they want the remaining running width of the road to be rehabilitated and access to the site removed. This could be achieved by removing one or more of the bridges.

Use of Overburden, Soil and Rehabilitation Materials

25 The mine planning includes salvage of all soil and vegetation. This is a critical part of the operation since these materials underpin successful rehabilitation. These materials will either be immediately reused (where achievable, which avoids costs of double-handling and gains benefits from enhanced soil quality) or stockpiled for future use.

26 Any overburden removed during pit development will be placed in Engineered Landforms (ELFs), either as temporary storage (to be re-handled later to backfill the mine void) or to form a final ELF.

27 The strategy for the construction of the ELFs has considered the following factors:

(a) physical delimiting of ELF boundaries to minimise their footprint and edge effects on adjacent undisturbed ecosystems;

(b) building from 'edges or outside in' to allow early rehabilitation of lower slopes to quickly re-establish clean water features;

(c) placement of overburden from the Paparoa pit at the base and in a layer over the outer 3 m of all ELFs due to its non-acid forming properties (as detailed in evidence of Dr James Pope);

(d) placement of overburden back into the Paparoa pit to reinstate the ridgeline as early as possible;

(e) ongoing establishment of final and temporary rehabilitation slopes and reduction in disturbance footprint;

(f) minimising the quantity of overburden and soils that are rehandled (shifted twice);

(g) using the original topography as a guide for the final landform, approximately following the ridgeline profile (as detailed in evidence of Peter Rough); and

(h) using an overburden bulking factor[9] of 20%.

28 The mine plan identifies three ex-pit ELFs. The progression of the ELF schedule follows the progression of mining in both pits (and is shown in Figures 6 –10 of Ms Brewster's evidence). The ELF east and adjacent to the first mining area in the Brunner pit is the main ELF. A portion of this ELF is used as the Run of Mine (ROM) pad after the first two years of mining. This location reduces the overall mine footprint.

29 Soil will be stockpiled in up to three different areas within the mine footprint until used in rehabilitation. Some rehabilitation will occur each year and follow the progression of mining. Some of this rehabilitation will be temporary; such areas are removed at the end of coal extraction (and used for rehabilitation of final surfaces). Overburden will be rehandled to infill the final void to bury high walls and create the designed ridgeline.

30 I understand the landscape setting to be as described in Peter Rough's evidence, and for the purposes of my evidence I adopt his description.

[9] The percentage of the volume change of an excavated material compared to its original 'undisturbed', *in situ* volume

METHODS TO MINIMISE THE TE KUHA FOOTPRINT AND IMPACTS WITHIN THE FOOTPRINT

31 The mine and road rehabilitation objectives for Te Kuha, and Rehabilitation Management Plan prioritises avoidance of impacts. However, by its nature, coal mining must occur where the resource is present, so it is not possible to avoid removing ecosystems that overlie coal that is extracted, or additional areas where overburden from the initial cut must be placed. The following are examples of where the design of the Te Kuha project has avoided impacts to date.

32 Avoidance along the access road. This has focused on minimising the road footprint by:

(a) designing a single lane haul road with passing lanes (not continuous double lanes);

(b) avoiding side-casting; instead the road will be built up from a retained base to confine the road footprint;

(c) preferring cut batters over fill batters, subject to consistency with landscaping and geotechnical objectives. This reduces the cleared width because cut batters are stable at steeper angles than fill slopes;

(d) avoiding high-value individual trees and ecosystems by moving the road within the specified road corridor;

(e) using bridges rather than culverts to reduce footprint and impacts to sensitive waterways. Bridges can also enhance connectivity of ecosystems;

(f) prioritising use of direct transfer sods onto all road batter fill slopes for rehabilitation, helping reduce potential for erosion and sedimentation (for example, **Appendix 1**, photo 37); and

(g) creating large stockpiles of soils, vegetation and overburden stripped from the road on farmland, not in native forest. This reduces areas for stockpiles in forested areas but increases costs due to longer haulage distance.

33 Within the mine site, some originally-planned adverse effects have been avoided by the following actions:

(a) locating ex-pit overburden dumps on less sensitive ecosystems, in particular, covering the ephemeral pond to retain yellow-silver-pine vegetation associations;

(b) locating mine infrastructure either at the base of the hill within farmland, or within the ex-pit landform, not on native ecosystems;

(c) reducing the area of ex-pit soil stockpiles by increasing depth of soil stockpiles from 2 to 4 m; these may be increased to at least 10 m and even higher if site topography, soils and access is favourable;

(d) reducing the footprint of ex-pit overburden by building-up from the base in short lifts (each ~2 m height as described by Dr James Pope), rather than unconfined end-tipping;

(e) minimising edge effects on ‘buffers’. Buffers are areas adjacent to cleared areas that can be vulnerable to degradation by sediment, and/or increased wind and light exposure (decreased humidity), changed hydrology and pest plants. The Rehabilitation management plan (MP) and Construction MP are required to reduce edge effects (Conditions 48(b) and 49 (d) (f) respectively);

(f) reducing the area impacted by cut-off drains and ex-pit roads to water infrastructure by removing stripped material not required for safety-windrows to stockpiles or rehabilitation areas; and

KEY FEATURES OF TE KUHA WHICH UNDERPIN REHABILITATION OUTCOMES

34 In this section I identify the key features of the Te Kuha site, mine plan and mining process that underpin the planned rehabilitation objectives and rehabilitation methods. I also describe how these compare with other mines. My experience with rehabilitation of other mines and other projects has informed my assessment of

the rehabilitation outcomes that can be practically achieved at Te Kuha. However, not all examples from other sites are applicable to Te Kuha because site characteristics, rehabilitation objectives, and project constraints vary.

35 The proposed rehabilitation at Te Kuha has eight key features, and I will consider each in turn:

(a) there are a high proportion of natural (pre-mining) slopes of less than 18 degrees and small areas of rockfield or sandstone pavement.

(b) there is adequate space to store all stripped soil and much of the wood and weathered boulders.

(c) the mine plan provides for rehabilitation using ‘direct transfer’.

(d) the mine plan is generally sequential, so rehabilitation is less likely to be delayed.

(e) the mine plan provides for substantial areas of early rehabilitation that will be used to inform the later (bulk) rehabilitation.

(f) very few non-native plants and potential weeds are currently present.

(g) rehabilitated landforms are designed to meet adjacent land levels along all site boundaries.

(h) potentially Acid Forming (PAF) rock is managed.

There are a high proportion of natural slopes of less than 18 degrees and small areas of rockfield or sandstone pavement

36 This means about 75% of vegetation and soils can be salvaged as high-quality materials, i.e. by excavators with minimal soil structural breakdown. This contrasts with many other sites, including some where coal measures are present. For example, in areas of Mt William North and Millerton previous underground mining activity and burning areas compromised soil salvage due to unstable, unsafe ground.

There is adequate space to store all stripped soil and much of the wood and weathered boulders

37 Adequate depth, volume and quality of soil underpin successful revegetation and plant growth. About 14 ha are available to store materials from the initial 84 ha cleared; a further 3.4 ha are available in years 4 and 5 if needed. This means, all rehabilitated areas (except road cut batters and road surface) can be covered with suitable soil quality and depth to supports the anticipated growth rates of native plants.

38 An indicative soil budget is presented in **Table 1**.[10] It is indicative because soil volumes striped each year will change depending on the Annual Work Plan. Storing enough soil to cover rehabilitated areas means stockpiles cover areas of native vegetation that would otherwise not need to be impacted. However, I consider this is a necessary trade-off as inadequate volume and/or quality of soil and root zones is the most common reason for poor rehabilitation outcomes across all mines in New Zealand (Simcock and Ross 2017, Appendix 2). The Annual Work Plan Condition 63(a) requires soil volumes to be reported annually and 63(b) requires estimates of soil and root zone materials potentially available for use in rehabilitation to be recorded, while (f) requires reporting of deficits in root zone. This information allows Council to ensure adequate rehabilitation resources are available to rehabilitate the site by early identification of soil resource deficits (most commonly due to over-thickening in initial rehabilitation). Response actions can include separation of suitable overburden materials and their amendment with organic matter.

39 Condition 48(c) also requires the Construction Management Plan to ensure conservation of overburden, suitable soils/root zone materials, vegetation, wood, and rocks, for subsequent use for backfilling and rehabilitation.

[10] This budget will be updated as the mine plan is updated. It was based on a smaller mine footprint that did not include soil stripped from under all the topsoil storage areas or water treatment area.

Table 1. Indicative topsoil stockpile schedule (2016[11]). Note more soil appears to be used than stripped due to cover and salvage of temporary rehabilitated areas.

Year	Soil stripped (m^3)	Soil used for rehabilitation at mine site (m^3)	Available stockpile area (ha)
1	334,100	0	14.4
2	11,200	47,000	14.4
3	34,700	17,300	14.4
4	12,400	15,600	14.4
5	12,000	22,800	12.6
6	0	11,040	12.6
7	17,500	18,000	12.6
8	4,500	23,900	12.6
9	6,900	8,700	12.6
10	3,400	17,800	12.6
11	0	3,200	12.6
12	0	16,700	12.6
13	0	3,200	12.6
14	0	18,600	12.6
15	0	0	12.6
16*	0	32,500	12.6
17*	0	17,000	12.6
18*	0	118.800	4.9
19*	0	112.000	0
Total	436,700	504,000*	14.4

The mine plan provides for rehabilitation using 'direct transfer'

40 The mine plan allows a relatively small, but ecologically significant, area of 'direct transfer' to rehabilitate mined areas (**Table 2** and **Appendix 1 photo 20**). Direct transfer is recognised as a high-quality, cost-effective method of rehabilitation on accessible landforms. It has been used at coal and gold mines in native ecosystems in the Westland region over the last 5 to 29

[11] Adapted from Mitchell Partnerships 2015. Appendix 11 of Te Kuha AEE and updated using 21 February 2016 mine plan schedule (V9, T. Rock).

years.[12] High quality outcomes at Stockton Mine have occurred with techniques developed from the late 2000s.[13]

41 Condition 51(a) requires a minimum 15 ha to be rehabilitated as direct transfer. This must include at least 1 ha of yellow-silver pine shrubland and at least 500 m^2 of herbfield. The Condition also requires the consent holder to maximise the amount of vegetation direct transfer as much as reasonably practicable.

42 Condition 62 requires an Annual Work Plan to be submitted to Councils that includes 63 (a) an estimate of the area and type of direct transfer completed or in storage and 63 (b) a description of rehabilitation, including the amount of direct transfer planned.

43 Condition 68 requires submission of an Annual Environmental Monitoring Report. Condition 69 (b) requires this to report areas of direct transfer by vegetation type. This allows progress in meeting the minimum areas of direct transfer criteria to be assessed.

44 The minimum required area of direct transfer is a relatively small proportion of the site, but ecologically significant in terms of the area (15 ha of 105 ha footprint which excludes the edge buffers as these are not stripped, and the road) and value it provides in conserving genetic resources (especially herbfield, rockfield and yellow-silver pine species), conserving invertebrates and buffering adjacent undisturbed habitat from edge effects (especially along roads).

[12] The first direct transfer was at Giles Creek coal mine in 1992 of beech forest root plates and saplings

[13] For example (1) Appendix 2 (section on direct transfer) and (2) Cavanagh et al (2018) Mine Environment Life-cycle Guide: coal mines www.cmer.nz/publications/2018

Table 2: Indicative area stripped in each year that is suitable for salvage and re-use as Direct Transfer, excluding access road and coal handling area. Rounded to 1 decimal place. Brackets indicate area stripped but not able to be used as direct transfer as suitable rehabilitation areas on which to place it are not available. DT = Direct transfer, ys = yellow-silver

Year Mine stage	Area stripped (ha) TOTAL	Physically Suitable for DT	Possible DT y-s pine – mānuka scrub	Possible DT beech/ys & pink pine
1	79.8#	65.6	(10)	(41.5)
2	2.8	2.5	1.1	0.8
3	8.7	6.6	0	6.5
4	3.1	3.1	0.2	2.8
5	3	1.6	0.4	1.1
6	0	0	0	0
7	4.4	2.7	0.6	1.8
8	1.1	0.8	0	0.8
9	1.7	0.5	0.05	0.4
10	0.8	0.4**	0.01	0.4
11	Stripping complete			
TOTAL	105*	18.2	1.4	14.3**

This area could potentially be reduced by 3–6 ha by delaying stripping of this area until year 2 and/or reducing northern topsoil stockpile area (Tracey Rock 2018 pers. comm.) but mine planners prefer flexibility of having the larger footprint until more site data from on-site stripping and stockpiling operations is available
* Total area stripped now includes buffers and road so is larger, but buffers are not stripped, and the road fill batters are likely to receive a high proportion of direct transfer
** total takes account of rounding

The mine plan is generally sequential, so rehabilitation is less likely to be delayed

45 The sequential mine plan starts at the south-western end of the site and works its way towards the north and east. The Brunner and Paparoa pits overlap, and this, together with the mine schedule helps ensure rehabilitation areas are available throughout mine life for rehabilitation with the exception of year 6 (**Table 2**). Condition 54 requires progressive rehabilitation as

areas of practical working size become available. However, the requirement to backfill the pit (to reinstate an approximately similar ridgeline topography, Condition 50 (a), means large areas cannot be rehabilitated until all mining is completed.

46 The sequential approach is an advantage over sites like Stockton, where many pits with varying coal qualities are open concurrently, constraining release of land for rehabilitation.

The mine plan provides for substantial areas of early, monitored rehabilitation that will inform the later (bulk) rehabilitation.

47 The mine plan provides for 16 ha of rehabilitation in years 2 and 3. Monitoring the performance of this area over the following 10–15 years will inform fine-tuning of rehabilitation methods and costings for use in the c. 70 ha of revegetation scheduled for years 16–19. Measuring baseline conditions at the time of revegetation is required in Condition 31 (b) which is the Closure Condition Table. Installing replicated trials in this 16-ha area is provided for by Condition 51 (f), with reporting of results required by Condition 69 (b) (c) and (d) (Environmental Monitoring Plan and Report) and linked to both 31 (b) and Condition 60 (Mine Closure Plan). The mine plan also includes up to 3.4 ha of temporary rehabilitation in years 4 and 5 (if the area is not used for stockpiling soil, rock, or wood) that is retained until year 16. This 10- to 11-year period is long enough for plants and seeding material to reach a condition at which they are valuable for use as rehabilitation materials in years 15 and 16, e.g. for brush-layering/seeding or transplanting.

48 The value of these trials and especially of the monitoring practices has been demonstrated at the Globe Progress Mine at Reefton for native vegetation, and at Macraes and Waihi Mines for rehabilitated pasture. At Globe Progress and parts of Stockton, networks of 100-m^2 permanent plots were established, with new plots in each new area and year of rehabilitation. While small-scale trials at the beginning of a large mining project are common, few mines undertake ongoing monitoring of representative rehabilitated areas unless it is a condition of consent. However, the value of such monitored plots increases over time and is

particularly useful for regulatory agencies and miners as sites near closure. Hence, for Te Kuha, measuring baseline conditions at the time of revegetation is required in Condition 31 (b).

Very few non-native plants and potential weeds are present.

49 Unlike Stockton and Denniston, very few non-native plants and potential weeds are present on the Te Kuha mine site with non-native plants are concentrated in the ephemeral pond and near an old field hut. In contrast, there is a range of common pasture and woody weeds on the farmland at the bottom of the proposed access road, including at the load-out site. Biosecurity practices that create an effective barrier to weed spread between the two areas is therefore a priority (and described in the Rehabilitation Management Plan). The lack of weeds at the mine site, combined with adequate strippable soil cover, creates conditions that favour natural regeneration of native plants. The density (numbers) of native seedlings is likely to naturally increase rapidly within 6–12 years based on records at parts of Strongman Mine[14], Stockton Mine, Globe Progress Mine and Wangaloa Mine in places where cover of pasture grasses and legumes is low.

50 These four mine sites also have some areas where non-native groundcover plants have been deliberately introduced to rapidly stabilise steep or erosive areas. In some of these areas pasture grasses and/or legumes have formed dense groundcover that supresses regeneration until a native canopy cover is present. The use of pasture grasses and legumes is not planned for Te Kuha.

51 Natural regeneration of native seedlings and increase in plant cover enhances erosion resistance (**Appendix 1**, photos 10, 14, and 15). In most cases the majority of these adventive seedlings are sourced from precocious planted species (Hebes/Veronicas, Ozothamnus, Olearias and mānuka (*Leptospermum scoparium*)). Where a canopy is present, native bird-dispersed plants regenerate. Native wind-dispersed plants can also establish in high densities once ground conditions are favourable. Such

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[14] For example, at Strongman Mine, 17 areas were planted at an average density of 4700 seedlings/ha between 2005 and 2009; by 2012 to 2015 more than 11,400 seedlings/ha over 10 cm tall were present on average.

conditions are created in areas rehabilitated to forest by spreading logs, stumps, and ‘slash’ to create microsites for ferns (required to be specifically conserved by Condition 48 (c)) with volumes required to be recorded by Condition 63 (a) (b) and managed to maximise their use in rehabilitation by Condition 50 (e). Natural regeneration is expected to be a widespread and dominant process at Te Kuha where there are bare soils, due to the narrow shape of the site meaning intact native ecosystems are close, and favourable soils/microsite conditions will be created using replaced soils.

Rehabilitated landforms are designed to meet adjacent land levels along all site boundaries

52 The mine plan allows for the rehabilitated landforms to meet natural land levels along all site boundaries This is underpins the re-establishment of connectivity with adjacent unmined ecosystems and minimisation of visual impacts (e.g., **Appendix 1**, photos 37 and 38). Several Conditions are relevant: 50 (a) requires reinstatement of the ridgeline profile; 50 (c) requires integration with surrounding existing topography; 50 requires rehabilitation at Te Kuha to be consistent with the Rehabilitation Concept Plan and rehabilitation plan; and, Condition 50 (h) specifies no permanent high walls or pit lakes.

53 The extent to which rehabilitated landforms are designed to meet natural landforms at Te Kuha contrasts with the conventional approach of retaining areas of highwall, or flooded pits. The conventional approach reduces costs of backfill and can enable earlier rehabilitation, as external overburden does not need to be rehandled back into the pit but has much higher landscape impacts.

54 Backfilling and contouring to meet natural ground levels also helps minimise edge effects, particularly for tall forest. It is probably less important for low-stature ecosystems, where edge effects are most effectively managed using direct transfer (**Appendix 1** photo 23) where creating landforms that meeting natural ground. Management of edge effects is addressed in Te Kuha Biodiversity MP (particularly 174 for birds, 179 for

bryophytes, 186 for forest ringlet butterfly) and Condition 49 (d) (boundary marking).

Potentially Acid Forming (PAF) rock is managed

55 Dr Pope's evidence explains key aspects of the Overburden Management Plan that ensure Potentially Acid Forming (PAF) rock is highly unlikely to adversely influence any rehabilitated root zone. The Construction MP, Condition 49 (b) requires PAF management as does the Overburden Management Plan required by Consent Condition 131 (RC-2016-0098-05), which provides for PAF and Non-Acid Forming rocks to be classified, separately handled, and placed to minimise impacts of acidic drainage (**Figure 1**) and specifies a monitoring programme to confirm the efficacy of the methods used. Condition 69 (d) requires the Annual Environmental Monitoring Plan to include a comparison of actual and predicted results. Dr Pope's evidence also identifies that Te Kuha has a surplus of Non-Acid Forming (NAF) rock.

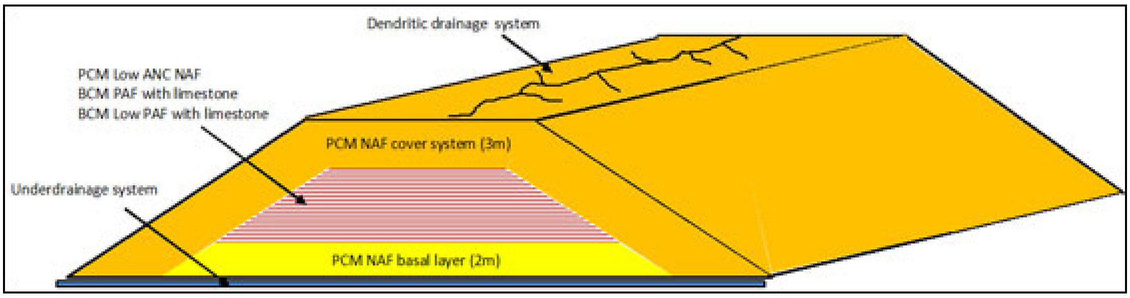

Figure 1. Schematic of ELF with subsurface drain showing 3-m Paparoa coal measures (NAF) cover system planned for Te Kuha.

REHABILITATION AND RESTORATION

56 Before discussing the rehabilitation objectives and the various methods required by the conditions to meet the objectives and outcomes, this section of my evidence discusses the general approach to rehabilitation I have used in my recommendations to Stevenson, and as the basis for the methods to be adopted at Te Kuha.

57 The Society for Ecological Restoration's (SER) definition of 'ecological restoration' is 'the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed'.[15] All the experts at the Rehabilitation expert conferencing (JWS 19 June 2018) agree that rehabilitation is not intended to restore vegetation, ecosystems, or landscape to their pre-mining condition. Fundamentally, rehabilitation re-establishes a recovered (healthy, functioning) condition, whereas restoration re-establishes a former condition.

58 Having said that, my approach to rehabilitation has been to develop methods to re-establish ecosystems that are as close as practical to those currently existing at Te Kuha. Ecologists at the Rehabilitation JWS, generally agree that the methods of rehabilitation proposed are appropriate for use at the site. We also agreed on the prioritisation of these methods based on efficacy/outcomes, specifically, prioritising direct transfer. However, Dr Lloyd and I disagree on:

a) the degree to which rehabilitated ecosystems will be resemble existing ecosystems; and

b) the value of using existing rehabilitated areas at other mine sites as guides to medium-term rehabilitation outcomes at Te Kuha.

I address both these differences later in my evidence.

59 The capacity to rehabilitate native ecosystems to their pre-mining state is necessarily limited for ecosystems that take many decades or centuries to develop, for example, some trees are hundreds of years old, and some soils are thousands of years old. Rehabilitated ecosystems will not be the same as before mining, nor distributed in the same fine-grained mosaic across the landscape. However, I expect rehabilitation at Te Kuha as provided for by the consent conditions to re-establish the following elements of the current environment:

[15] See the Rehabilitation JWS Section 10 page 16.

(a) rockfield and shrublands on gently sloping and higher areas, and forests on steeper slopes and lower areas, as shown in the Rehabilitation Concept Plan;

(b) the majority of locally occurring native plant species (i.e. a subset of the Ngakawau Ecological District);

(c) a subset of the types of ecosystems which are present prior to mining;[16]

(d) a wide range of the native fauna that are present in adjacent areas, including roroa, lizards, forest ringlet butterflies, and large, slow-moving native invertebrates; and

(e) successional processes that require minimal human input post closure and are as resilient to fire, weeds, and pests as adjacent areas.

60 Some vegetation associations and ecosystems at Te Kuha will not be targeted for rehabilitation. These include the large boulder /beech tree association with distinctive bryophyte curtains because the trees that create the sheltered, humid conditions are probably hundreds of years old). Bluffs over ~3–4-m height will not be re-established because they would need to be made geotechnically stable to be safe. Likewise, most backfill slopes over ~28º are geotechnically unstable.

61 Some vegetation associations and ecosystems at Te Kuha will be greatly reduced in area. The area of herbfield and area of pink and yellow-silver pine vegetation will be reduced because the mine schedule does not allow for direct transfer to be used extensively, and this is the only effective method by which they can be rehabilitated with high certainty of success within the required timeframe for closure (~10 years from the last revegetation), given limited nursery experience growing large numbers of the native pine species as nursery seedlings. Therefore I do not consider planting can be used to re-establish large areas of these associations.

[16] Tall forests take centuries to develop; yellow-silver pine, pink pine and bog pine will be in lower abundance as they are largely restricted to areas rehabilitated using direct transfer.

REHABILITATION OBJECTIVES AND OUTCOMES – DEFINING SUCCESS

62 This part of my evidence identifies the rehabilitation objectives for the Te Kuha site, and how success is proposed to be measured in the short term, at mine closure. Closure has been targeted for 10 years after completion of initial vegetation treatment (planting or direct transfer) at the mine site, and after 5 years for the haul road.[17]

63 In my opinion, it is important that there are clear objectives for rehabilitation, that they are set out in the conditions, and monitored. This provides clarity against which success can be assessed and focuses the rehabilitation management plan. Rehabilitation objectives are set out in Condition 50. These are based on the eight key characteristics described earlier (para 35) and my experience with rehabilitation at other mine sites.

64 The proposed Te Kuha rehabilitation has three overall priority outcomes.[18]

(a) achieve a high certainty of low visual effects so the site integrates visually with surrounding vegetation (i.e. achieves the designed landscape outcome);

(b) create stable, erosion-resistant surfaces, with a soil cover and root zone that favours seed germination, plant establishment, and sustained ecosystem development (i.e. water quality outcomes); and

(c) deliver a set of specific ecological objectives.

I now describe each of these three primary outcomes in more detail.

Achieve a high certainty of low visual effects so the site integrates visually with surrounding vegetation

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[17] The Draft Te Kuha Mine Rehabilitation Management Plan, section 2.1 and 2.2 specifies the goals and objectives.
[18] Condition 50 sets out 12 separate objectives within these 3 outcomes,

65 This outcome is generally underpinned by the contour of rehabilitated landforms covered by a coarse mosaic of designed native ecosystems present at closure that will continue to develop over time. The rehabilitation methods to achieve this outcome are illustrated in the overall Rehabilitation Concept Plan (**Appendix 1**). The objectives set out in conditions 50(a), (c), (f), and (g) support this overall outcome, together with condition 49 (e) (Construction management for the road) and condition 61 (d) (Mine Closure Plan).

Create stable, erosion–resistant surfaces

66 This outcome is designed to protect surface waterways from sediment and limit soil loss from erosion so soils remain on site to underpin plant regeneration and growth. At Te Kuha most existing soils are accessible for stripping. Combined with sufficient stockpile areas, this means enough soil will be available to cover all rehabilitated fill areas at the mine site.[19] This contrasts with other mines on coal measures, which have soil deficits. Specific objectives in conditions 50 (d) and 50 (e) support this overall outcome.

Deliver a set of specific ecological objectives

67 The third priority outcome for rehabilitation is to deliver the following five ecological objectives:

(a) footprint minimisation and reducing edge effects (Condition 50 (g) supported by Construction Management Plan conditions 49 (f) and 48 (a));

(b) establishing self-sustaining native vegetation that is likely to develop into a mosaic of vegetation associations that are 'no more vulnerable than at present' to pest plants (weeds), pest animals (deer, goats and hares), drought and fire[20]. (Conditions 49 (i), 50 (h) (i) (k));

[19] Note that most of the running surface of the access road is not proposed to be rehabilitated with soils when the road is downsized and then closed; instead, the surface will be decompacted and roughened as has been successful at other sites.

[20] Specific wording in 'quotes' agreed in in JWS Rehabilitation p7

(c) conserving genetic resources, particularly those of threatened or at-risk plant and animal species, within the footprint (largely by using direct transfer to establish sites where these species can maintain dominance) and outside the footprint, through effective buffering of undisturbed habitat, provision of connectivity, and pest plant and animal control (Conditions 50 (e), 51 (j) and (l));

(d) providing for habitat favourable for recolonization and reintroduction of species listed in the Te Kuha Biodiversity Management Plan (Conditions 50 (b), 50 (e), and 50 (l)); and

(e) creating permanent and ephemeral pond habitats, (Condition 51 (b), specifically 'a minimum of 50m^2 of permanent pond habitat and 600 m^2 of ephemeral pond habitat, both of which are designed to benefit indigenous fauna'.[21]

68 The methods required by the conditions to achieve these three priority outcomes are discussed later in my evidence.

69 I consider details about conservation of genetic resources are best addressed in the Rehabilitation Management Plan and the Te Kuha Biodiversity Management Plan. Both plans are to be finalised in consultation with the Buller District Council and the Department of Conservation and must be certified by the Buller District Council. Condition 51(d) requires the management plan to set out "How the rehabilitation objectives set out in Condition 50 are to be achieved". Attached to this rebuttal evidence is a draft Rehabilitation Management Plan dated May 2018 which was attached to my 2018 evidence in chief.

CLOSURE CRITERIA FOR TERRESTRIAL REHABILITATION

70 Short term measures of success at closure identify whether or not rehabilitated areas are on the right trajectory to meet the

[21] As agreed at JWS Rehabilitation p8

objectives in condition 50 because it takes many decades to centuries to develop shrubland and forest height that deliver ecosystem structure (layers) and soil organic layers. These short-term measures are proposed as closure criteria (**Appendix One**, which is Condition 32, Table 1 and notes) and must be met before the bond is released. While rehabilitation is an ongoing requirement[22] which means some areas of the mine could be 'closed' before others, I have developed rehabilitation methods that should meet these closure criteria across the footprint within 10 years of the initial revegetation treatment (e.g. direct transfer, planting seedlings, regeneration). At that point, the closure criteria represent the conditions under which rehabilitated areas are highly likely to continue to develop naturally through succession into more complex native ecosystems with minimal human intervention (i.e. minimal maintenance as pest control and weed control).

71 The closure criteria (**Appendix One**) build on ones developed for, and approved by, the Courts in the Cypress, Escarpment, and Mount William North mines, all of which include a range of coal measure ecosystems. The proposed Te Kuha criteria do not include Cypress Mine's 'tussock wetland' ecosystem because these ecosystems are not at Te Kuha. While 'boulder fields' of Escarpment Mine are present at Te Kuha, a different rehabilitation method is proposed, not overburden with boulders up to 30 cm diameter. Hence 'boulderfield' is replaced by 'Rockfield' rehabilitation at Te Kuha,

72 The closure criteria in **Appendix One** also reflect experience with direct transfer of a range of ecosystems at Stockton Mines since 1998, including shrublands and felled forest in 1997–1998 and small-scale hand- transfer of herbfield and rockfield plants in 2001, followed by hectares-scale transfer from Mt Augustus and adjacent ridgeline from 2007 through to 2012, and a trial transferring boulders in 2011. For example, the closure criteria for 'rockfield' (**Appendix One**), has a requirement to have no more that 10% of fines with a diameter of less than 10 mm and 200 mm depth. This specification results directly from monitored outcomes

[22] Condition 54

of the 2011 boulder trial, and is intended to create a surface that is highly resistant to plant establishment (an issue of concern to Dr Lloyd and Dr Marshall[23]).

73 Likewise, the inclusion of a maximum contiguous rock area for rockfield in closure criteria (**Appendix One**) is designed to deliver habitat connectivity (as extensive areas of rock are barriers for some species) and a mosaic that underpins visual and ecological outcomes. Forest criteria include a minimum density and height of species that are long-lived trees (not used at Stockton) and require the presence of 'adventive seedlings'. The latter has been proposed for Globe Progress Mine near Reefton as a key indicator of sustainable ecological processes.

74 The inclusion of 'no visible flowering or seeding weeds' closure criteria (**Appendix One**) is adopted from Escarpment Mine. This criterion incentivises sub-annual, 'rapid-response' weed control that aims to prevent weed-seed banks. Note (i) of the closure criteria Table (**Appendix One**) requires monitoring to be during the growing season, November to March, which is when many native plants and weed species flower. The details of management to achieve the criterion must be addressed in the Te Kuha Rehabilitation Management Plan (Condition 51).

75 Weed management builds on practices at other mines. The Escarpment Mine closure criteria condition is to 'minimise the potential for weed problems (e.g., gorse, exotic broom, Himalayan honeysuckle, blackberry, montbretia, pampas grass, *Juncus squarrosus*) and pests to invade the site and otherwise to eradicate or control weeds and pests'. Defining what is considered a weed (also called a 'pest plant') is important. Most non-native grasses are not considered weeds at Escarpment (pampas is an exception) and no non-vascular plants are noted.

76 Weed species and adverse impacts to be avoided need to be identified alongside rehabilitation objectives to provide certainty that weeds that are not predicted at the time of consent are identified and controlled. For example, at Strongman Mine, a single acacia, silver birch, and tiger lily patch were identified over

[23] JWS Rehabilitation p7

6 years of rehabilitation monitoring and removed. Although gorse, broom, and *Juncus squarrosus* have heavy seeds, are not dispersed by wind or birds, and are not present at Te Kuha, they will be included as weeds to ensure specific risk management practices to avoid their establishment at Te Kuha. I also consider Hydrangea (found at the load-out) should be included as a weed along with most fleabanes and fireweeds, but not small herbs often linked with nursery plants such as *Segina procumbens, Epilobium ciliatum,* and *Euphorbia peplus*. The definition of weeds for the Te Kuha site will be finalised in the Rehabilitation Management Plan.

CONCERNS RAISED ABOUT CLOSURE CRITERIA

77 Section 7 of the Rehabilitation JWS[24] sets out four concerns about the closure criteria raised by Dr Lloyd. I will address each of these in turn.

“Poor capture of vegetation structure and composition”

78 Dr Lloyd would like a condition added ‘to say that, for example, herbfield has to retain a low-growing structure dominated by specific species, and that shrubland and forest could include criteria relating to height categories… knowing what tree species are present is important…’ (JWS section 8, p. 15).

79 I think this is unnecessary detail, but I have added a height (in m) as a descriptor in the first column ‘Vegetation/ecosystem height’ of the **Closure Table (Appendix One)**, and added comments on structure to the ‘Rationale’ column where they were absent. For example, under ‘herbfield‘,’<0.3 m’ has been added along with a new sentence ’Low-growing herbfield species must be dominant’. In ‘forests’ >5 m height potential’ has been added to the ‘vegetation/ecosystem type’ column, reinforcing the sentence in the ‘Rationale’ column that ‘forests are expected to be >5 m height in medium to long term’. Note (ii) now includes a direction to classify seedlings to <1, 1–2 and > 2 m height.

“the standards not capturing important plant species”

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[24] Page 15

80 As noted in the second bullet point in section 7 of the Rehabilitation JWS I agree it is helpful to identify the important plant species in the table. These may not be dominant species by cover or number at closure. The **Closure Table (Appendix One)** has a new column headed 'key vegetation species'. I am confident these species can be present, as nearly all have been successfully shifted by machine or hand direct transfer. An exception is *Metrosideros parkinsonii*. Although this has been successfully propagated over several years in the Bathurst nursery, and some of these plants reintroduced to rehabilitated areas at Stockton with some encouraging results, only small numbers of plants have been established and only relatively recently (Dr Bramley pers. comm.). The 'Forest' vegetation contains a minimum density of 1000 seedlings of specified native trees per hectare (10 per /100-m^2 plot) (**Closure Table Appendix One)**. A separate provision in the Biodiversity Management Plan addresses plant species that are very uncommon at Te Kuha such as *Microsame montana* and *Celmisia similis* (Dr Bramley's evidence). The Biodiversity Management Plan also addresses *Lepidothamnus intermedius, L. laxifolius,* and yellow pine (*Halocarpus biformis*). These are very successfully rehabilitated using direct transfer when less than ~0.5 m tall. However, there is very little experience in establishing this species using nursery-grown seedlings at scale.

"the monitoring plot sizes being too small"

81 I do not agree that the plots are too small, especially given the height of vegetation at closure and the high spatial variation typical of mine sites, and which is specifically targeted at this site to create a mosaic of ecosystems. The combination of short vegetation and high variation means it is useful to have a higher number of 100-m^2 plots. Both Stockton and Globe Progress mines used 100-m^2 monitoring plots in planted shrubland and forest. Stockton has also used 25-m^2 and 9-m^2 plots in direct transfer shrubland and down to 1m^2 plots along transects in herbfield and tussock vegetation, reflecting the greater time required to monitor these more species-diverse and variable vegetation types. However, I agree that a greater consistency of sizes will better

allow comparison of results across the site. Hence, I have increased the plot sizes for rockfield and shrubland to be the same as forest, i.e. 100-m^2 in the **Closure Table (Appendix One).** However, 'Herbfield' plots remain 1-m^2 ,to reflect the small stature and high diversity of this rehabilitation, which is only rehabilitated using direct transfer.

"monitoring in winter" won't reveal flowering plants

82 Monitoring of rehabilitation is not usually done in winter because some plants, especially in herbfields, are difficult to identify without their flowers, orchids are absent, and short daylight hours make monitoring inefficient and miserable. However, for clarity, Table note (i) of the **Closure Table (Appendix One)** has been amended to specify that vegetation measurements should be made during the plant growing season, between November and March.

RECENT CHANGES TO REHABILITATION CLOSURE CRITERIA

83 In addition to the changes noted above and recorded in section 8 of the JWS Rehabilitation, further changes to the closure criteria have been made since the version discussed in the June 2018 conferencing. I recommended these to further strengthen and clarify the criteria.

84 Condition 31 (b), the introduction to the **Closure Table,** (**Appendix One**) has been amended by adding "maintained for a period of five years or earlier, if monitoring data provides confidence that rehabilitation trajectories are highly likely to deliver the closure criteria". This has been added following my assessment of Globe Progress rehabilitation in 2020/21 noting the high value placed by mining companies on early closure, which has increased investment in rehabilitation trials and analysis of monitoring data.

85 In addition to specifying the time of year for vegetation monitoring, note (i) of the **Closure Table** (**Appendix One**) now also specifies the minimum number of monitoring plots based on vegetation type and area rehabilitated, and the requirement to install these within 12 months of revegetation. This is to ensure an adequate number

and representative coverage of plots, while considering a reduced intensity as rehabilitation areas increases.

86 Note (i) also further clarifies areas that should not be included in monitored areas. This takes account of the planned use of habitat wood piles that could cover most of a 100-m^2 plot in rehabilitated forest areas, and allows for potential agreed infrastructure (e.g. roads) to be retained. It also specifically excludes cut rock faces (e.g. road cuts) as these are not covered by the vegetation/ecosystem types.

87 'Small ponds' have been added to the **Closure Table** (**Appendix One**). This has been added to ensure these are included and considered alongside other rehabilitation types however, as with herbfield, these ecosystems will cover less than 0.1% of the >100-ha mine site.

Additional change suggested by Dr Lloyd

88 While not discussed at the rehabilitation conference in June 2018, Dr Lloyd's evidence from May 2018 suggested an additional change to the closure criteria. He suggests[25] sapling or tree size distribution or total basal area is measured. The closure criteria (**Closure Table** (**Appendix One**) have been amended to specify a minimum density of specified trees is a closure requirement for 'forest', and seedlings of forest species will be recorded in <1, 1–2, and >2-m height classes. However, because the criteria are designed to assess closure at ~10 years after planting, not similarity to original forest, I consider basal area or stem diameter are not necessary or useful to include.

REHABILITATION METHODS AT MINES

89 This section of my evidence explains the methods proposed, and required by the conditions, to achieve the overall rehabilitation objectives and the specific closure criteria. The methods have been adapted from experience at a variety of comparable mine sites and ecosystems over the last 25 years, and especially over

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[25] 2018 evidence p216

the last 5 years. Many of these are summarised in Cavanagh et al. 2018 and Simcock and Ross 2017 (Appendix 2).

Relevance of other mine sites

90 Before discussing the specific methods that I recommend for Te Kuha, I briefly comment on the relevance of other mining sites.

91 In the last 5 years, large-scale rehabilitation at a few other mine sites has reached an age and/or condition equivalent to 'closure standard'. Sites with greatest similarity in environmental conditions to Te Kuha include Strongman Mine and other Paparoa ridgeline mines down to the Stockton and Denniston Plateaux. The Globe-Progress Mine near Reefton is another medium-size, ridgeline site with extensive planting that has small areas of shrubland and forest developed over coal (which was earlier mined).

92 All these mines affect mosaics of native vegetation that include a) stunted mānuka/wire-rush and podocarps growing on soils with impeded to poor drainage (and very shallow roots restricted to the upper organic horizon) and b) beech forest growing on deeper and /or better-drained soils (with much deeper roots extending into subsoils). Undisturbed soils at all the mines are moderately to extremely acidic with low levels of the plant macro-nutrients nitrogen and phosphate, and elevated soluble aluminium concentrations. A benefit of these low fertility and high acidity conditions is that they inhibit many non-native species, particularly herbaceous legumes (hence helping reduce their competitiveness). Nearly all these sites experience very little drought, receive high intensity rainfall events, and have generally mild temperatures with occasional snowfalls that do not usually lie on the ground for more than a few days. All have some plants that are vulnerable to browsing mammals.

93 Although rehabilitation growth rates are locally influenced by root zone characteristics and topography, it is useful to compare the fundamental environmental conditions at Stockton and Strongman with Te Kuha using Land Environments New Zealand data (**Table 3**). The analysis shows environmental conditions at Te Kuha mine site generally lie between Stockton and Strongman.

Mean temperature, winter temperature, vapour pressure deficit, and potential evapotranspiration (water use) indicate growth rates at Te Kuha are likely to be at least as good as all Stockton sites, and on lower parts of the backfill probably similar to Strongman. They also indicate environmental conditions for direct transferred sods are likely to be similar, and highly favourable, all other things being equal[26] due in part to minimal drought stress.

Table 3: Comparison of environments at Stockton, Strongman and Te Kuha using Land Environments New Zealand (LENZ) for higher or lower elevations at each site.

Site	Strongman		Stockton			Te Kuha	
	lower	higher	lower	higher	R5/6	lower	higher
Elevation (m)	465	595	815	882	837	622	736
Deficit	0	0	0	0	0	0	0
Winter Solar Radiation	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Mean Solar Radiation	13	13	13.3	13.3	13.3	13.3	13.3
Mean Temperature	9.5	9	8	7.7	7.9	9	8.4
Winter Temperature	0.7	0	-1.2	-1.5	-1.2	-0.1	-0.7
R2 Potential ET	90	92	158	163	156	103	110
Slope	23	6	5	4	7	10	9
Vapour Pressure Deficit	16	15	6	4	6	12	9
Drainage	5	5	4	4	4	4	4

Relevance of specific rehabilitation sites at Stockton mine

94 Dr Marshall[27] lists some of the rehabilitation sites she has visited at Stockton. The names of some of these differ from those I have used (Appendix One) and some of her assessments differ from my assessments and. In some cases, sites Dr Marshall lists are not included in my evidence. In the absence of a map, I have taken the sites Dr Marshall visited to be as described in the following paragraphs. Together, these sites represent a range of rehabilitation methods, and variable quality. I think it is important the Court understands the context of the examples and the extent

[26] Globe-Progress Mine at Reefton has lower elevation (500 m) but similar mean temperature 9.2 C, Winter temperature -0.9, winter solar radiation 3.9 and zero annual moisture deficit.

[27] In para 8, 2018 evidence

to which they apply to the Te Kuha proposal. These comments aim to help interpret outcomes, especially if these sites are viewed by the Court

95 Two sites were not included in my evidence:

a) 'Augusta snail restoration site, A10'. I did not refer to this site in my evidence because the standard of direct transfer was extremely high, and the source material was also highly favourable with few rocks and few larger trees. It is the 'gold standard', not an outcome that can be consistently achieved.

b) 'early hand-manipulated revegetation site, Gardens'. I think this is an area on Downers Dump Terraces known as the 'Mount Augustus Garden' that I helped establish in 2001. Three relatively small areas (<~200 m^2) demonstrate the persistence (and spread) of herbfield and rockland species such as *Celmisia dallii, C. dubia*, *Actinotus nz,* and at least three low-growing *Dracophyllum species,* even when placed on elevated windrows or (adjacent) backfilled slopes >12 degrees. This area usually has water ponding between the windrows on flat to gently-sloping overburden to create both ephemeral and permanent ponds, as planned at Te Kuha.

96 Two sites Dr Marshall listed were included in my primary evidence:

c) 'sandstone pavement restoration site' = 'Hook Dump Stockton' (**Appendix One** photo 7) and in the site visit memo called 'Hook Dump rock pavement trial'. This is another site where water ponds on the surface of an overburden backfill, Survival and growth of direct-transfer yellow-silver pine is high. Large, weathered boulders have also been transferred with attached plants; however, the operators were extremely skilled. Such placement of boulders is difficult, slow, and so not an outcome likely to be consistently achieved at Te Kuha.

d) 'older revegetation sites, R6' = R6 Stockton in **Appendix One**, photo 22 and 23, graph 21 and 24. These are examples of direct transfer (DT) of shrubland, low forest and herbfield from former Mt Augustus ridgeline placed in 2007/2008. After about 5 years internal access roads were planted with nursery-raised seedlings.

97 The R6 direct transfer area itself is unusually complex, as it contains a) a very wide range of direct transfer suitability (i.e. forest to herbfield), b) a wide range of DT quality that reflected changing machine configurations, and c) some areas that were effectively 'ploughed' by people searching for snails before being shifted, which damaged smaller plants. However, the highest edges of the R6 block are useful places to view edge effects (photo 23 **Appendix One**) and options for their management.

98 An area adjacent to direct transfer and also in R6 is an example of nursery planting into soils on overburden (photo 14 **Appendix One**). It contains a rehabilitated rock 'outcrop' or landscape feature created using large, ~1 to ~4 m^2 boulders (photo 5 Appendix 1). Such features are planned for Te Kuha.

99 Dr Lloyd also provides data from a plot he measured on Campbells Dump, Stockton Mine.[28] I suggest this slope is included in the court's field visit because it shows large-scale, direct vegetation transfer with some transferred boulders to a relatively steep slope, well in excess of 12 degrees.

100 I suggest the Court visit the Cypress mine light vehicle access and haul road to see road batter and edge/footprint treatments. The mine boundary was clearly defined before areas were stripped and silt fences installed to contain silt and protect areas beyond the site boundary (**Appendix One** Photo 37 and 39). These practices are required in Conditions proposed for Te Kuha through the Construction Management Plan 48 (b), (d) and Rehabilitation Management Plan 52 (e), with Condition 69 (b) requiring Annual Monitoring Report outcomes of methods used to minimise edge effects.

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[28] para 200-202.

101 I consider a lower priority for the site visit is Mount Frederick, although Mt Frederick, Stockton No.2 South and Mt Augustus and R6 (Attachment 3) are good examples of working near ridgelines using practices that minimised the impact of rock and sediment on adjoining areas in the short term, and would comply with the above Conditions 48 (b)(d) and 51 (e) if the sediment fences, rock fences and accumulated sandbags had been maintained and most importantly, removed once the area was stabilised.

REHABILITATION METHODS AT TE KUHA

102 As identified earlier, the proposed Te Kuha rehabilitation has three overall priority outcomes:[29]

(a) achieving a high certainty of low visual effects so the site integrates visually with surrounding vegetation;

(b) creating stable, erosion–resistant surfaces, with soil cover and root zone that favours seed germination, plant establishment and sustained ecosystem development; and

(c) delivering a set of specific ecological objectives.

103 This section of my evidence describes the methods used to achieve these outcomes, consistent with the draft Rehabilitation Management Plan.

First priority rehabilitation outcome

(a) achieving a high certainty of low visual effects so the site integrates visually with surrounding vegetation

104 The overall contours of rehabilitated areas are largely determined by this rehabilitation outcome. This is delivered by creating mined landforms that abut natural ground levels and return most areas to approximately natural overall landforms within three constraints:

a) a maximum 27 degrees slope;

b) the creation of new external overburden landforms; and

[29] Condition 50

c) ensuring mine drainage controls.

105 These landforms are created using a variety of backfill slopes, slope lengths and bench widths, and avoiding extensive linear features. This topographic variation is shown in the Rehabilitation Concept Plan (required by Condition 50). The plan shows variation of topography complemented by placement of rockfield and shrubland on the lowest-slope areas and ridgelines. Forest is rehabilitated on areas with steeper slopes (**Figure 2)**.

106 Linear features such as benches will be masked as vegetation grows There will be no exposed highwalls in the rehabilitated mine site and no permanent lakes, as required by Condition 50(h) and shown in the Te Kuha Rehabilitation Concept Plan (**Figure 2**).

107 Integration of the rehabilitated areas with adjacent vegetation will also be delivered by complementing the surface colours of these areas by:

a) planting species with dominant grey-green and green coloured plants (mānuka, beech species, flax, Ozothamnus, Hebe/Veronica, Gahnia and broadleaf (*Griselinia litoralis*)); and

b) strategic placement of rockfield with rock mulches and weathered sandstone boulders (greys) to create a mosaic.

108 For this reason, seasonally- or permanently- brown or fawn-coloured plants such as native grasses (toetoe/Cortaderia and some Chionochloa species) will not be planted, despite their widespread use and proven growth under suitable conditions at Stockton. This approach has been developed with Mr Peter Rough and illustrated in his evidence.

109 A low visual impact will also be achieved by ensuring backfill is topographically and hydrologically variable with a variety of slopes, root zones, and local growing conditions. This variety underpins a variation of plant heights and dominant plant species within the forest and shrubland units. Height differences also contribute to textural variation seen in adjacent natural landscapes.

Second priority rehabilitation outcome

(b) creating stable, erosion-resistant surfaces, with soil cover and root zone that favours seed germination, plant establishment and sustained ecosystem development

110 In this section I discuss the topography, micro-topography, and root zones that minimise erosion and underpin the ecosystem mosaic of forest, shrubland and rockfield. This includes ecosystems with impeded drainage. Dr Lloyd and Dr Marshall have questioned the ability to create impeded drainage on rehabilitated overburden landforms. Soil moisture status / drainage is discussed in depth in Dr Craig Ross' evidence.

111 A diverse micro-topography contributes to an ecological mosaic. A rough micro-topography minimises erosion and creates stable, sheltered areas in which seedlings and nursery-raised plants can establish more successfully.[30] To create a rough micro-topography, wood, small rocks, and vegetation are mixed with soil during stripping. In areas that are steeper, additional large wood (stumps and logs) and boulders are used to further protect slopes from erosion.[31] As in naturally-revegetated forests, the protected sites created enhances natural colonisation of ferns, while clusters of large boulders create local sheltered areas that allow taller plants to grow, as shown in **Figure 3**, in a natural landscape, and in rehabilitated landscapes in **Figures 4 and 5**, (and Photos 5, 12 and 34 in **Appendix 1)**.

[30] Except for herbfields, where a very smooth surface with minimal bare soils is created by direct transfer sods as this is more likely to result in sustainable herbfield
[31] Noting that additional wood will not be placed in herbfields or rockland rehabilitation units

Figure 3. Large boulders and rocky outcrops with stunted vegetation present at Te Kuha (photo by Peter Rough 2013).

Figure 4. Salvaged boulders in a high-quality area rehabilitated with direct transfer on Augustus ridgeline, Stockton, 2017. Note die-back of taller plants at left.

Figure 5. Rehabilitated 'outcrop' of salvaged boulders in area planted with nursery tussock, toetoe, and broadleaf seedlings, R6 block Stockton, about 2017.

Root zones

112 Rehabilitation of ecosystems dominated by species typical of coal measures is favoured by covering areas with soils stripped from areas of coal measure soils, and creating extensive areas with shallow, imperfectly to poorly drained root zones. In areas rehabilitated with stripped soils (not direct transfer sods), three factors combine to affect such conditions on rehabilitated backfill: climate, soils, and slope. I describe the contribution of these factors below.

113 The Te Kuha climate delivers a large surplus of rain over plant evapotranspiration (i.e. removal to the atmosphere) every month, and rain falls on more than 50% of days on average (**Figure 6** and **Table 4**). This maintains very high soil moisture levels. The nearest long-term rainfall record to Te Kuha is Westport airport. From 1944 to 1980, Westport received 2192 mm per annum on average. The Te Kuha rainfall is approximately double this, and averaged 5,107 mm per annum over the 5 years for which complete records are available (**Table 4**). The closest available weather station with long-term records of open-pan evaporation is Wellington. This will over-estimate Te Kuha evaporation due to Te Kuha's cooler temperatures and lower radiation. Figure 5 shows that even at Westport, rainfall exceeds open pan evaporation in every month on average. Te Kuha's rainfall exceeds the 90^{th} percentile for Westport – which shows at least a 100-mm monthly surplus of rain (**Figure 6**).

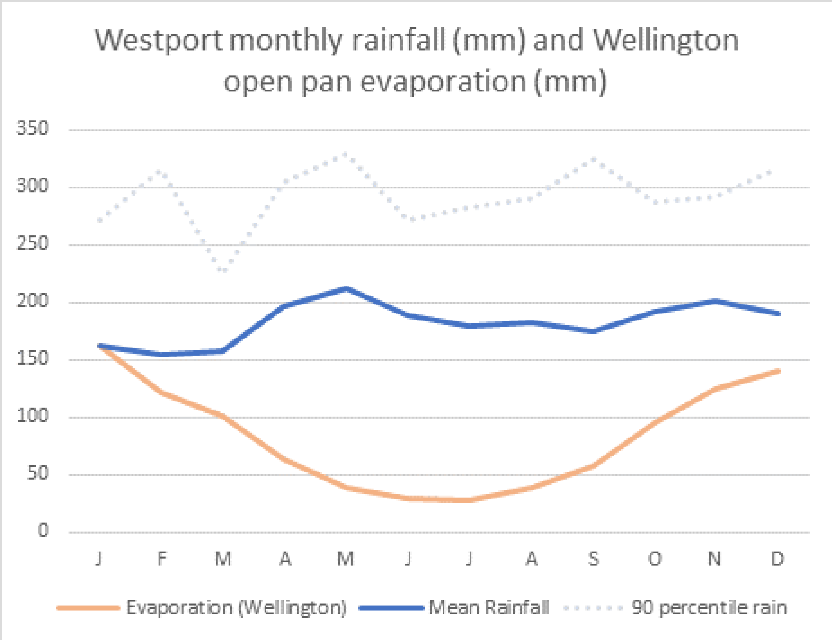

Figure 6. Westport long-term monthly average- and 90th-percentile rain, and Wellington open pan evaporation (mm).

Table 4. Number of rain days at Te Kuha, 2013 to 2020[32]

Year	Total Rain days (%) >0.1 mm/day	Total Wet days (%) >1 mm/day	Days with data	Rainfall (mm)
2013	69	53	359	4838
2014	68	51	364	4786
2015	73	55	310	5196
2016	74	61	211	Incomplete
2017	72	55	365	Incomplete
2019				5305
2020				5409

114 On flat to gentle slopes, or where landforms change from steeper to more gentle gradients, water ‘ponds’ if the underlying soil (**basal root zone)** is slowly permeable (**Appendix 1**, photo 14 left of the waratah stake where flax growth is stunted). Some overburdens become slowly permeable when trafficked during construction of engineered landforms. At Te Kuha, specific

[32] Email from Aaron A Dutton, CRL 22 March 2018, and total rainfall mm from J. Pope 2021 (2018 excluded as equipment verification not received)

overburdens will be deliberately compacted, so they are slowly permeable. This minimises water and oxygen movement into underlying overburden and thus prevents acid drainage as described in Dr Pope's evidence. Water ponds where lateral drainage is constrained. This sideways drainage can be slowed by bunds (for example, on Mount Frederick and Downers Terrace, Stockton (**Appendix 1** photos 13 and 34) or direct transfer sods (**Appendix 1**, photo 35). Direct transfer sods from Denniston have low permeability and very high moisture storage, as detailed by Dr Craig Ross' evidence.

115 Low-permeability soils are also mapped at Te Kuha. When direct transfer sods are placed in a pattern that prevents continuous 'drainage' lines, water cannot escape laterally.

116 My assessment of rehabilitation outcomes at Te Kuha is based on mine plan models that show enough soil will be stripped, stockpiled, and replaced to cover the site with at least 100 mm of soil (over a chemically benign non-soil root zone for forest) or 300 mm of soil (for shrubland). A feature across the site is 'armouring' of the surface with small and large rocks, hence more soil is able to be stripped than is indicated by surface probing (**Figure 7** is an example from Millerton). The soils at Te Kuha are complex mixes: about 20% Raw Soils (organic-enriched topsoil on rock) and about 60% Gley Soils, which are deeper soils, but which also have 'peaty', organic-enriched topsoils; 20% of the site area, with taller forest, has deeper, imperfectly drained Brown Soils and Podzols.

Figure 7. Millerton soil profile showing salvageable soils under boulders (photo 2002).

Implications of hydrology for proposed rehabilitation

117 Dr Lloyd's and Dr Marshall's view[33] is that "establishing extensive areas with impeded drainage is unlikely to be achievable or practicable". Impeded drainage is important because it underpins development and persistence of low-stature coal-measures ecosystems with characteristic pine species.

118 I agree with Drs Marshall and Lloyd that generally poor to impeded soil drainage is a key characteristic of the coal plateau ecosystems, and these coal plateaux are generally gently-sloping (Lloyd para 23, 24, 45, 46). However, I note that:

(a) Gently sloping ecosystems are not all poorly drained; most are shallow soils, classified as Raw Soils. Some of these areas are imperfectly drained, for example slightly elevated areas or small catchments adjacent to deep rock fractures or outcrops. This allows taller vegetation and/or *Phormium*

[33] JWS page 12

cookinaum (flax) to dominate. Such profiles can be seen where the Cypress haul road cuts through coal measures to expose the soil pattern.

(b) Not all steeper slopes are well-drained; the deeper soils are mapped and classified as Acid Gley Soils and Humose Iron Podzols (paragraph 13 in Dr Ross' evidence). These have characteristics of impeded drainage and low aeration.

(c) The variation helps explain why the different coal-measure ecosystems are not consistently linked to slope as shown in **Figure 8**. Three of the four key vegetation types have their greatest are on slopes of 5–12 degrees but are all also found on slopes of 0–5 degrees and 12–18 degrees.

119 Dr Ross explains the soil properties of direct transfer that mean a poorly-drained condition is maintained. Mānuka-dominant wetland on gentle coal measure landforms 'wire rush wetland', are highly amenable to DT (both referred to as pakihi in Fred Overmars' evidence). The maintenance of wetland hydrology is demonstrated at Hook Dump, at parts of R6 block created with overburden backfill (and also on coal floor), and on gently sloping to flat areas of overburden backfill at Stockton (Downers Terraces) where small ponds have persisted over 10+ years (**Appendix One** and Mitchel Partnerships 2017 section on tarns).

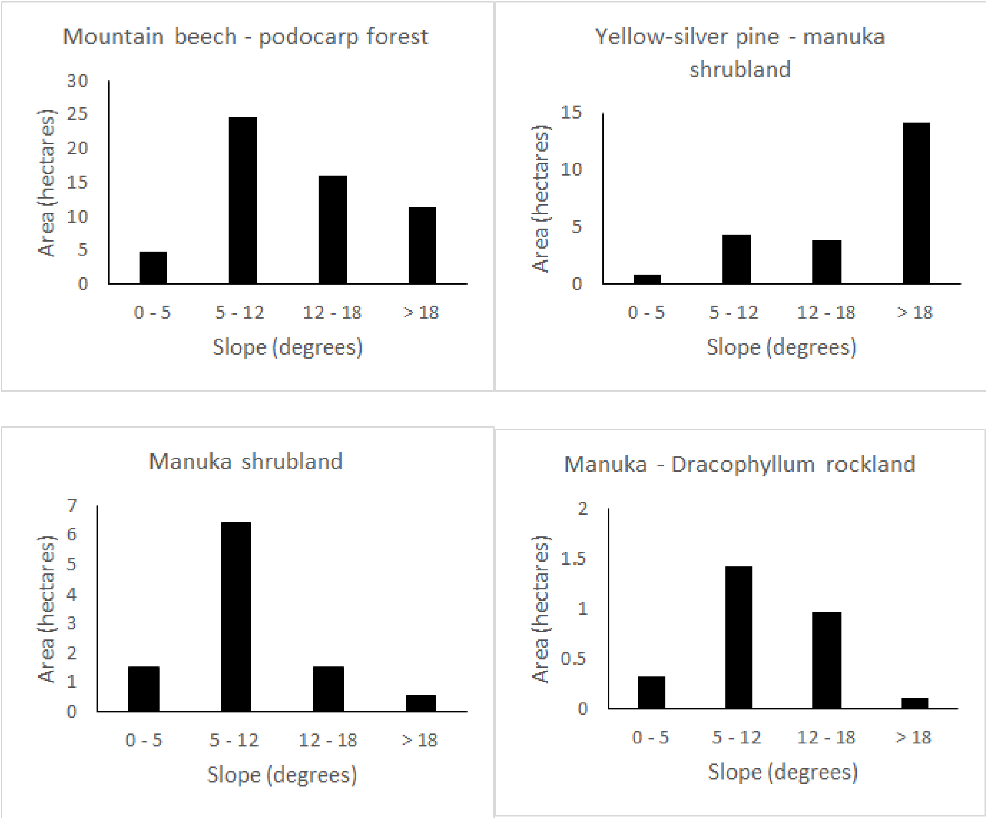

Figure 8. Area of the major vegetation types across slope classes within the Te Kuha footprint

Third priority rehabilitation outcome

(c) Delivering a set of specific ecological objectives

120 The third priority outcome for rehabilitation is to deliver the following five ecological objectives:

a. Footprint minimisation, i.e. avoiding impacts where practicable. This is required by Condition 50 (g) supported by Conditions 48 (b), 49 (d, f) – the Construction Management Plan) and Condition 78, which limits the total disturbance area;

b. Establishing self-sustaining native vegetation that can develop into a mosaic of vegetation associations that is 'as similar as possible to the existing vegetation and that is no more vulnerable than at present' to pest plants (weeds), pest animals (deer, goats, and hares), drought and fire. (Conditions

50(i) and 50(k)) (‘’indicates agreed amendment at JWS Rehabilitation);

c. Conserving genetic resources, particularly those of threatened or at-risk plant and animal species, both within the footprint (largely by using the direct transfer rehabilitation technique to establish individuals and to establish sites where these species can maintain dominance) and outside the footprint, through effective buffering of undisturbed habitat that minimises edge effects and through pest plant and animal control. (Conditions 51 (e) and 50 (j));

d. Providing for habitat favourable for recolonization and reintroduction of species listed in the Te Kuha Biodiversity Management Plan (Conditions 50 (b), 50 (e), and 50 (l)); and

e. Creating a minimum of 50 m^2 of permanent pond habitat and 600 m^2 of ephemeral pond habitats, both of which are designed to benefit indigenous fauna’ as required by Condition 51 (b) (‘’indicate agreed amendment at JWS Rehabilitation).

121 The following paragraphs of my evidence discuss each of these specific ecological objectives (intended to achieve the third priority rehabilitation outcome) in turn.

Footprint minimisation

122 I discussed strategies to minimise the footprint in para 22, 28 (location of moveable mining components), 27 (ELF construction) and 31 to 33 above.

Establishing self-sustaining native vegetation

123 At the June 2018 conferencing on rehabilitation, the ecologists agreed that Condition 50(i) should be amended from the condition as it then read (dated 7 April 2018) to read:

i) Establish self-sustaining native vegetation that is as similar as practicable to the existing vegetation that can naturally *develop into a mosaic of native vegetation associations which are no more vulnerable than at present to fire, weeds and pests;*

124 In relation to this issue:

(a) Dr Lloyd considers that it will be impossible to have vegetation rehabilitation outcomes that are no more vulnerable to ungulate browsers and weeds than at present;

(b) Dr Marshall considers that the vulnerability to the site to weeds will be long term and unavoidable; and

(c) Dr Smith considers it is not possible to plant vegetation that is resistant to ungulates without compromising other rehabilitation objectives.[34]

125 Condition 50 (i) has now been amended. The purpose of this amendment is to add clarity to the objective and prevent perverse outcomes where other-wise suitable species are not used in rehabilitation because of their palatability, vulnerability to fire or weeds.

126 I agree with Dr Bramley's evidence in this regard, and further note that the dominant plant species across the site, mānuka, has low palatability. Experience at Stockton and Globe-Progress has shown palatable species such as rātā can be successfully established with deer control.

Rehabilitation methods for different ecosystems and plant species

127 Plant establishment methods can influence visual outcomes and long term ecosystem complexity in both the short term and post-closure. The two main plant establishment methods – a) direct transfer and b) planting of nursery-raised seedlings – have starkly different visual outcomes until the latter reaches a moderate plant cover. Ecosystem complexity and species diversity is also typically much greater in areas rehabilitated using direct transfer than planted areas, and this persists until natural establishment of seedlings occurs and plant cover creates sheltered conditions.

[34] Page 7 Joint Witness Statement on Rehabilitation 19 June 2018

Tables 5 and 6 (located at the end of my evidence) list the mapped vegetation associations/ecosystems at Te Kuha and summarise a) the outcome and priority for rehabilitation using direct transfer, and b) the canopy and sub-canopy species planted as nursery-raised seedlings at other mine sites.

Rehabilitation providing habitat

128 I used my knowledge of the construction and development of comparable rehabilitated areas to identify rehabilitated sites at Stockton for assessment by experts in invertebrates (Mr Toft), vegetation and bryophytes (Dr Bramley and John Terry). Mr Toft's and Dr Bramley's evidence details the extent to which they consider rehabilitated elements have significant ecological values for plants, animals, and ecosystems.

Vulnerability of rehabilitation to weeds

129 An exception is rehabilitated areas that are vulnerable to pest plants such as gorse, broom and *Juncus squarrosus.* These pest plants can smother and displace smaller native plants. Fortunately, these three plant species are absent at Te Kuha and their heavy seeds will not be blown in, or spread by birds, given these species are spread in soil and gravels via people, machinery, and imported materials. The risks will be managed through a specific weed management section of the Te Kuha Biodiversity Management and Enhancement Plan[35] using a combination of biosecurity and monitoring with controls.

130 The vegetation types that are most vulnerable to weeds are low-stature and slow-growing: i.e. herbfield, rockfield, and ephemeral small ponds. The latter are particularly vulnerable to establishment of non-native rushes with very light seeds that can establish onto exposed sediments during dry conditions. It could be difficult to maintain the ephemeral ponds in a weed-free state. In contrast, herbfields, although short, can be established with very little bare soil, and the small area of herbfields means it is feasible to maintain them until a complete cover of native herbfield vegetation occurs, and use rocks to prevent vulnerable bare areas being exposed. Closure conditions include specific parameters for

[35] Conditions 180-181

pest plants, divided into sites above 500 m ASL and below 500 m ASL.

Rehabilitating a mosaic of ecosystems

131 The rehabilitation approach proposed for Te Kuha is to create a variety of root zone drainage, depth and chemistries suitable for native plant species that are as similar as possible to the existing vegetation, by manipulating topography (slope), overburden and soil depth while controlling erosion. Some variation is intrinsic given the variation in stripped soils, even after storage. Placing large rocks on rehabilitation surfaces creates further variation. The placement of stumps and wood in areas rehabilitated to forest create variation by influencing the establishment of adventive seedlings, especially ferns

132 Significant areas of rehabilitated Te Kuha landforms are <5 and <12 degrees in slope. In areas under 5 degrees slope, the impeded drainage that underpins (stunted) shrubland re-establishment can be confidently created, as detailed by Dr Craig Ross (paragraph 30). The extent of rehabilitated areas with 0–5 and 5–12 degree slopes is shown in **Figures 9** and **10** below, and indicated in the Rehabilitation Concept Plan in **Figure 2**[36] as most areas of rockland (light grey) and shrubland (dark grey)**.**

[36] And required ‘to achieve an outcome substantially in accordance with the Rehabilitation Concept Plan (Attachment 1) under Condition 50.

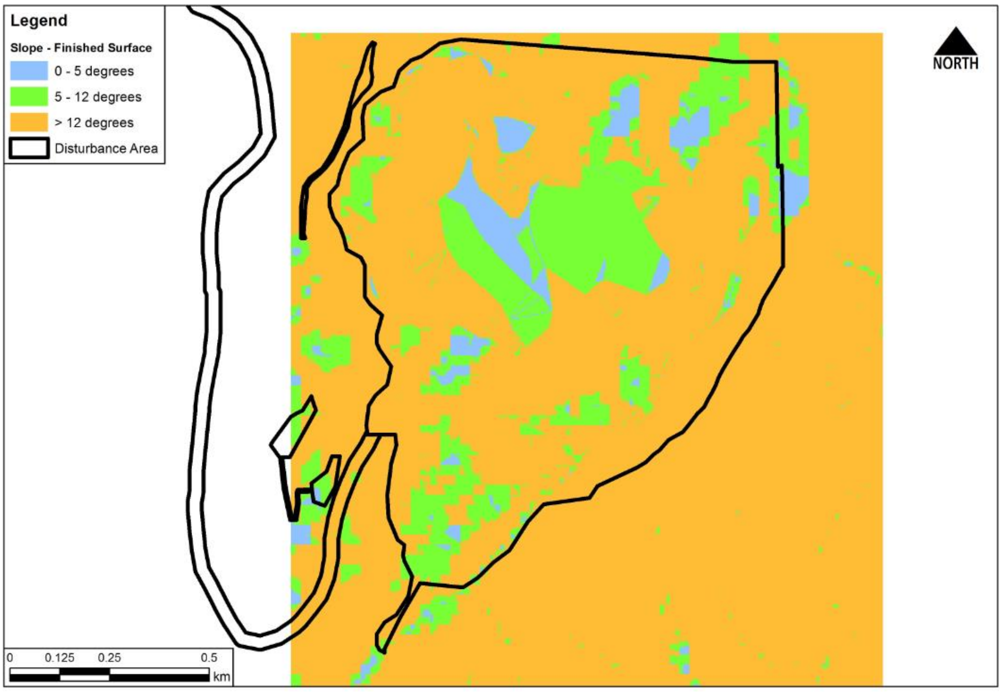

Figure 9. Slope classes of the indicative, finished, rehabilitated surface. This figure uses the same contours as presented in the following **Figure 10**

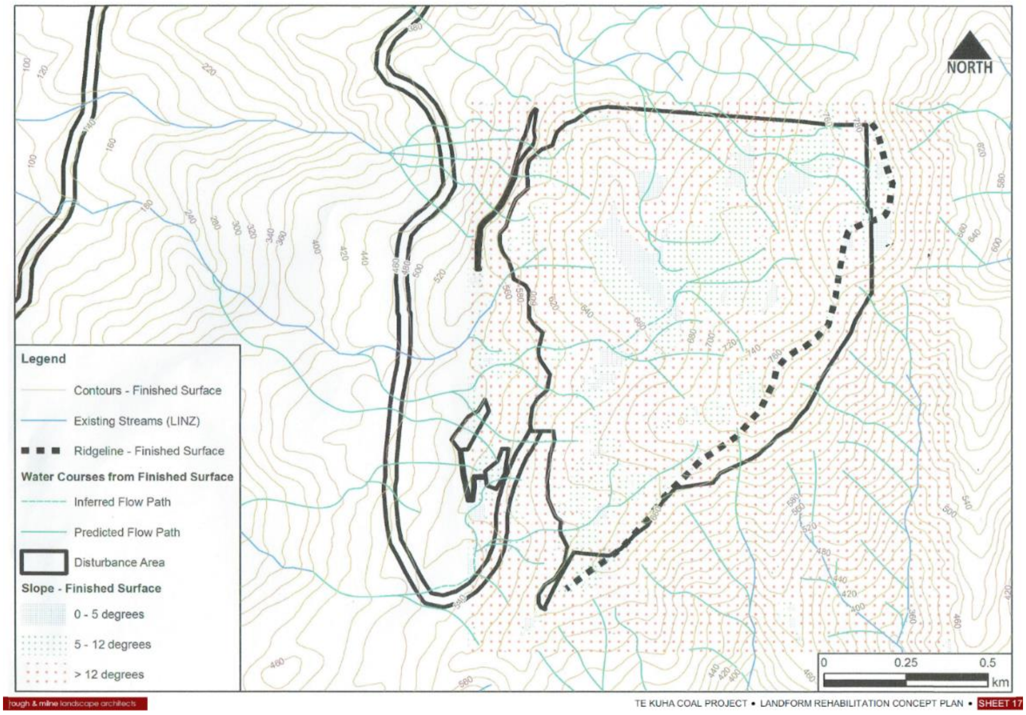

Figure 10. Finished surface indicative contours (Source file**:** 2018053_Te Kuha_GS_Sheets17-20.pdf, evidence of Mr Peter Rough)

133 Planted areas become more visually diverse as different species and individuals grow at different rates, and new seedlings establish (Appendix 1, photos 10, 14, 26, 33, 38). Four ‘vegetation/ecosystem types’ are used in planning rehabilitation: herbfield, rockland, shrubland, and forest (**Closure Table Appendix One**). Ponds are included, but managed separately as they can be a variety of vegetation types. Differences between the four vegetation types are reinforced by establishment methods that use different rock or log covers (as required in closure standards), that target different slopes (as shown in Rehabilitation Concept Plan), and that use different ‘founder plants’ (as reinforced by closure standards). For example, long-lived trees such as beech will only be planted in areas designated for forest.

Seeding techniques

134 Seeding techniques for native species, such as brush-layering, can also be used at Te Kuha (if economic) to establish rockfield, shrubland and forest because the weed-free soils and decision not to hydroseed with non-native grasses means native seedlings are able to establish without competition from weeds or pasture, despite probably taking 3–6 years to reach 500 mm height (**Appendix 1**, photos 32 and 33).

Conservation of genetic resources

135 Rehabilitation objectives relating to conservation of genetic resources are set out in Condition 51 (j).

Creating favourable habitat for specific species

136 The direct transfer rehabilitation method offers the greatest benefits for conservation of a wide range of native flora and invertebrate fauna. It is particularly valuable for providing habitat and conserving populations of vulnerable invertebrates, such as large bodied, relatively low-mobility species such as Carabid beetles, wētā, and Helms stag beetle, as discussed in detail by Mr Richard Toft.

Responses of 'key vegetation species' to rehabilitation treatments

137 Direct transfer by hand and machine has conserved healthy individuals of most of the key vegetation species listed in Closure Criteria Table (**Appendix One**) target plant species found in open habitats such as herbfields and rocklands (**Tables 5 and 6**) (**Appendix One**, photos 1, 3 and 4, and associated data). The high rainfall combined with shallow, competent soils held together by dense root mat that is almost entirely confined to the humose topsoil layer means plants suffer minimal shock. The whole of their root system is shifted, and these low (<1 to 2 m) ecosystems suffer minimal transplant (drought) stress. The Te Kuha herbfields are more amenable to shifting than some of the herbfields of Happy Valley, Cypress Mine growing on deep, 'liquid' peat.

138 Celmisias are particularly responsive to direct transfer by hand or machine and can also be grown as nursery plants. *Celmisia dubia* and *C. dallii*, parent plants survive shifting, and rapidly produce seed that is wind-blown to bare soils with light levels as long as drainage is adequate, and soils are stable. The wetland herbs *Euphrasia wettsteniniana* and *Actinotus novae zealandiae* are also conserved in direct transfer at Stockton for at least 6 years for the former and since 2001 for the latter. Stockton experience also shows Dracophyllums (including *D. densum and D. rosmarinifolium*) and <0.5 m high yellow-silver and pink pines have high transplant success, as do all beech species of similar stature. However, these species have not established new seedlings over the 5–9 years after shifting (**Appendix One**, photos 7 and 19 with data for Hook Dump and R6 respectively). To my knowledge, direct transfer of *Metrosideros parkinsonii* has not been attempted; however where this species is in open shrubland less than 3 m height, I would expect favourable outcomes. The easiest plant to 'direct transfer' is flax (*Phormium cookianum*) and this has been targeted extensively at Stockton, as well as grown as nursery-seedlings in the 100,000s. Flax responds vigorously to increased fertility and rapidly increases biomass, as long as drainage conditions are moderate; it does not tolerate poor drainage.

Rehabilitation of Bryophytes and their habitat

139 There is limited data on which to assess the efficacy of rehabilitation methods for ecosystem components, such as bryophytes or for invertebrates. However, a 2017 bryophyte survey at Stockton Mine found the greatest number and range of native Bryophytes was in direct transfer shrubland where a range of substrates included weathered sandstone boulders and tree stumps. Bryophytes adapted to relatively exposed (sun and wind) conditions are most likely to survive or colonise rehabilitated sites. Rehabilitated areas are unlikely to support species adapted to conditions within tall forest, until tall forest develops over decades to centuries. Condition 51 (g) (v) requires placement of boulders within direct transfer to enhance habitat for bryophytes.

140 Rehabilitation strategies for bryophytes are discussed in Dr Bramley's evidence and based on August 2017 lichen survey of rehabilitated areas of Stockton Mine (Jon Terry Ecology 2017). I selected the sites visited based on the age, method and outcome of rehabilitation, none of which contained any features specifically designed to assist bryophyte species.

141 At Stockton Mine, the greatest number and range of native Bryophytes were observed in c. 10–20-year old direct transfer shrubland (placed from 1999 to 2008). Bryophyte diversity was highest where a variety of 'substrates', including weathered boulders, tree stumps and logs, and many sheltered, high-humidity microsites, were present. These conditions were found within more densely vegetated direct transfer. The oldest direct transfer (c. 500 m^2 from 1999) had 2 lichen, 26 liverwort and 11 moss species (including 2 naturally uncommon species). Bryophytes typically found in undisturbed taller forest areas were generally absent.

142 The Rehabilitation Management Plan specifically includes placement of weathered boulders within direct transfer to enhance the density of sheltered, high-humidity zones that the 2017 survey results indicate enhance rehabilitation outcomes for bryophytes. This is required in the closure conditions for rock-shrubland as a

minimum 50% rock cover, up to 33% cover in shrubland, and up to 10% rock cover in forest.

Rehabilitation of habitat for fauna

143 Direct transfer of cutty-grasses *Gahnia setifolia* and *Gahnia rigida* conserves the preferred food for the caterpillars of forest ringlet butterfly. *Gahnia* can be transplanted by hand (in larger sods, 20 x 20 x 20 cm) but machine direct transfer in 1–2 m^2 sods enables large, more robust plants to be relocated (**Appendix One** photos 19 and 22, and adjacent table show *Gahnia procera* abundance in R6 plots was maintained in about half the plots over 7 years). Direct transfer of *Gahnia* onto access road fill batters will be prioritised as in many places this will be adjacent to forest, which I understand is a favourable location for forest ringlet butterflies.

144 Up to 85% of the Te Kuha site will be rehabilitated using planting. In these areas, natural regeneration of unplanted seedlings from seed and spores spread from adjacent undisturbed ecosystems will be encouraged by creating sheltered microsites. In forest units, this is done by (re)placing coarse wood such as logs and stumps. Where salvaged wood volumes are available, wood piles (up to ~1 m high and ~10 m^2, i.e. a truckload) will be created in forest units as habitat enrichment. In rockland and shrubland units, sheltered microsites are created using salvaged boulders, individually, as stacks and as clusters. Both wood and boulders also help accentuate habitat variation as both alter distribution of water and are themselves habitats. Wood provides a substrate for specialist invertebrates and habitat of specialist fauna of fungi, bryophytes, and epiphytes.

145 The recolonisation of rehabilitated areas by fauna is encouraged by managing the mine edges to ensure adjacent ecosystems are minimally impacted by the mine clearance (Condition 50 (g)) and receive pest control (specified in the Te Kuha Biodiversity Management Plan). A suite of edge management tools is included in the Draft Rehabilitation Management Plan, and required in Condition 51 (e). For example, the Annual Mine Plan and Rehabilitation Management Plan must report actions to avoid disturbance within the mine footprint. This is designed to

maximise retention of habitat and propagule sources as close as possible to rehabilitated areas.

146 Two specific rehabilitation methods will be employed to enhance rehabilitated areas as habitats for kiwi: placement of tree stumps with hollows as daytime refuges, and construction of ‘compost mounds’ made from c. 0.5 m deep chipped trees. This would favour high densities of invertebrates that would then be food for kiwi. These methods require development, but are not technically difficult, nor costly (and will be included in the Draft Rehabilitation Management Plan).

147 Where data on the efficacy of rehabilitation methods for identified species is absent or limited, such as for bryophytes, research by management and off-site mitigation is proposed in the Te Kuha Biodiversity Management Plan (as detailed in the evidence of Dr Bramley). Rehabilitation trials are required in Condition 51(f) with reporting of such trials required in the Annual Environmental Management Plan (Condition 69 (c) and (d) along with progress towards closure criteria (Condition 69 (h)).

148 Overall, the rehabilitation priority of creating a coarse mosaic of different ecosystems, while partly driven by landscape objectives, is also likely to enhance ecosystem outcomes. The addition of small, ponded areas further contributes to site ecosystem values.

Rehabilitation methods to recreate small ponds

149 A minimum 50 m^2 total area of permanent pond habitat and 600 m^2 of ephemeral pond habitat is required to benefit indigenous fauna (Condition 51 (b) and Closure table, **Appendix One**). Small ponds are desirable in rehabilitated areas as they enhance habitat for some invertebrates and some birds. Ponds with shallow water (about 0.3–0.6 m depth) will be created on low- to moderate-sloped overburden landforms. Construction methods have been informed by surveys of rehabilitated ponds at Stockton in 2012 and 2015.[37] Examples of outcomes are shown in **Appendix One**, photos 34, 35.

[37] Mitchell Partnerships 2016. Te Kuha AEE addendum. Results of additional ecological surveys for Department of Conservation. Fieldwork November 2015

150 The procedures for creating resilient permanent ponds within minimum areas of 5 m^2 (which are large enough for people to see and avoid) and target depth of ~0.5 m are listed below. Depth is important to help prevent establishment of non-native, wind-blown rushes that would contravene closure criteria:

a) Identify sites with 0–5 degrees slope where 3–5 ponds can be clustered off-line (i.e. not connected by surface water flow, as this increases resilience to weeds);

b) Create vertical edges that will completely vegetate by using direct transfer sods, preferably with a high proportion of wire-rush. Direct transfer sods form a physical barrier and filter to sediment movement into the ponds and buffer inflowing water with natural humic acids. The sod edges are potential burrowing sites for invertebrates; and the relatively high diversity of plants within the sods potentially supports adult phases of some invertebrates. Overhanging taller plants /leaning trees enhance shading and increase leaf and insect inputs into the water (which is generally beneficial);

c) Add sandstone boulders to create access sites that allow monitoring with minimal damage to edge-vegetation. However, these will comprise no more than 30% of pond edges (contrasting with **Appendix 1**, photo 35). Where ponds are established in shrubland or forest direct transfer, coarse wood may be added to enhance invertebrate colonisation and refuges within the ponds.

151 Condition 51 (b) requires the recreation of both permanent and pond habitat within the rehabilitated footprint. The purpose of this condition is to ensure ponds had a high proportion of dense vegetation around them, unlike some ponds that were seen on the upper levels of Mt Fred, Stockton. The experts agreed at conferencing that this condition should be amended from the previous version so that ponds were explicitly to provide habitat.[38]

[38] JWS page 8

152 We also agreed that permanent and ephemeral ponds should be included in the closure criteria table. That is now reflected in condition 31 (Table 1).

IDENTIFICATION AND MANAGEMENT OF REHABILITATION RISKS

153 I have identified four main risks to achieving the anticipated rehabilitation outcomes.

(a) About three quarters of the total area, about 84 ha, is stripped in the first 2 years. If an adequate volume and quality of soils are not stripped and suitably stockpiled from this initial area, the rehabilitation potential is likely to be reduced over large areas of the site.

(b) Backfilling is proposed to eliminate high walls, minimise visual impact, maximise buffering of adjacent ecosystems and underpin re-establishment of connectivity into and across the rehabilitated site. This backfilling is expensive (due to double-handling and an uphill haul) and happens near the end of mine life when most of the coal has been extracted.

(c) About 70 ha is rehabilitated at the end of mine life. This area is unlikely to contain any direct transfer materials, unless some are stored on the temporary rehabilitation that covers overburden used to backfill the pit. This absence of direct transfer reduces the biological diversity of rehabilitation in this last 70 ha.

(d) Weeds and pests could invade rehabilitated ecosystems to the extent some closure conditions cannot be met. Rockfields, herbfield and ephemeral pond areas are the most vulnerable to weeds. If the definition of ‘weed’ is extended to include species that are difficult to identify (e.g. some rushes, lichens, liverworts, mosses), and these establish, it is likely to be very difficult to eradicate them. Deer and goats need to be able to be controlled within the constraints of current mining regulations that do not allow firearms on a mine site.

154 To address and minimise these risks, Dr Bramley and I have provided consent conditions and drafted management plans which specify outcomes to be achieved and the methods of achieving and reporting outcomes. These drive early identification of issues and adaptive management to tailor rehabilitation to Te Kuha conditions. While similar ecosystems have been rehabilitated at similar mine sites, some plant and animal species in the Te Kuha Biodiversity Management Plan have not been deliberately or intensively managed at the scale planned at Te Kuha to my knowledge. This includes the forest ringlet butterfly, bryophytes, and large-scale yellow-silver pine establishment.

155 Each major new coal-mine that has impacted coal measures ecosystems in the Buller Region has managed new plant and invertebrate species: at Cypress Mine, *Powelliphanta patrikensis* and red tussock wetlands, at Mount Augustus, *P. augustus* (in captivity); at Mount William, *Celmisia dubia, C. dalllii* and *Dracophyllum densum*, and at Escarpment Mine, Sticherus fern species and *Forstera mackayii* (with other plant species). In each case, successful rehabilitation techniques have been developed.

156 Conditions and plans require monitoring that provides early warning indicators and specifies contingency actions. In most cases, these contingency actions involve significant additional expenditure, e.g. additional planting, placement of rock mulch, and/or intensive weed management. This approach contrasts with some Escarpment conditions, for which the 'mitigation action' was 'more monitoring', which doesn't necessarily achieve improved outcomes.

WILL THE PROPOSED REHABILITATION BE SUCCESSFUL?

157 There is disagreement between ecologists over the likelihood of success of rehabilitation of certain habitat and ecosystems. Those disagreements are summarised in section 5 of the Rehabilitation Joint Witness Statement. While all ecologists agree that there is a degree of uncertainty with all rehabilitation (which applies to all projects, not just Te Kuha), I consider the outcomes I describe above reflect the 'average' that will be achieved using

the methods I have specified (which will be detailed in the Rehabilitation Management Plan), combined with an adaptive management process based on specified, quantitative monitoring and reporting of specified Closure Criteria (**Table 1** in **Appendix One**). This allows for early, successful adjustments to rehabilitation that provide confidence to Stevenson, the regulators and DOC of the quality and trajectory of rehabilitation.

158 I consider the assessment of rehabilitation outcomes by Dr Marshall and Dr Lloyd in their 2018 evidence and as recorded in the JWS Rehabilitation to be overly pessimistic. Dr Marshall appears to be influenced by a negative assessment of the potential for successful rehabilitation by a 1990 report by Mr Fred Overmas. Mr Overmas' supplementary evidence for the Escarpment Mine hearing 21 years later (22 July 2011) presents a very different, and more positive, assessment. The overall rehabilitation goal for Escarpment was similar to Te Kuha: 'to create an environmental condition that is compatible with the natural landscape, and from which a stable indigenous system will develop in the long term that is compatible with the intended post-mining land use'.

159 Dr Lloyd's experience with direct transfer of plants and sods in Otago (Macraes) and Central Otago drylands with drought-adapted flora and well-drained Pallic and Brown Soils appears to have influenced his negative assessment of:

a) the stability and resilience of rehabilitated areas at closure, and

b) the *ex-situ cultivation and re-establishment of vascular plants being often difficult and unsuccessful*'.[39]

In my opinion, rehabilitation conditions in dry areas of Otago are very different from the shallow-rooted, imperfectly to poorly drained, super-humid, and low-fertility adapted flora of the West Coast coal measures in general, and Te Kuha in particular. Re-establishment and hand-transplanting of a core group of 'wild' vascular plants at Stockton from areas to be stripped into respread soils of rehabilitation slopes has been extremely

[39] Lloyd 2018 evidence para 176.

successful. The success was a reason the mine used 1,500 to 2,000 'wild' transplants/ha in their rehabilitation from about 2002 to 2010.

160 Both Dr Lloyd and Dr Marshall provide very detailed comments in their 2018 evidence on a range of technical issues associated with risks and uncertainties of rehabilitation. Rather than address these in yet more detail, counsel for the applicant has asked me to summarise the issues by identifying the key erroneous assumptions or approaches to rehabilitation at Te Kuha that underpin Dr Lloyd's and Dr Marshall's 2018 evidence.

161 In my opinion, there are five erroneous assumptions or approaches:

a. The mining will result in the complete loss of approximately 150 ha of intact native vegetation associations.

b. Soil hydraulic conditions in rehabilitated areas will be unsuitable for coal measures /stunted forest / shrubland.

c. Rehabilitation at closure (i.e. existing rehabilitation examples shown in Appendix 10) will not be sustainable / persist in the long term.

d. All ecosystem 'classifications' (whether 8,10 or 14) and all species should be present post rehabilitation within the rehabilitated areas.

e. The areas used in my primary evidence, Appendix 1 to illustrate rehabilitation outcomes are unusually high quality, i.e. are not representative of business as usual, or range of outcomes.

First flawed assumption – Mining will result in the 'complete loss of approximately 150 ha of intact native vegetation associations'[40]

162 In my opinion, this overstates the effects because:

a. The site will be rehabilitated to standards specified by realistic closure conditions that require, among other

[40] Marshall 2018 evidence para 24

things, dominance of native species from the ecological district

b. Rehabilitation uses (coal measures) soils and vegetation stripped from the footprint; mostly after stockpiling but including relatively intact direct transfer of low vegetation.

c. Site conditions favour native species and ecosystems continuing to dominate and recolonize the site because it is relatively narrow and surrounded by intact native ecosystems required to be managed to reduce impacts of pests (enhancing propagule flow into the site); weed pressures are low.

d. The native vegetation associations within the mine footprint are well represented outside the mine footprint.

Second flawed assumption – Soil Hydraulic conditions in rehabilitated areas will be unsuitable for coal measures /stunted forest / shrubland[41]

163 I have addressed this issue in paragraphs 113–120 above, as has Dr Craig Ross.

164 In addition, if the Court visits Downers Dump Terraces (Mt Augustus Garden), Hook Dump Trial, R6, the tussock storage pad, (and any of the 'tarn sites' referenced in Appendix A), they can see a variety of ponding mechanisms and water depths on flat to gently sloping rehabilitated landforms. Poor drainage is also often evidenced by patches of poor growth of planted nursery species that are intolerant of poor drainage (i.e. stunted flax, less Ozothamnus and broadleaf). Dr Pope's evidence discusses the ELF construction methods to control acid mine drainage. These contribute to poor drainage on gently sloping areas. The rehabilitation plan builds on this by manipulating:

(a) the topography of ELFs to control the size of micro-catchments and efficiency of lateral surface drainage lines.

[41] Eg, Marshal 2018 evidence paras 25, 64, 80 and Lloyd 2018 evidence paras 179, 180, 187, 225- 231

Runoff is slowed, and water ponds where slopes change from steep to gentle (e.g. R6 planting)

(b) the placement of soil. Direct transfer soils and some stripped soils slow lateral movement of water.

165 However, the drainage status of steeper rehabilitated slopes spread with stockpiled soils is likely to be enhanced. This means, overall, a higher proportion of the rehabilitated site is expected to have imperfectly to well-drained soils that support taller forest than pre-mining.

Third flawed assumption –- Rehabilitation at closure will not persist in the long term

166 Factors that might lead to non-persistence have been considered in the Rehabilitation Management Plan, and mitigations considered in the selection of landforms and root zones, the selection of rehabilitation methods, and nursery-grown seedlings, in the selection of closure criteria, and post-closure management. The key risk factors that might arrest outcomes – or change to a different trajectory are:

a. severe browsing of plants

b. invasion by aggressive weeds

c. massive, severe erosion and

d. fire.

167 In my opinion, rehabilitation at closure is highly likely to persist and continue to develop once it has reached closure condition because much of the site is established in low-palatability species, pest control continues after closure, closure requires a high vegetation cover, and low bare ground, and very low weed cover, which means a) very few sites are available for most potential weeds to colonise, and b) the soils are physically covered and root-reinforced against erosion. In relation to fire, the main risks are mitigated by excluding people after closure, but plant species selection and rock placement in 'fire break zones' can also contribute to reducing risk.

168 In the light of my experience with similar rehabilitation examples, I am confident that vegetation that meets closure criteria will continue to develop through natural successional processes, as native propagules from the surrounding areas establish.

Fourth flawed assumption – All ecosystem 'classifications' should be present post rehabilitation

169 In my opinion, is completely inappropriate to assess rehabilitation at closure with undisturbed ecosystems. Nor is it appropriate, and or useful, to have vegetation composition criteria specific to more than a small number of ecosystem types (e.g., five as in the Closure Table, **Appendix One**) for three reasons:

a. It assumes vegetation is 'stable';

b. It narrows the target outcome, and this can lead to perverse consequences; and

c. It promotes a subjective, predetermination of outcome at a higher resolution that is too prescriptive.

170 This is why the rehabilitation approach is to use five rehabilitation types (rockfields, shrubland, forest, herbfield and small ponds), rather than 12, 14 or 16 types. At closure, planted shrubland and forest will probably be 10–25 years old, so not have reached maturity at which comparison with undisturbed vegetation is relevant. At closure, basal area volume of this rehabilitated 'forest' is not going to be that of pre-mining forest and seedlings are likely to be 1–8 m tall. Tall forest trees and deep leaf-litter layers take many decades to develop after closure.

171 Using a high number of rehabilitation types with narrowly prescribed criteria based on pre-mining condition is likely to lead to perverse outcomes. An example of a perverse outcome is shown in Dr Lloyd's reporting of his monitoring of Campbell's Dump slopes.[42] The rehabilitated landform had 4% rock or bare ground. He regards this is as 'bad' because the natural forest had no bare ground or rock. However, including rocks in all habitat types is a deliberate rehabilitation practice to enrich the habitat and enhance the spatial heterogeneity that is characteristic of coal

[42] Lloyd 2018 evidence, paras 199-206

measures landscape. He considers the area ‘fails’ because the mānuka is too dense and upright with emergent trees. However, the site has a mosaic of healthy native vegetation with no sign of erosion (stability).

172 Negative assessments by Dr Lloyd and Dr Marshall also relate to ecosystems that are not included in the Te Kuha rehabilitation plan (and hence not included in the Closure Criteria) because they are technically difficult to create, or the mine schedule does not allow their salvage by machine direct transfer (as recorded in Item 7 of joint statement on rehabilitation). These ecosystems include boulderfields overlaid by forest (particularly those suitable for development of curtains of bryophytes), large rock outcrops, pink-pine forest and herbfield (to the extent that it is not directly transferred), cliffs, and bluff habitat. The parts of the ridgeline on which many of these ecosystems occur is composed of fractured exposed sandstone and large boulders; these are important ecosystems that are not being targeted for rehabilitation.

Fifth flawed assumption – The areas used in Dr Simcock’s primary evidence, Appendix 1 to illustrate rehabilitation outcomes are unusually high quality[43]

173 The areas I have in Appendix 1 are deliberately not high quality. As I identify in para 96, some sites identified by Dr Marshall, were not included in my primary evidence as I considered the standard to be unrealistically high, for example the (award-winning) ‘Augusta snail restoration site’ (A10). Instead, I focus on DT in areas such as R6, which is useful to show a wide range of quality outcomes. I have also been clear to identify in para 97 the very high quality of DT boulders in the Hook Dump trial and difficulty of achieving this outcome.

RELEVANT PLANNING PROVISIONS

174 I have been asked by counsel for Stevenson Mining to comment on regional and district planning provisions relevant to

[43] Eg Lloyd 2018 evidence para 210

rehabilitation. My comments are set out in **Appendix 3**. In summary I consider the proposal to be consistent with the relevant planning provisions insofar as they refer to or relate to rehabilitation to minimise and address effects.

CONCLUSION

175 I have confidence that the planned landscape outcomes can be achieved based on rehabilitated landforms and vegetation covers delivered for similar ecosystems over the last 5–20 years at similar sites on the West Coast (**Appendix 1**). The survival rates, range of growth rates, and generation of self-established (adventive) seedlings from nursery seedlings and direct transfer can be confidently predicted at Te Kuha, given the mine schedule and plan allows a) for suitable soil quality and volume to be salvaged and reused on rehabilitated areas, and b) underpinning landforms are backfilled to meet natural ground levels, and to create significant areas of 0–12 degrees slope treated to create conditions favouring shrubland (over forest).

176 In my opinion, most rehabilitated forest areas at Te Kuha should deliver a very high proportion of native plant cover about 1–2 m high within 10 years of initial revegetation, noting that in some areas plant cover is proposed to be deliberately reduced by use of wood habitat piles, boulders, and rock mulch, or poorer drainage (e.g. herbfield and shrubland).

177 A minimum 15 ha of the site will be rehabilitated using direct transfer (Condition 52(a)). This provides for genetic conservation of yellow-silver pine, *Celmisia, Dracophyllum densum,* and other priority vascular plants. Probable exceptions are *Metrodsideros parkinsonii* (because there is limited experience with propagating this species) or *Euphrasia* (because there is very little herbfield available to be salvaged). The rehabilitation potential of bryophytes has received very little attention; but rehabilitated Stockton sites indicate success of some species in rockland and yellow-silver pine – mānuka shrubland.

178 Ecosystem complexity and intactness will inevitably be reduced after the completion of mining, i.e. the natural fine mosaic of

ecosystems will be replaced by a much coarser mosaic that is inevitably more regular.

179 The development of deep leaf-litter layers and tall, complex vegetation structure will take many decades in most planted areas. Tall, structurally complex native forest will be the slowest to recover. Invertebrate and vertebrate species that require such conditions are therefore likely to be affected to a greater degree than those of open areas. This is consistent with all other large-scale vegetation clearance.

180 Even with best weed control and biosecurity, the diversity and cover of non-native species is likely to increase, at least in the medium term.

181 The rehabilitation proposed and required by the conditions, is in my experience and opinion, best practice within the constraints of the current mine schedule that limits use of direct transfer and builds on experiences and successful results from previous mining operations. I consider my assessment is conservative, not overly optimistic, given the core rehabilitation methods that have been applied to many components of coal measures ecosystems, at suitable scales (tens of ha) and for durations (10–20+ years) that provide confidence in rehabilitation trajectories. These methods need to be refined for the Te Kuha site, and this refinement is provided for by the mine schedule and rehabilitation management plan. The anticipated rehabilitation outcomes are supported by closure criteria and consent conditions I have helped draft and consider are best practice. They allow an appropriate degree of flexibility while maximising the likelihood the consented outcomes will be achieved. Annual monitoring and reporting should a) encourage adaptive management and b) ensure that if rehabilitation targets are at risk of not being achieved, there is time to adjust and apply remedial actions.

Robyn Simcock

August 2021

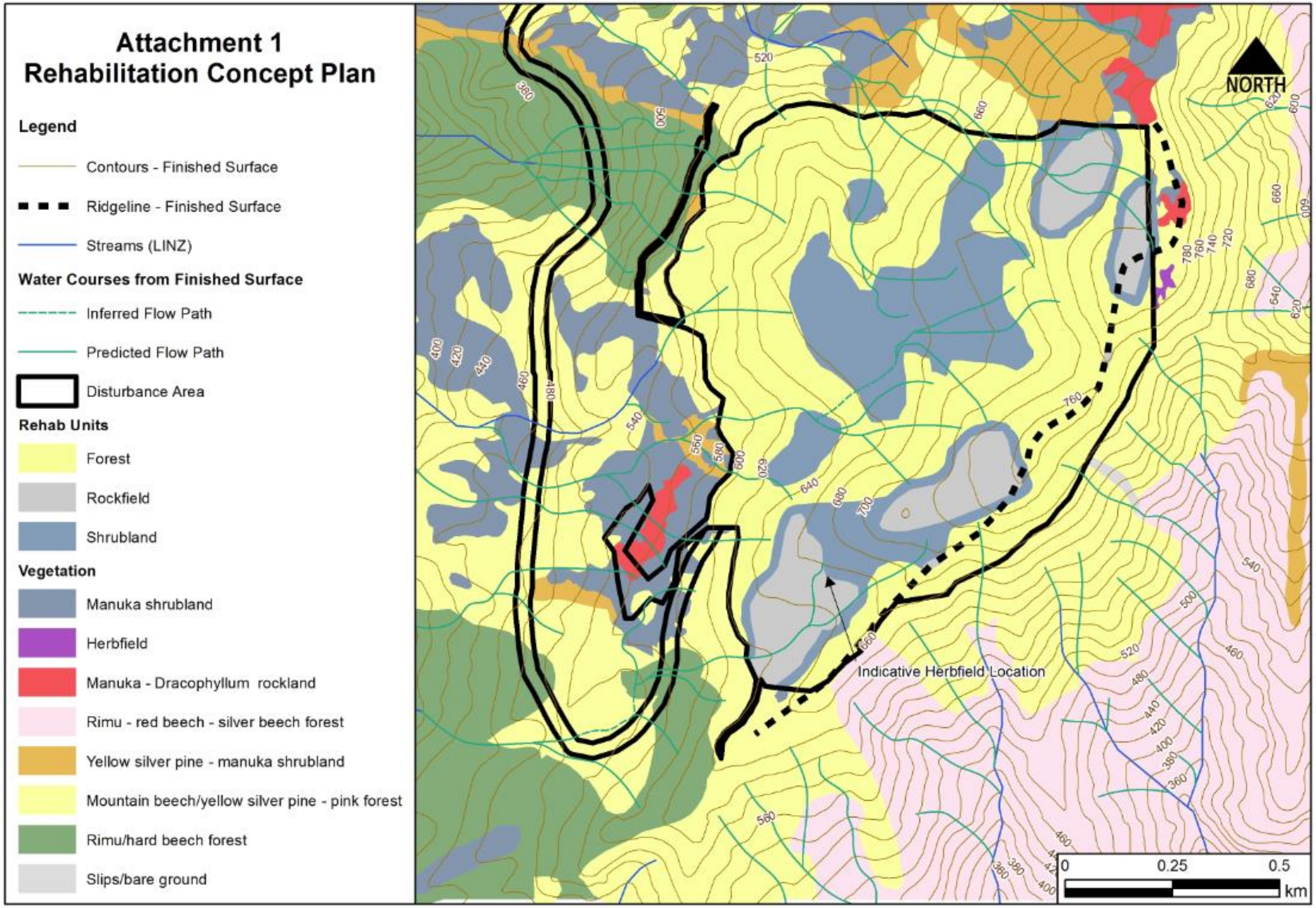

Figure 2. Te Kuha Ecological Rehabilitation Concept Plan.

Table 5. Impact on individual ecosystems at Te Kuha for rehabilitation by Direct Transfer and planting nursery-raised seedlings[44]

Vegetation Association / Ecosystem Rehabilitation strategy	**DT priority**	**Main plant species** Tolerant of high exposure and light levels, so can be successfully targeted for DT salvage where under 2m tall (Bold =>20% cover)	**Canopy and sub-canopy plant species planted as nursery seedlings**
Mountain beech/yellow silver pine – pink pine forest Nursery plantings with small DT areas Changed ecosystem[2]	MODERATE High along access road	***Empodisma minus, Gahnia procera**[1],* quintinia, mountain and silver beech, mountain toatoa, kamahi, yellow-silver pine and pink pine, *Pseudopanex linearis, Myrsine divaricata, Pittoporum rigidum, Pseudopanax colensoi, Astelia nervosa*, mountain flax, *Gahnia procera, Empodisma minus*	Mountain beech, silver beech, southern rata, *Pseudopanax linearis*, Groundcovers: *Astelia nervosa*, mountain flax
Yellow-silver pine – mānuka shrubland DT and planting; reduced area[3]	HIGH	***Empodisma minus*, mānuka,** southern rata, quintinia, mountain beech, pink pine, bog pine, Dracophyllum species and most understorey species. *Celmisia dubia* and *C. dallii, Gahnia procera, Empodisma minus*	Mānuka, southern rata, kamahi, mountain beech, mountain flax, *Pseudopanax linearis, Gahnia procera* *Interplant Celmisia hand transplants*
Herbfeild – *Euphrasia wettsteiniana* DT only; reduce area (genetic salvage)	HIGH	***Empodisma minus****, Actinotus novae-zelandiae*, mānuka, *Epacris alpina, Donatia nz, Euphrasia* spp, *Celimisa* spp etc… resilient to DT but vulnerable to weeds	Not applicable (only rehabilitated with DT)

[44] Mitchell Partnerships 2015. Appendix 11 of Te Kuha AEE, Table 12

Rimu/ hard beech/podocarp forest Planting; DT stumps	LOW[4]	Emergent rimu over hard beech, silver beech, mountain beech, diverse understorey changes with elevation but most are intolerant of sudden light /exposure changes	Quintinia, kamahi, beech species, toatoa, southern rata, nikau
Open mānuka shrubland (Parkinsons' rata, bryophytes) DT & planting	HIGH	***Empodisma minus*, mānuka, tangle fern,** *Epacris alpina, Gahnia procera*, southern rata, pines and dracophyllums, mountain flax	Mānuka, southern rata, mountain flax interplant *Celmisa hand transplants*
Mānuka – dracophyllum rockland Hand DT only; (genetic salvage) unless machine salvageable	MODERATE	**Mānuka, *Empodisma minus*, *Dracophyllum species*, tangle fern,** *Celmisia dubia,Celmisia dallii, Lepidothamnus laxifolius* Patches favourable to DT if rock exposure allows removal of intact soil sods and ridgeline backfill surfaces available with weed buffer	Mānuka (prostrate), Celmisia hand transplants

1 Success rate is high with plants <1 m height within intact DT sods 1 m by 1 m+ or larger with low root disturbance, but success as small sods (spade width) for individual plants probably relatively low

2 Ecosystem change due to a low proportion of DT for this ecosystem type and much simpler planting regime with high proportion of mānuka and flax and insignificant proportion of pines mean this ecosystem would be greatly reduced in area

3 Reduced extent is anticipated after-rehabilitation because similar ecosystems can only be established with certainty through DT; however, nursery planting includes most of the canopy species present so this has the potential to produce a greater area of a simpler, less diverse system in the medium term.

4 Outcome is poor because the trees are large. The canopy structure is absent for many decades and most understorey species (which aren't tree seedlings) are intolerant of sudden light exposure, especially ferns and bryophytes. However, DT is still effective for erosion control, to create protected microsites for seedling establishment, for introducing tree seedlings that are larger than nursery-raised plants and better able to compete against weeds and particularly for conserving topsoil and litter communities (including invertebrates).

Table 6: Potential for successful salvage and rehabilitation with dominant canopy species of different of ecosystems at Te Kuha.

Vegetation Association / Ecosystem (high-value plant species)	**Approximate area as % of coal measures vegetation in the local area**	**Approx. Canopy Height (m)**	**% cover <1 m height (Suitability for Direct Transfer)**	**Dominant plant species (>20% cover) <1m height**	**Dominant plant species over 1m height**	**Rooting depth and soil continuity (together these determine the ease of salvage)**
Mountain beech/yellow silver pine – pink pine	20%	4-8 m	50 (moderate)	*Empodisma minus*, *Gahnia procera* some yellow-silver & pink pine	Mountain beech; Yellow-silver pine; pink pine	Deep, continuous
Yellow-silver pine – mānuka shrubland (bryophytes)	20%	<3 m	50 (moderate to high)	*Empodisma minus*, mānuka	Parkinson's rata, yellow-silver pine, mānuka	Continuous
Hard beech/podocarp forest	<5%	<25 m	30 (low to moderate)	Some places have dense ferns (*Blechnum*, *Sticherus*)	Diverse: quintinia, kamahi, beech, toatoa, rata	Deep, continuous
open mānuka shrubland (Parkinsons' rata, bryophytes)	12%	<2 m	60 (high)	*Empodisma minus*, mānuka, tangle fern	Mānuka	Variable depth with some rock armouring and boulders, continuous
Mānuka – dracophyllum rockland	27%	0.5 m	100 (moderate)	Mānuka, *Empodisma minus*, *Dracophyllum*, tangle fern	Mānuka	Discontinuous, low salvageability where very shallow or boulders are large

Herbfield – *Euphrasia wettsteiniana*	100%	<0.5	100 (moderate)	*Empodisma minus*, bog pine?	Nil	Probably discontinuous between patches of Herbfield?
Pakihi	<5%	0.5	100 (high)	Mānuka, *Empodisma minus*, tangle fern	Mānuka	Continuous

Appendix Two. Extract from Simcock R, Ross C 2017. Mine rehabilitation in New Zealand: overview and case studies. Chapter 18. Pp 334-357. Spoil to soil: Mine site rehabilitation and revegetation Editors N.S. Bolan, M.B. Kirkham, Y.S. Ok. CRC Press

Appendix Three. Relevant planning provisions

Regional Land and Water Plan, Objective 4.3.1: ‘Policy 4.3.1: *To manage the disturbance of land and vegetation in order to avoid, remedy or mitigate any adverse effects on: (a) The stability of land (e.g. slumping, subsidence, or erosion), river banks, and riverbeds and coastal margins; (f) Soil depth and soil fertility; and (i) Significant indigenous vegetation and significant habitats of indigenous fauna*.

1. The Te Kuha mine closure criteria and other conditions which require a Rehabilitation Management Plan have been designed to deliver stable landforms covered with soils of suitable depth and fertility (and diversity) that support the three major ecosystem units (rockfield, shrubland and forest). The characteristics that underpin soil fertility of these three native ecosystems are moderate to high acidity (pH 4-5), moderate to high organic content (supplying N and P), and variable depth of soil. Shrubland and rockfield are typically on shallow, poorly-drained soils, whereas forest is on deeper, more freely-draining soils (particularly tall forest).

2. The mine impacts significant indigenous vegetation and significant habitats of indigenous fauna. In my opinion, the strategies and methods outlined in the conditions and the rehabilitation plan and biodiversity plans have been developed to avoid and remedy these adverse effects in the short and medium term to the extent practicable.

Buller District Plan Policy 4.5.5.5: *‘To require mineral resource related activities to incorporate measures to protect water quality and ecosystems, and provide for the rehabilitation of disturbed areas to generally their original condition or another suitable condition as approved by Council’.*

3. I consider this is addressed by the proposed conditions and closure criteria supported by rehabilitation objectives and Rehabilitation Management Plan which together: ‘*include practices to protect ecosystems adjacent to the mine site by management of edges (buffer zones) and minimising the impacted footprint through avoidance strategies’* and ‘*provide for rehabilitation to a condition that can naturally develop towards those of pre-mining ecosystems under a (funded) low maintenance regime’*. The post-mining condition will not be the same as pre-mining (i.e. the outcome will not be restoration), but will be consistent with adjacent and pre-mining ecosystems and useful as habitat for wildlife. The better-drained root zones over parts of the backfilled landform and their greater evenness (i.e. loss of the fine scale mosaic), combined with trees and soils that take many decades to develop a tall, multi-layered canopy mean achieving the original condition is not practicable and probably not possible.

4. However, the rehabilitation as proposed delivers a predominantly native plant cover that retains some of the essential elements (species and habitat types). This assessment is

underpinned by salvage, storage and replacement of soils, boulders, wood and plants, the establishment of nursery-grown seedlings from locally-sourced propagules, and achieving closure criteria that a) differentiate three main ecosystem types and b) minimise the influence of plant pests on the natural successional trajectory.

Buller District Plan Policy 4.8.7.1: '*The adverse effects of land use activities on natural habitats and ecosystems shall be taken into account when considering development proposals which impact on these areas'*.

5. The rehabilitation plan sets out how the adverse effects of ecosystem clearance and mining on natural habitats and ecosystems at Te Kuha have been taken into account with respect to on-site footprint minimisation and revegetation. It includes pest plant and animal management, and is integrated with biodiversity plans for specific species including lizards, ringlet butterfly, great spotted kiwi and bryophytes.

Regional Policy Statement 2020 Objective 4 *"Maintain the region's terrestrial and freshwater indigenous biological diversity."*

Regional Policy Statement 2020 Policy 8 *'Maintain indigenous biological diversity, ecosystems and habitats in the region by: a) Recognising that it is more efficient to maintain rather than to restore indigenous biological diversity; b) Encouraging restoration or enhancement of indigenous biological diversity and/or habitats, where practicable…"*

6. The Rehabilitation Management Plan for the Te Kuha mine project has been developed with three priority outcomes, all of which are relevant to this Objective and Pol;icyPriority outcome 3, in particular, is: '*Establish self-sustaining native vegetation that can develop into a mosaic of vegetation associations resistant to pest plants, pest animals, drought and fire; and conserve genetic resources, particularly those of threatened or at-risk species*. This is consistent with Policy 8, noting that open-cast mining and road building necessarily damage ecosystems by removing overlying soils and plants to access the minerals resource and build ex-pit landforms**.**

Regional Land and Water Plan, Objective 4.2.1: *'To avoid, remedy or mitigate adverse effects from land disturbance so that the region's water and soil resources are sustainably managed'.*

7. The mine and road rehabilitation objectives for Te Kuha, and Rehabilitation Management Plan, supported by proposed closure criteria, have been designed to deliver sustainable management of soil resources. Specifically, the mine plan provides adequate footprint space to store all stripped soils, the contour of the mine site allows most soils to be salvaged, and the re-use of soils to provide root zone for rehabilitation underpins

rehabilitation. Backfill of the mine pits with rehandled overburden means no permanent pit highwalls or lakes are proposed. The establishment and development of dense vegetation cover (as required by the closure criteria condition) will protect soils from erosion and over time develop humus layers.

8. The following strategies minimise the effects of mining operations at Te Kuha. Rehabilitation methods are designed to achieve the proposed closure criteria that remediate adverse effects to the extent practicable under the current mine plan.
9. In my opinion, these rehabilitation methods are current best practice and have been demonstrated as effective elsewhere on the West Coast. The outcomes are supported by conditions requiring annual reporting and auditing of key rehabilitation resources and measurement of indicators of success. Impacts have been minimised using the following key approaches:

- Avoiding stockpiling and using Direct Transfer where the mine plan allows, including a minimum area of Direct Transfer.
- Salvage, stockpiling and replacement of coarse wood for use in areas destined to be forest.
- Salvage and relocation of weathered boulders and lichen flora; use of boulders to create lizard habitat features throughout rehabilitated rockland and shrubland.
- Using local genetic resources for rehabilitation – not introducing plant material from outside Ngakawau ED or below 500 m (for mine site).
- Biosecurity. Weed management focuses on prevention of weed establishment, supported by closure criteria, rehabilitation of the road fill batters with direct transfer, and integration of rehabilitation with earthworks plan to ensure risk assessment of potential sources of weeds in road gravels and materials used in erosion control, cleaning of any earthworks equipment, and nursery-grown seedlings.

Proposed Buller District Plan, Chapter 2.3: Objective – '*Mineral extraction activities: to enable mineral extraction activities that provide economic and social benefits to the community, in a manner that avoids, remedies or mitigates adverse effects on the environment'*. The rehabilitation approach proposed for Te Kuha has included avoidance and will continue to do so. However, by its nature, coal mining must occur where the resource is present, so it is not possible to avoid removing ecosystems that overlie coal which is extracted (see #Avoidance for detail). It is my opinion, however, that the conditions as proposed will result in best practice remediation and mitigation of effects.

Proposed Buller District Plan, Chapter 2.3, Policy 4 – *Rehabilitation: 'to ensure that during and after mineral exploration and extraction activities, sites are progressively rehabilitated to enable the establishment of a land use appropriate to the area'.*

10. This approach has been adopted for Te Kuha within the mine plan, for example, the haul road fill batters (9 km) rehabilitated within the first year and about 16 ha of ex-pit overburden to be rehabilitated in years 2 and 3. Over the 19 year mining phase, there are just 4 years in which no new permanent areas of rehabilitation are planned. However, in practice revegetation is likely to occur in all but one year to smooth nursery and rehabilitation practice. Progressive rehabilitation is required by proposed condition 50.