Business and Biodiversity Offsets Programme (BBOP)

BBOP Pilot Project Case Study

Strongman Mine – New Zealand

SOLID ENERGY
Coals of New Zealand

BBOP
Business and Biodiversity Offsets Programme

Forest Trends, Conservation International and the Wildlife Conservation Society provided the Secretariat for BBOP during the first phase of the programme's work (2004 – 2008).

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About this document

To help developers, conservation groups, communities, governments and financial institutions that wish to consider and develop best practice related to biodiversity offsets, the Business and Biodiversity Offsets Programme (BBOP) has prepared a set of Principles, interim guidance and resource documents[1], including pilot project case studies, of which this document[2] is one. All those involved in BBOP are grateful to the companies who volunteered pilot projects in this first phase of its work.

The ability to test methods and learn from practical experience in a set of pilot projects has played an important role in the development of the BBOP principles on biodiversity offsets and supporting materials during the first phase of the programme's work (2004 – 2008). Six organisations (five companies and one city council) volunteered to undertake pilot projects during BBOP's first phase, with some joining at the outset, and some at later stages. While BBOP has offered some support and technical advice to the individual pilot projects through its Secretariat and Advisory Committee, each pilot project has been directed and managed by a team employed or contracted by the companies and city council leading the respective projects. Each of the case studies prepared by the pilot projects explains the approach taken and how close the project has come to completing the design of the biodiversity offset concerned, and sets out the developer's current thinking on the most appropriate offset. This may change as the project teams finalise their offset design and start implementation. The nature of the guidance used by the pilot projects has varied according to which drafts of the evolving BBOP Handbooks were available to them at the time. This and the individual circumstances and context of each pilot project have affected the extent to which they have used or adapted the BBOP guidance. Consequently, the case studies do not necessarily reflect the range of interim guidance currently presented in BBOP's BIODIVERSITY OFFSET DESIGN HANDBOOK, COST-BENEFIT HANDBOOK and IMPLEMENTATION HANDBOOK.

Solid Energy New Zealand Limited is still working on the design of the proposed biodiversity offset discussed in this case study and the document reflects the position as at March 2009. Consequently, none of the suggested or projected activities based on fieldwork to date represent a commitment on the part of Solid Energy New Zealand Limited and its potential partners to proceed with the offset as described in draft form in this document or at all. The information and data relating to possible offset sites, areas and activities are presented here to communicate the initial work that has been done on a potential offset design and to illustrate one possible approach to the design of a biodiversity offset intended to comply with the BBOP PRINCIPLES.

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BBOP is embarking on the next phase of its work, during which we hope to collaborate with more individuals and organisations around the world, to test and develop these and other approaches to biodiversity offsets more widely geographically and in more industry sectors. BBOP is a collaborative programme, and we welcome your involvement. To learn more about the programme and how to get involved please:

See: **www.forest-trends.org/biodiversityoffsetprogram/**

Contact: **bbop@forest-trends.org**

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1 The BBOP Principles, interim guidance and resource documents, including a glossary, can be found at **www.forest-trends.org/biodiversityoffsetprogram/guidelines/**. To assist readers, a selection of terms with an entry in the BBOP Glossary has been highlighted thus: **BIODIVERSITY OFFSETS**. Users of the Web or CD-ROM version of this document can move their cursors over a glossary term to see the definition.

2 This case study was prepared by Dr R. Bartlett, Dr R. Simcock, M. Pizey and M. Morgan with contributions from R. Harrison and R. Buckingham.

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1. Introduction

1.1 BBOP framework

Biodiversity offsets are conservation actions designed to compensate for the significant RESIDUAL IMPACT on biodiversity caused by development, to ensure no net losses, and preferably, a net gain of biodiversity. They offer one mechanism to balance the impacts of development activities with the conservation of biodiversity, the sustainable use of its components and the fair and equitable sharing of benefits. As such, biodiversity offsets provide one mechanism to support 'sustainable development'.

The Business and Biodiversity Offset Programme (BBOP) is a partnership between companies, governments, conservation experts and financial institutions that aims to explore whether, in the right circumstances, biodiversity offsets can help achieve better and more cost effective conservation outcomes for biodiversity than normally occur in infrastructure development, while at the same time helping companies manage their risks, liabilities and costs.

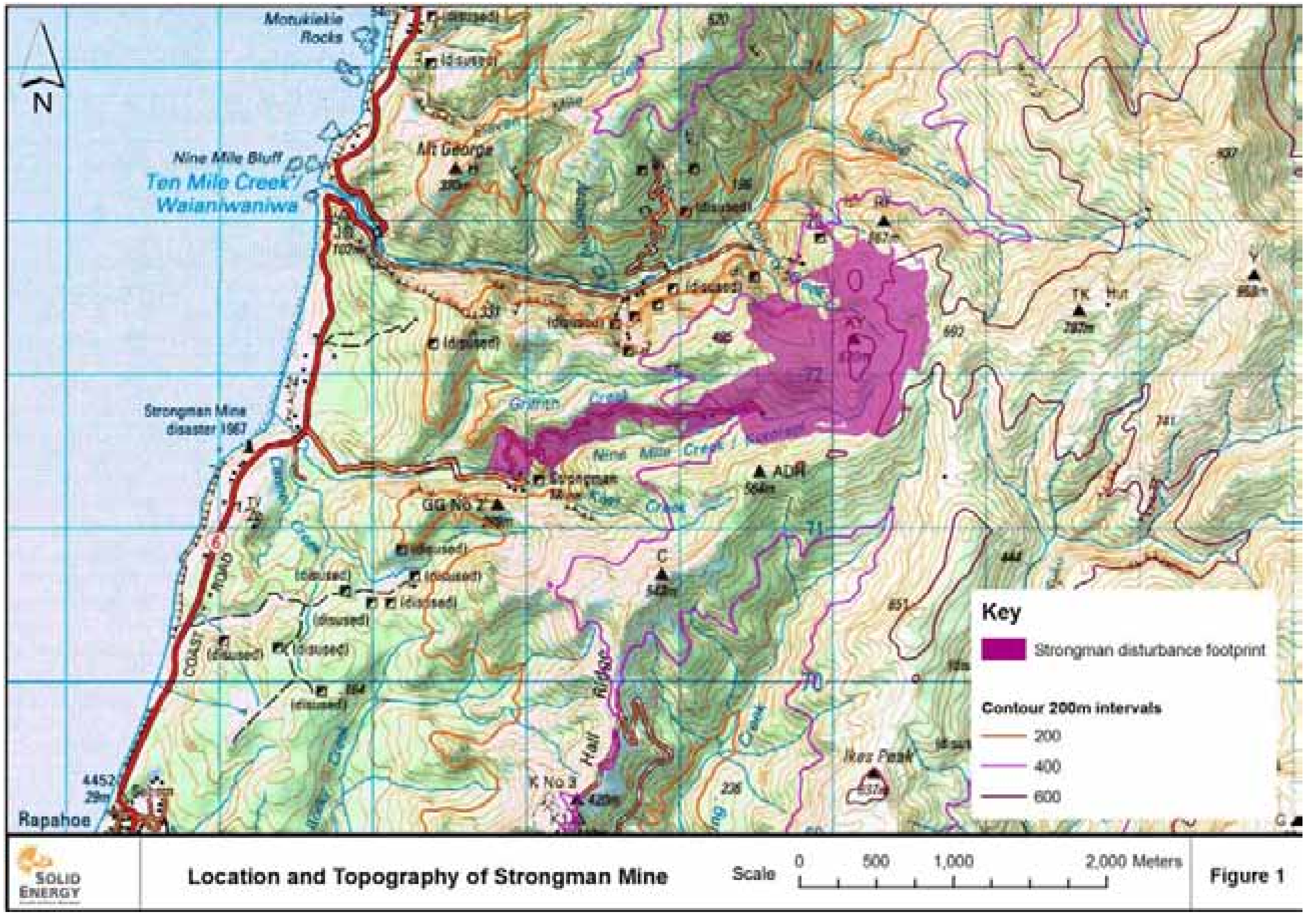
The approach to biodiversity offsets being piloted by BBOP is to compensate for significant residual adverse impacts on biodiversity arising from land use activity. Prior to an offset being considered a hierarchy of first avoiding then minimising and finally mitigating the FOOTPRINT of the activity should be considered during the project design. Impacts may be direct (e.g. removal of HABITAT) or indirect (e.g. weeds / edge effects) and may also be CUMULATIVE. Successful biodiversity offsets assist in achieving a 'NO NET LOSS', and ideally, a NET GAIN of biodiversity with respect to:

- Species PERSISTENCE PROBABILITY (as assessed in terms of population viability, species occupancy, population size, relative abundance, or other appropriate measures).
- Habitat extent and CONDITION (height, mass, complexity).
- ECOSYSTEM SERVICES (e.g. surface water quality and quantity, stability / erosion).
- Social, cultural and aesthetic impacts (e.g. harvesting / traditional use, walkways).

1.2 The Strongman Mine project

The Strongman Mine, operated by Solid Energy New Zealand Limited (Solid Energy), is situated on the West Coast of the South Island, near the town of Greymouth and is landlocked within a large area of indigenous vegetation (Figure 1). Underground mining began in the Strongman Underground Mine in 1939 and continued until 1994 when production commenced at the Strongman 2 Underground Mine. In 1997, the Strongman Opencast Mine operation commenced, to recover the balance of the shallower coal resource which could not be extracted from underground operations.

Figure 1: Location and topography of Strongman Mine



Strongman 2 Underground Mine closed in 2004 and mining was completed in early 2005. The site has since been the subject of significant REHABILITATION work including landform development, surfacing with growth media and revegetating. The mine site and associated access road is the focus of the Strongman Mine BBOP Pilot Project.

This biodiversity offset pilot project is being undertaken in retrospect rather than as part of the development and design of a new project. The pilot project only began in 2008, by which time most of the negative impacts from the three stages of mining had already been incurred. The critical implications here are: (i) the window of opportunity to avoid and minimise impacts had largely closed (albeit not the opportunity to rehabilitate / restore) and therefore the project could not strictly adhere to the MITIGATION HIERARCHY, as enshrined in the BBOP PRINCIPLES; (ii) because the residual impacts had already taken place, they could be measured rather than predicted (as is the case for several other BBOP pilots), in theory, therefore, the Strongman case study should be able to quantify the size and nature of the offset required much more precisely. Initially there was some concern that not all of the necessary data would be available to construct a pre-operation biodiversity BENCHMARK; however the subsequent fieldwork data collection stage has provided a robust BASELINE data set. Because of the time delay between biodiversity impact and initiation of an offset, the size of the offset is increased.

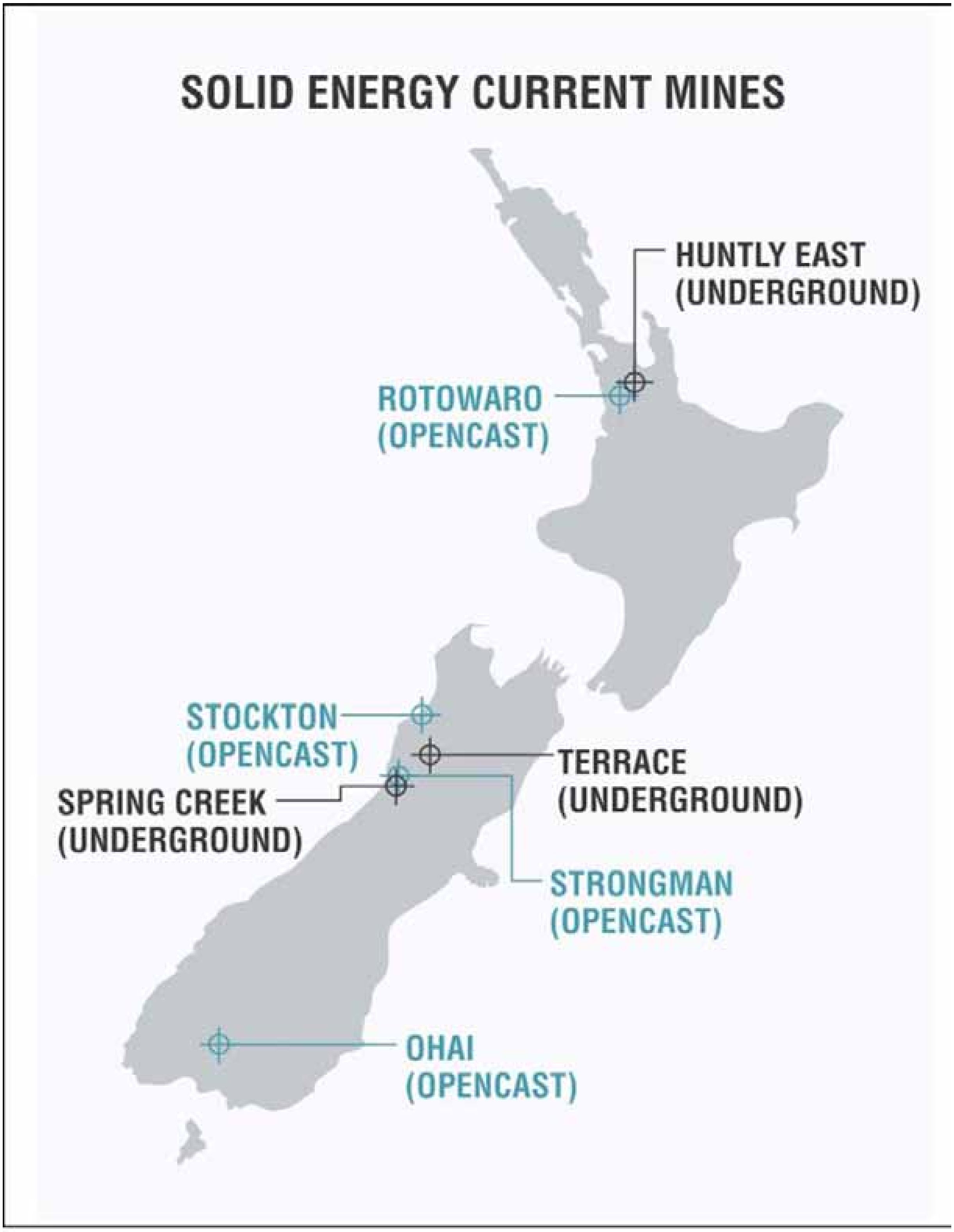
This document is a 'work in progress' and at this stage does not cover the offset proposed, implementation plan or project outcomes.

1.3 Project context

Coal mining in New Zealand is controlled by several pieces of legislation. The legal framework controls such things as access to minerals, the use of water, rehabilitation standards and health and safety. A common requirement is for land to be used sustainably, which is achieved in part through ensuring appropriate rehabilitation of disturbed land. Control of mining as a land use is split between central and local governments, the former dealing with access to the mineral resource and the latter concerned with the effects on the environment. It is common for a financial bond to be established with one or both of these parties before mining commences. The quantum of this bond is determined by the potential rehabilitation and CLOSURE costs of the operation in question.

Solid Energy is a State Owned Enterprise (a Government-owned but independently operated company) that owns and operates opencast and underground coal mines, as well as renewable fuels businesses and coal gasification interests, throughout New Zealand. The company produces approximately 4 million tonnes of coal per annum of which 50% is metallurgical coal exported to the steel manufacturing industry, with the balance split between electricity generation and domestic industry users. The mine sites are distributed throughout the country as shown in Figure 2.

Figure 2: Solid Energy's coal mining interests in New Zealand

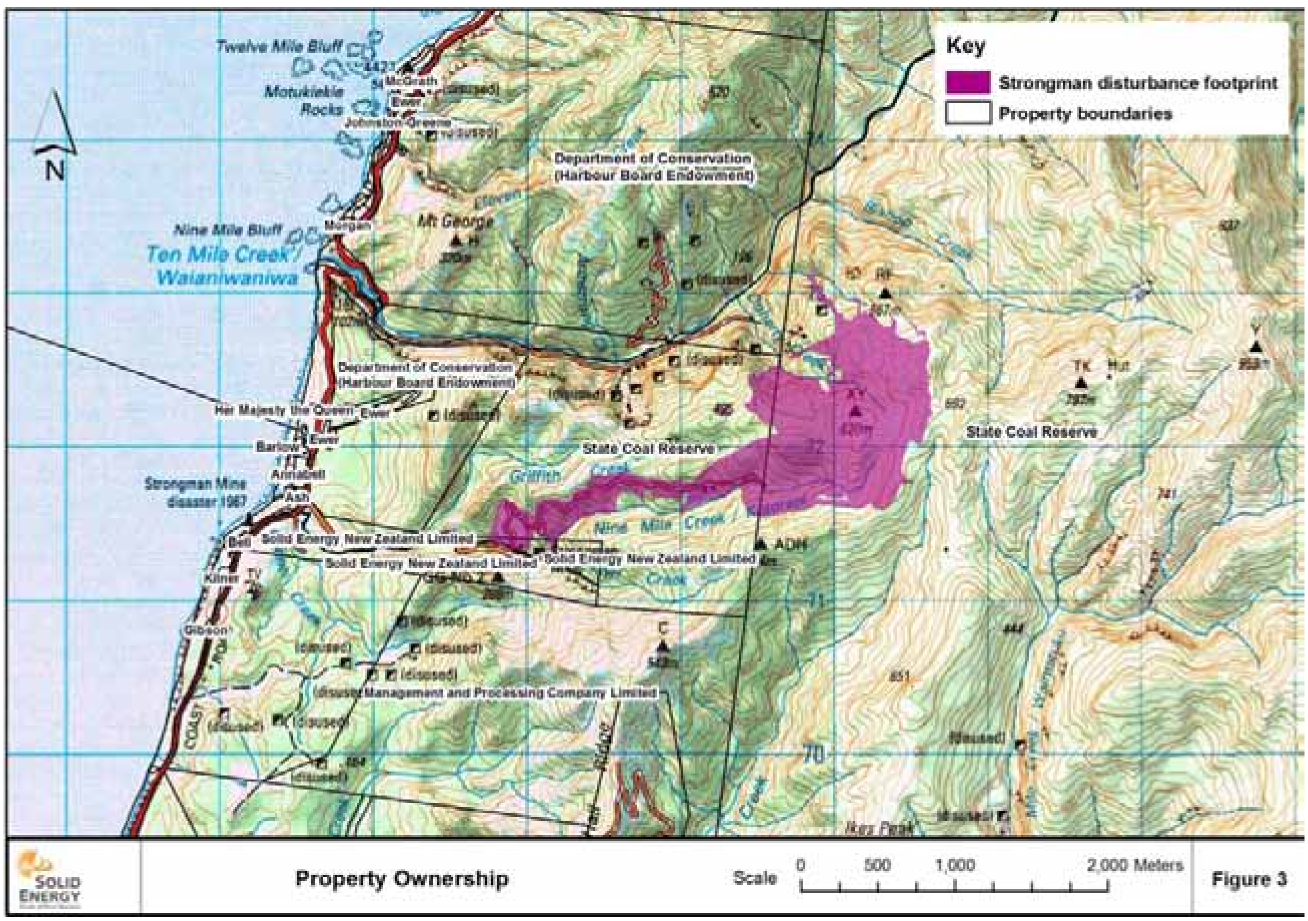


SOLID ENERGY Coals of New Zealand	**Solid Energy's coal mining interests in New Zealand**	**Figure 2**

The Strongman Mine is located on Government-owned land administered by Ministry for Economic Development (MED) as shown on Figure 3. Solid Energy carried out mining operations there under Mining Permit 37-159, granted in 1987; the Strongman access road operates under ancillary licence CML37159-01. Resource consents issued under the Resource Management Act 1991 permitted the mining and mine-related activities undertaken at the site subject to certain conditions. Conditions do not specifically relate to biodiversity. Indirect references to biodiversity in the CML include three specific objectives for site closure and rehabilitation: (i) to return land 'to a state suitable for recreation, wildlife habitat or other use as specified in the detailed rehabilitation plan' (ii) to preserve and restore landscape values in consultation with interested local agencies and (iii) to control noxious weed species within the license area (Golder Associates 2007).

The land surrounding the mine area is Coal Reserve, which is in turn surrounded by Conservation Estate (Reserves, Conservation Areas and Harbour Board Dryland Endowments), managed by the Department of Conservation. The Department of Conservation is the government agency charged with managing such land under the provisions of the Reserves Act 1977 and Conservation Act 1987. It is the primary conservation and environment agency in New Zealand, administering about 30% of the land area (including about 90% of the West Coast of the South Island) and charged with conserving the natural and historic heritage of New Zealand.

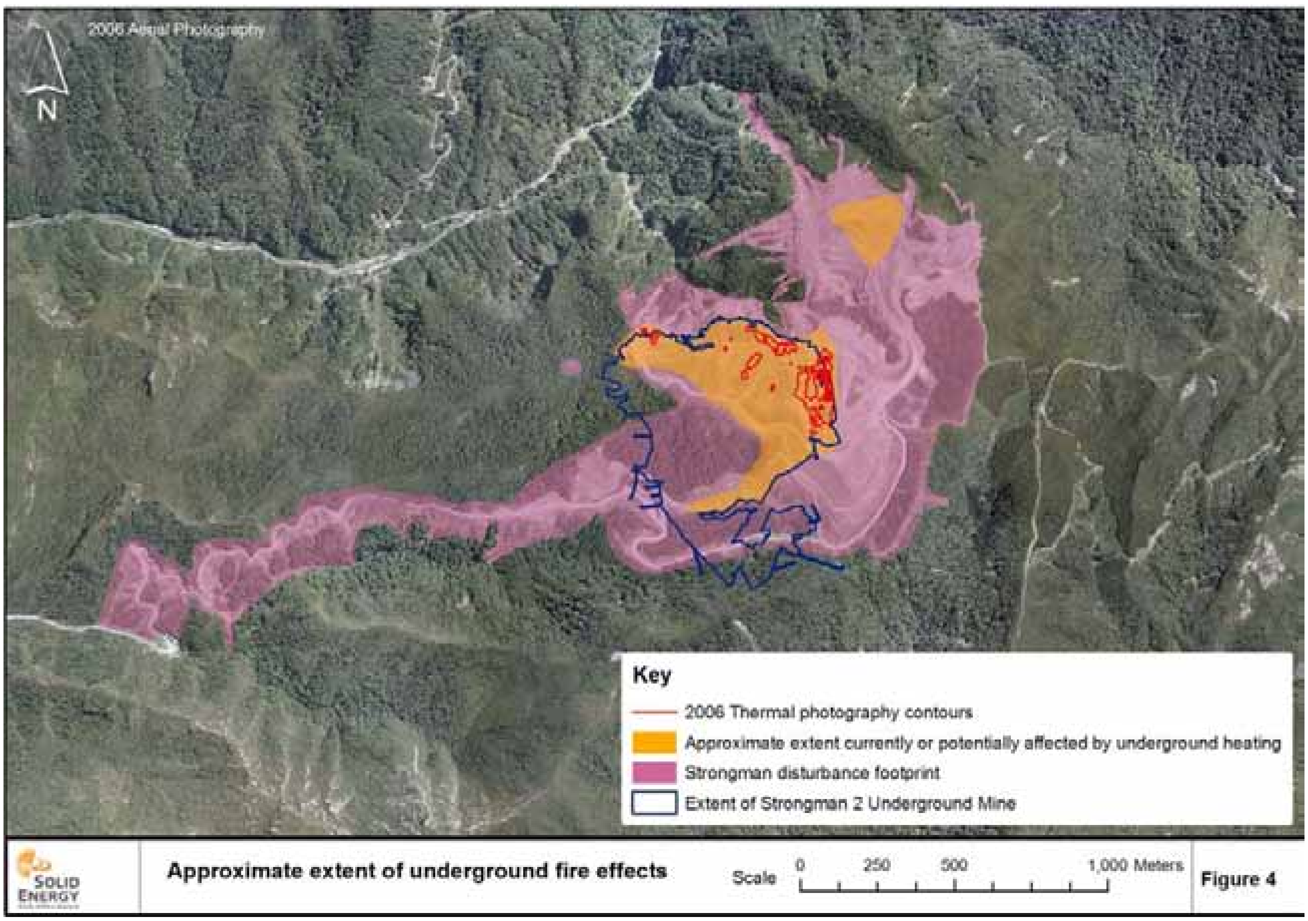
Figure 3: Property ownership



Underground production in the Strongman 2 Mine was undertaken using 'hydro mining' where the mine is developed up-dip (i.e., uphill along a rising coal seam) and a sump is installed with suitable crushing, screening and pumping equipment. Coal is then cut using a high pressure water jet and transported by the water to the sump and thence to the surface facilities. This technique allows for high recovery rates of the coal with up to 80% being recovered compared to only 20 – 30% recovery in conventional bord and pillar mining techniques[3]. The system is especially suited to the thick seams present in the Grey coalfields. Coal was transferred by truck to the Rapahoe coal handling facility for blending and transported by rail to the port of Lyttelton, near Christchurch.

The Strongman coal is particularly prone to spontaneous combustion. Hydro mining also induces significant subsidence because of the high extraction ratio and this combined with the proximity to the surface (<35 m) for some of the extraction panels has lead to the ignition of coal that was not mined, through the ingress of oxygen and subsequent spontaneous combustion. The resultant fire has burnt through to the surface in places destroying some vegetation (the larger south western area shown in orange and red on Figure 4). This vegetation removal has been a factor in the instability of adjoining steep slopes, and failure of small areas of revegetation. Fire has also developed within a discrete area of overburden at the north east of the site where overburden was placed on top of hot rock transferred from another fire area, and the carbonaceous materials within the overburden subsequently ignited (shown in orange as the smaller north eastern area on Figure 4).

Figure 4: Approximate extent of underground fire effects



3 Further information describing this technique is available at **http://www.teara.govt.nz/EarthSeaAndSky/MineralResources/CoalAndCoalMining/6/ENZ-Resources/Standard/2/en**.

The fire in the Strongman Mine was first noted in 1998 when opencast operations began at the head of Nine Mile Creek, and has burnt continuously since. Fire has recently been brought under partial control through the use of grouting techniques (to exclude air by filling cracks, portions of underground workings and some drillholes); however, it will probably continue to burn in some south-western areas for the foreseeable future and will require ongoing management. The fire is currently restricted to areas where the underground workings are beneath a relatively shallow overburden layer, meaning that this area is more accessible to air and hence to continued combustion. Deeper workings may be fire affected however they do not have the same effect at the surface. The majority of the area above the underground mine and the adjoining opencast mine is not affected by the fire and rehabilitation of this ground has progressed. Extinguishing the fire is difficult, but Solid Energy is committed to working towards achieving control over it, although the company acknowledges that fire could spread further within the area of underground workings.

Opencast mining required construction of a culvert on Nine Mile Creek and the diversion of, and discharge of settling pond water into, Waterfall Creek, a headwater of Ten Mile Creek. Extraction expanded in 2001 with the development of the Strongman North opencast which straddles a ridge dividing the Ten Mile and Seven Catchments. All opencast mining used conventional truck and shovel methods; some overburden was used to reduce air movement into the Strongman 2 underground workings and other overburden was used to backfill completed opencast pits. Mining ceased at Strongman in early 2005 by which time approximately 101 ha of vegetation ranging from tall mixed podocarp and beech forest to sub-alpine shrubland had been removed or covered. Plate 1 shows the site viewed from the north when mining was still progressing, but near the end of mine life.

Plate 1: Oblique aerial photo of the Strongman Opencast Mine site

At the time the Strongman Opencast project commenced, Solid Energy was required to 'avoid, remedy and mitigate' its effects under the Resource Management Act 1991 (similar to BBOP's 'avoid and minimise' approach) and attempts were made to minimise the footprint of the mine, however this was not consistently applied. The company operated in compliance with the New Zealand statutes (including its Coal Mining Licence and resource consent conditions). Attention was paid to aquatic biodiversity monitoring and the maintenance of water quality, with effort also expended on the recontouring, resurfacing and replanting of the opencast area.

In 2003, following the development of the underground fire, complaints about water quality and a major landslide from the opencast mine site to the river below, Solid Energy made a public commitment to address the environmental impacts of the mining operation beyond the rehabilitation of the site alone. The three mitigation projects include the rehabilitation of an 'orphan' opencast mine site in the district, the re-establishment of native riparian plantings in the adjoining catchment and the development with the community of appropriate AMENITY resources to compensate for the loss of values from the mine site and adjoining land. These initiatives are described further in Appendix 6.

All these mitigation activities have been underway for several years. The mitigation activities did not apply the BBOP methodology as this BBOP case study only commenced in 2008.

1.4 Issues of particular importance in New Zealand

The following issues are of particular importance in New Zealand, and influence the biodiversity offset approach taken in the Strongman case study.

- About 30% of the land area is in public ownership under conservation management by a single authority, the Department of Conservation. Approximately 25% is farmland and within that over 90% of indigenous ecosystems have been lost. These ecosystems were concentrated in lowland areas (Walker et al. 2006).
- The indigenous plants and animals are highly distinctive, with high levels of endemism (>80% in many groups) and many unusual forms, particularly birds and large invertebrates that filled the niches occupied by marsupials or mammals in other countries, but were absent in New Zealand until relatively recently. The larger birds and large insects are extremely vulnerable to mammalian browsers and predators (e.g., McLennan *et al.* 1996). Conservation of biodiversity requires removal or control of mammals.
- ADAPTIVE MANAGEMENT regimes focusing on eradication or control of predators or browsers are established and have resulted in positive responses of many native species (Elliott and Suggate 2007; Innes *et al.* 1999; 2004).
- Virtually no terrestrial indigenous species are harvested or managed for economic gain. Most indigenous animals are absolutely protected and cultural use extremely limited.
- Existing mechanisms are available for biodiversity protection on private land through covenants administered by Queen Elizabeth 2 National Trust / Nga Kairauhi Trust (**http://www.openspace.org.nz/**).
- Although the presence of threatened species is specifically taken into account during Resource Consent process under the Resource Management Act (1991), the practice of biodiversity offsets and environmental compensation is ad hoc and variable with no established procedures (Borrie *et al.* 2004).
- Relatively rich national databases are available, including National Vegetation Survey based on >14,000 permanent and 50,000 temporary plots measured over the last 50 years (Wiser *et al*. 2001), NZ Carbon Monitoring Scheme (>1400 permanent plots across an 8 km grid in shrubland and forest), satellite imagery (Land Cover Database), and Land Environments of New Zealand database (Leathwick *et al*. 2002; 2003), combined with survey data from the Department of Conservation, Protected Natural Areas Programme (Wildlands Consultants 2004).

1.5 Business case for a biodiversity offset

In Solid Energy's case there are four factors that make the adoption of biodiversity offsetting either a requirement for, or attractive to, future business planning:

- Solid Energy's Environmental Policy.
- Granted consents.
- Social license to operate / right to mine.
- Potential biodiversity marketing.

1.5.1 Solid Energy's Environmental Policy

Solid Energy's Environmental Policy states that the cumulative result of all of its activities is to have a *positive net effect* on the New Zealand environment. To achieve this, the company undertakes, amongst other things, appropriate non-mining projects that have significant positive benefits for the New Zealand environment. To date Solid Energy has focused on the reduction of impacts on-site where possible and on the direct financial support of programmes, usually undertaken by a third party, designed to achieve a benefit in biodiversity terms. An example is the provision of funding for predator control to enhance the breeding success and survival of the nationally endangered blue duck (*Hymenolaimus malachorhynchos*) in the Oparara catchment in Northwest Nelson and the Styx and Arahura Rivers in the Westland District. The inclusion of offsets designed to address the impacts of a specific project permits closer control of cost-benefits and accurate project costing.

1.5.2 Granted consents

Consents granted to Solid Energy contain conditions requiring the company to undertake specific activities to enhance biodiversity in areas immediately adjacent to the mine sites. These activities are designed to offset the impact of the mining activity on kiwi and snail populations within the mine footprint particularly at West Coast sites; and on aquatic habitat and biota at many other sites (including Strongman). A recognised tool to quantify the level of investment required to achieve the consent conditions is necessary.

1.5.3 Social licence to operate

The operations of the minerals industry in New Zealand (and indeed, internationally) have increasingly come under public scrutiny. It is important to recognise that offsetting represents an opportunity for Solid Energy to build and enhance its social license to operate. Maintaining a social licence to operate is about operating in a manner that is attuned to community expectations, and which acknowledges that businesses have a shared responsibility with government and with society to more broadly facilitate sustainable development.

Being able to demonstrate ongoing excellence in maintaining and enhancing offsetting arrangements is critical to maintaining and enhancing confidence within the community that environmental impacts will be properly managed. The fact that these impacts are unavoidable, and therefore critical to the continuation of Solid Energy's business, means that maintaining this social licence to operate through effective offsetting is also a critical business requirement.

1.6 Engaging stakeholders

Consultation with STAKEHOLDERS commenced in March 2008 when a meeting was convened with key stakeholders to discuss the aims and methods of the proposed Strongman BBOP case study and to visit the Strongman site. Those involved included staff from the Department of Conservation's national and regional offices and Solid Energy staff and consultants. Discussions covered the methods that might be used to determine pre-mining biodiversity values and potential methods for quantifying the offset required.

A second meeting was held in December 2008 to report on the work to date and to seek feedback on the possible offsets under consideration. Staff from the Department of Conservation, the West Coast Regional Council and *Te Runanga O Ngati Waewae* (representatives of the local Maori tribe) attended this meeting. The type and details of the offset required are still under consideration.

Topics discussed at this meeting included the selection of INDICATOR species, the preferred hierarchy for selection of the offset site and type and the methodology for calculating BIODIVERSITY LOSS.

It was agreed that a cultural component that reflects the *mana whenua*[4] of *Ngati Waewae* (see Table 1) is required. Consultation with *Ngati Waewae* to complete this is underway.

As part of the offset design process (yet to be undertaken) Solid Energy expects to engage all parties listed in Table 1.

Table 1: Stakeholders and their areas of interest

Stakeholder group	Area of interest
Department of Conservation	Administration of and advocacy under the Conservation Act, conservation of biodiversity, land management
West Coast Regional Council	Regional Authority with responsibility for environmental management and permits
Ngati Waewae	The local Maori tribal group
Paparoa Wildlife Trust	Local NON-GOVERNMENTAL ORGANISATION (NGO) focusing on conservation of wildlife in the region
Grey District Council	Territorial Authority responsible for land use management
Ministry for the Environment	Government agency administering the New Zealand Biodiversity Policy
Land Information New Zealand	Land administration on behalf of the New Zealand Government
Ministry of Economic Development	Mineral estate administration on behalf of the New Zealand Government
Forest & Bird Protection Society of New Zealand	NGO with an interest in ecological and environmental issues
Queen Elizabeth II Trust	Administrator of land protected for the purposes of conservation

4 *Mana whenua* can be translated as territorial rights or power and prestige associated with the possession and occupation of tribal land.

2. The Offset Design Process

2.1 Preliminary steps

2.1.1 Project development

In July / August 2008 Mitchell Partnerships and Landcare Research New Zealand Limited worked with Solid Energy staff at Rapahoe, near Greymouth, (the administrative base for the Strongman Mine site) through the first three steps in the BBOP process, as outlined in the Biodiversity Offset Design Handbook (available at **www.forest-trends.org/biodiversityoffsetprogram/guidelines/odh.pdf**). The partners sought to adapt these steps to the context of the site and New Zealand, specifically making use of New Zealand databases such as the Land Environments of New Zealand ('**LENZ**') database (Leathwick *et al*. 2002), National Vegetation Survey Database and draft guidance on calculating BIODIVERSITY LOSSES and GAINS developed by BBOP (Treweek *et al*. 2008), in particular variations on the 'HABITAT HECTARES' approach.

The process followed was:

- Identify site boundaries spatially and temporally. The BBOP guidance documents recommend assessing the larger impact beyond the physical boundaries to include 'within-LANDSCAPE' impacts (corridors, impacts on recreation, etc.). Interpretation of aerial maps and ground surveys of vegetation was used to estimate buffer zones between the disturbed site and the surrounding undisturbed vegetation.
- Review existing data to identify KEY BIODIVERSITY COMPONENTS, including ECOSYSTEM TYPES (communities) as well as threatened and iconic species, and conduct field surveys for key fauna. Identify ECOSYSTEMS (based on vegetation). Key species such as great spotted kiwi (*Apteryx haastii*) may be suited to a species specific offset. The offset may be based on the number of individuals or territories impacted, or by using a Risk Index Model which compares the area currently occupied to that potentially occupied by a species, and the species abundance in an area in relation to the area's carrying capacity. A key precursor is to identify the drivers of ecosystem pattern.
- Identify and weight key ecosystem or habitat ATTRIBUTES (to provide practical SURROGATES for the key biodiversity components) through which losses and gains can be consistently measured.

  Attributes used in other BBOP projects include forest canopy cover and forest CONDITION class and density of streams along with stream invertebrate species and abundance, and key HABITAT features such as snags or cavities per hectare, rock piles per hectare or trees greater than a certain diameter at breast height per hectare. In New Zealand many methods have been used to assess ecosystem 'health', with a focus on forest condition in studies measuring the impact of the key introduced browsers (red deer (*Cervus elaphus*), goats (*Capra hircus*) and brushtail possums (*Trichosurus vulpecula*)) or the effectiveness of animal control operations (e.g., residual trap catches). The history of biological monitoring in New Zealand was summarised by Lee et al. (2005).

  In New Zealand 'mainland island' and Operation Ark (Elliott and Suggate 2007) conservation projects have used a wide range of ecosystem attributes to measure ecosystem health. These have often targeted individual species of high conservation value (birds, bats, or plants) or determined the density of controlled pests against a management target (e.g., residual trap catches or tracking tunnel visits). Mainland islands are ‘virtual islands’ in mainland New Zealand within which intensive, integrated pest-management regimes that aim to eradicate exotic predators or control them to low levels (Saunders and Norton 2001). The attributes proposed for Strongman focus on the indigenous components of the ecosystem, particularly vulnerable plants and birds, rather than using measures of exotic browsers or predators. The ‘nativeness’ and structure of the ecosystem are other key attributes.

- Undertake fieldwork to identify and describe ‘reference’ or ‘BENCHMARK’ sites. BBOP recommends that in the absence of ‘pristine’ equivalents of biodiversity that were present before mining began, projects should examine well-conserved examples of ecosystems and biodiversity components at the site. In the Strongman context reference sites are available adjacent to the site in ecosystems that have not been physically disturbed by people, but which lack the mammal control needed to prevent a gradual decline in biodiversity, i.e., a state of ‘benign neglect’, similar to the majority of the forests in the district. Mammal control is generally undertaken for one of two purposes: the most common focuses on reducing population densities of possums over large areas to allow vegetation recovery and / or control bovine tuberculosis. The second purpose is restricted to small areas (‘mainland islands’ or ‘arks’ which are intensively managed) and generally targets most or all the mammals present. This usually includes mustelids (stoats, weasels, and ferrets (*Mustela erminea*, *Mustela nivalis* and *Mustela putorius furo* respectively), possums, deer, goats, pigs (*Sos scrofa*) and rats (*Rattus* spp.). At Strongman an annual possum poisoning programme is carried out to protect flora and recreational deer hunting also takes place, but the latter may have little effect on the level of deer browse impacts.
- Within these reference or benchmark sites, survey fauna species to determine presence / absence and compare with surrounding habitat areas (great spotted kiwi, other bird species, *Powelliphanta* snails, aquatic biota).
- Estimate the pre-project condition of biodiversity attributes at the IMPACT SITE and subtract the estimated residual condition following remediation (calculation of biodiversity loss).
- Estimate the post-project condition of biodiversity attributes arising from suitable management actions at offset site(s) that are appropriate from the perspective of key biodiversity components (calculation of biodiversity gain).
- Decide the preferred offset tool for quantifying the loss / gain associated with the project.

The habitat hectares measure was selected as it is being tested at other BBOP pilot project sites and gives a better measure of the entire ecosystem than the measurement of single species. The use of this method allows for the inclusion of ecosystem services such as sediment control, land stability and also addresses cultural aspirations related to the value and enjoyment of intact ecosystems.

A specific offset calculation for great spotted kiwi was undertaken to assess complementarity with the habitat hectares approach. Kiwi in general are iconic species for New Zealanders, great spotted kiwi has threatened species status (‘gradual decline’ in Hitchmough *et.al.* 2007) and was selected on that basis. Hitchmough *et al*. (2007) provides the current most comprehensive listing of threatened species and their threat ranking in New Zealand – see Appendix 3).

2.2 Vegetation and fauna of the project area

2.2.1 Vegetation

Vegetation types present on the 1985 aerial photograph were mapped and overlaid on the mine footprint outline to assess whether similar vegetation remained outside the footprint or in isolated stands of vegetation within it. Vegetation was examined over a range of altitudes and geological types and plot-based surveys were carried out to record the species present. The site's geology is the Paparoa Coal Measures, within which three formations with slightly different characteristics are recognised, as shown on Figure 5. All contain mudstone, siltstone and conglomerate. The Rewanui Formation is present at higher altitude ('mpr' on Figure 5), the Goldlight Formation ('mpg' on Figure 5) is of higher fertility and occurs at mid-altitude, and the Dunollie Formation ('mpd' on Figure 5) is present at lower altitude.

On this basis six HABITAT TYPES were initially identified (five vegetation classes) at the Strongman Mine site as described below, shown on Figure 6 and summarised in Table 2. Plot data and photographs of the vegetation present are presented in Appendix 1 and a list of species present in the site and surrounds is provided in Appendix 4.

- **Scrub to 2 m height** (21 ha, mapped red on Figure 5), generally spurs and ridges greater than 550 m above sea level (ASL) with low SPECIES DIVERSITY dominated by manuka (*Leptospermum scoparium*), wire-rush (*Empodisma minus*) and tangle-fern (*Gleichenia dicarpa*) with podocarps, broadleafed colonising tree species and some monocot herbs (*Gahnia*, ferns and sedges). This is the habitat where *Powelliphanta* snails would be expected.
- **Yellow-silver pine (*Lepidothamnus intermedius),* pink pine (*Halocarpus biformis)* and manuka to 10 m height** (23 ha, mapped pink on Figure 5), generally slightly lower altitude and on Rewanui (mpr) geology vegetation.
- **Rimu (*Dacrydium cupressinum*) / mountain beech (*Nothofagus solandri*) / Halls totara (*Podocarpus hallii*) forest** (30 ha, mapped light green on Figure 5) is mostly associated with highest altitude and Rewanui lithology.
- **Rimu / beech (including red beech (*Nothofagus fusca*), silver beech *(N menziesii) and* mountain beech) forest** (73 ha, mapped mid-green on Figure 5) is dominant in mid altitude range on Goldlight (mpg) lithology. Emergent rimu c. 300 – 350 years old with mean diameters of 45 cm (n = 13, range 32 – 58 cm).
- **Lowland forest** (9 ha, mapped dark green) is restricted to valley floors and lower slopes on Dunollie lithology. The presence of the vines kiekie (*Freycinetia banksii*) and supplejack (*Ripogonum scandens*) with very tall and broad red beech (*Nothofagus fusca*) were key differentiating features. In a survey carried out in the Upper Seven Mile Creek area by Boffa Miskell (1997 – see below) this type of lowland forest also contained *Alseuosmia pusila, Leptopteris superba,* toro (*Myrsine salicina)* and pate (*Schefflera digitata).*

Figure 5: Geology

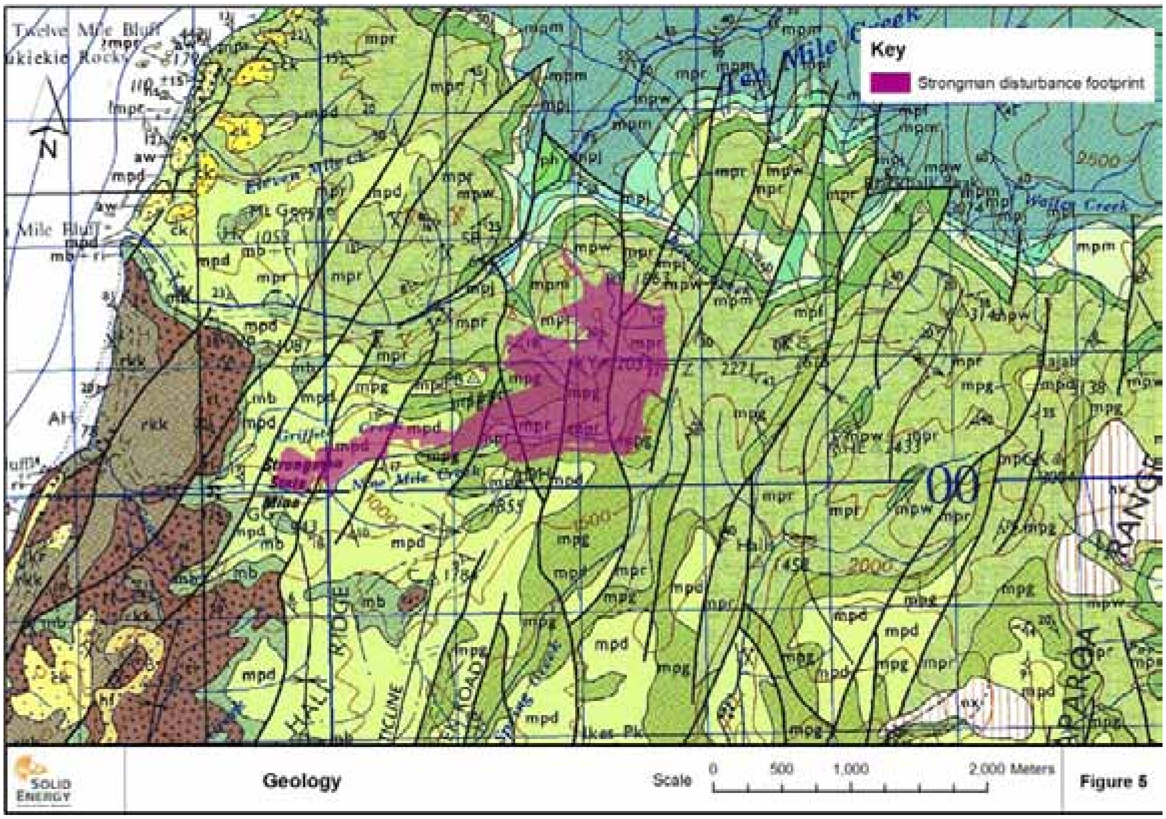


Figure 6: Vegetation classes and reference sites overlaid on 2006 aerial photograph

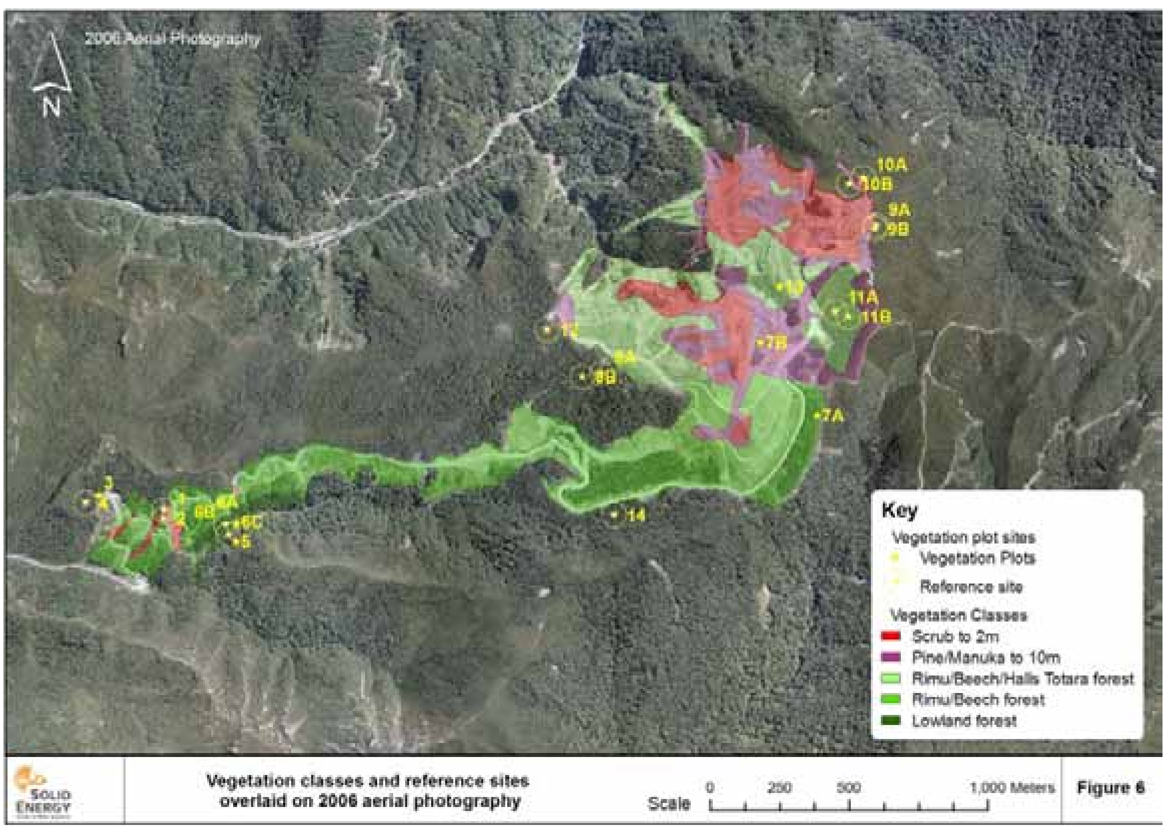


Table 2: Pre-mining reference plots and areas

Reference plot	Vegetation type, height	Geology	Area pre-mining within footprint (ha)
1, 2 9a, 9b, 10[a]	Scrub to 2 m	MPD MPR	20.6
10b, 12	Pine / manuka to 10 m	MPR	22.7
11a, 11b	Rimu / beech / Halls totara forest	MPR	30.2
3a, 3b, 4 8a, 8b, 14	Rimu / beech forest	MPD MPG	72.7
5	Lowland forest	MPD	8.7
	TOTAL		**154.9**

Field surveys of vegetation focused on identifying:

- Primary species – canopy dominants.
- Species diversity in layers – especially the 0.5 to 2 m layer as this is affected by deer and goats to the greatest extent.
- Canopy height, sub-canopy height and layers of vegetation present.
- Tree diameter (diameter at breast height – dbh). Tree rings were removed from each vegetation type for aging.
- Slope, altitude and geology.
- Exotic species present. The winter survey meant identification of grasses and rushes was difficult and a significant number of annuals and some perennials such as orchids and foxgloves are not included.

Species of conservation interest

A report prepared for Solid Energy (Boffa Miskell 1997) on the vegetation and fauna of the Upper Seven Mile area to the east of the Strongman Mine site, which supports similar vegetation but to a higher altitude (referred to hereafter as the "Upper Seven Mile report") identified four 'plants of interest': a single *Peraxilla tetrapetala* (a highly possum-palatable mistletoe with a "*gradual decline*" threat status), two plants of coal measure shrubland (*Dracophyllum densum* and *Exocarpus bidwillii*) and a plant at its southern limit (*Pimelia longifolia)*. These plants are present at higher altitude in the Seven Mile area and were not found during the recent Strongman vegetation survey. Coal measure plants would only be expected at the highest parts of Strongman Mine on the appropriate geology. Species that are highly-palatable to possum and deer recorded at Strongman included *Fuchsia excorticata*, wineberry (*Aristotelia serrata*), kiekie and lancewood (*Pseudopanax crassifolius*) (the latter two species were found in the lowest altitude forest, the former two species only on road edges). None of these species are under threat.

The Harbour Board's Ten-mile Dryland Endowment borders the Strongman Mine to the north and west. An undated Department of Conservation report (Department of Conservation undated) identified the Nine Mile and Ten Mile Creek Endowments as forming the known southern limit[5] for five plant species: *Epacris pauciflora, Pimelea gnidia, Calochilus paludosus, Lycopodium cernum* and *L. laterale* (the latter is also recorded at Strongman Mine). The report also notes that "*five species endemic to, or of localized distribution in North Westland*" are also very likely to be present; *Celmisia coriacea* var. *semicordata* (recorded at Strongman), *Senecio reinoldii* var. *ambiguus, Dracophyllum townsonii, Pimelea longifolia* and *Orthoceras strictum.* The effects of mining at Strongman on these species in the context of the entire (large) area of North Westland is not considered significant especially as they enjoy a wide distribution within this area.

Weeds

The natural forest and reference sites are distinguished by an absence of weeds (invasive exotic species). Before mining the area would have had very low abundance and diversity of weeds, however drill sites are clearly visible on the pre-mining aerial photograph, and these are likely to have supported a range of exotic pasture species brought in on machinery and clothing.

Exotic weed species commonly recorded on drill sites in the Upper Seven Mile report include browntop (*Agrostis capillaris*), Yorkshire fog (*Holcus lanatus*) and *Juncus effusus.* Berms and sidecasts along the Strongman access road have the highest abundance and diversity of adventive species, including gorse (*Ulex europaeus*), pampas (*Cortaderia* sp), broom (*Cytisus scoparius*) (confined to a gravel stockpile), Himalayan honeysuckle (*Leycesteria formosa*) and silver birch (*Betula pendula*) (both single plants – since removed), and two Acacia (probably *A. dealbata* – removed). Many exotic herbaceous species have established in rehabilitated areas including broad leafed plantain (*Plantago major*), foxglove (*Digitalis purpurea*), pearlwort (*Sagina procumbens)*, hawksbeard (*Leontodon taraxicoides)* and rushes. *Lotus pedunculatus* and browntop have been deliberately seeded in places to enhance soil stabilisation.

The Department of Conservation and the West Coast Regional Council recognise the large threat weeds pose to native ECOSYSTEMS and especially unstable areas like cliffs, bluffs, erosion scars and sidecasts and alluvial flood plains. The mild climate of the West Coast means that many of the more than 2000 naturalised exotic species in New Zealand could establish in the Strongman area, and they remain uncommon there because of the low human population. The Department of Conservation's Greymouth Biodiversity Action Plan (version 3, Department of Conservation 2003) identifies numerous terrestrial weed species that have not yet naturalised in the Greymouth area or are of very limited distribution, and terrestrial weed species that have been recorded in the Greymouth area but which have the potential to significantly spread. MONITORING and weed control in Strongman REHABILITATION areas is carried out to minimise the potential for weed invasion as part of the existing site management protocols.

2.2.2 Fauna

The southern Paparoa Range, within which Strongman Mine is located, is an important HABITAT for threatened snail and bird species. The area is described as containing "*one of the only two known habitats for the endemic land snail Powelliphanta gagei located in a small area near Rewanui*". The same report notes that "*Apart from the country north of the Buller River the Paparoa Range is the only other place in New Zealand where great spotted kiwi (Apteryx haastii) are known to exist in relatively high numbers*".

The greater Strongman site and sites of similar habitat nearby have been surveyed for fauna, principally birds and snails, five times between 1997 and 2008 (Buckingham 2008). This has resulted in reasonably reliable

5 To ensure the continued viability of a species it is considered important to protect it throughout its range with special reference to boundary populations where genetic variation may be of particular importance in relation to protection of evolutionary potential.

knowledge of the species of these two TAXA likely to be found there as the first of these surveys was undertaken prior to any surface mining. However, with every survey carried out more species not previously recorded in the area continue to be found (Buckingham 2008). Indigenous amphibians are only known from the South Island of New Zealand from the fossil record and less reliable knowledge is available about the species of lizard found at the Strongman site. Buckingham (2008) found no sign of lizards during the survey (although specialised searches were not made for them). The only amphibian recorded by Buckingham (2008) was the introduced whistling frog (*Litoria ewingi*), and these frogs were rather uncommonly heard.

Snails

Powelliphanta gagei has a "*nationally critical*" threat status (Hitchmough 2007). This species was the focus of specific surveys to determine their existing distribution around the Strongman Mine site and to determine whether they may have been present within the site pre-mining.

Snails were recorded in a survey of the Upper Seven Mile area (Boffa Miskell 1997) at around 800 m ASL in an area east of the Strongman site known as the Bishop Block and may have been present at Strongman. Anecdotal information from a mineworker indicates that shells were found in the mine site; these were provided to the Department of Conservation for identification but their provenance is not clear. A survey of the area to search for these snails was carried out over a three day period in August 2008 by MBC Contracting Limited but no snails were found. While conditions were not ideal for the survey, the report did note that if the snails are present in the vicinity they are at low density. Casual observation by Buckingham (2008) also failed to detect any snails.

The snail *Rhytida patula* is known to occur in the South Paparoa range area but was not recorded in any of the above surveys.

Given that the search areas contain similar habitat to the areas lost to mining, that the snail is found only at higher altitude in similar habitat to the east and that no snails were found during the searches, it is reasonable to assume that the project area did not contain either of the snail species and consequently the offset calculation ignores them.

Great spotted kiwi

Kiwi are nocturnal and are usually monitored according to a national protocol for call count surveys. Buckingham (2008) carried out a two hour listening survey for great spotted kiwi for 45 minutes after sunset and extended for two hours on several nights in November 2008. Details of each call heard were recorded separately for each hour. If no kiwi were heard during the survey then taped kiwi calls were played after the survey concluded with the aim of eliciting a call response should kiwi be present. Recorded calls were also played along roads.

Great spotted kiwi (*Apteryx haastii*) were found to be relatively common in the middle and upper parts of Nine Mile Creek and adjacent ridges, but no sign of them was found in the lower reaches of Nine Mile Creek, around Strongman No.1 Mine or in the coastal forest (Buckingham 2008). A total of 44 calls was heard during 18 hours of formal kiwi listening giving a relatively high mean calling rate of 2.4 calls per hour. This rate is higher than the mean call rate for great spotted kiwi in other parts of their range (e.g., Paparoa Range and surrounding valleys (1.8/hour), Arthur's Pass (1.1/hour), Karamea to Buller River (0.9/hour)), but lower than the 6.4 calls per hour recorded within the core population of North West Nelson. The call rate at Strongman Mine was similar to that recorded at the Mount William Range and Orikaka (2.5/hour), where the population is regarded as a nationally significant (Buckingham 2008).

Boffa Miskell (1997) recorded a higher calling rate (3.2 calls per hour) in the upper Seven Mile Creek area in October 1997, and an even higher rate (8.8 calls per hour) was recorded in the Bishop Creek / Seven Mile Creek area in January 2006 (Buckingham 2008).

An estimate of total kiwi population based on calls indicated approximately 25 kiwi and at least four pairs occupied the area covered by the listening survey (c. 350 ha). The results indicated that kiwi occupy 20 – 30 ha territories in the study area, and may be as dense as 7.1 individuals per 100 hectares. Kiwi were heard at six of the nine listening station nights, indicating a fairly wide distribution. As well as calls being heard, some sign (droppings and probe holes) was found during the day.

Bird species

A total of 25 species of birds (including 20 indigenous and five introduced species) was recorded during the Buckingham (2008) survey (listed in Appendix 2). This compares to 20 forest birds recorded at both the upper Seven Mile Creek area in October 1997 (Boffa Miskell 1997) and at the Bishop Block area in January 2006 (Buckingham 2008). These surveys recorded 16 and 15 indigenous species and four and five introduced species respectively.

A total of nine threatened bird species were recorded during the 2008 survey (Buckingham 2008). These were great spotted kiwi, New Zealand pigeon (or kereru, *Hemiphaga novaeseelandiae*), kakariki (*Cyanoramphus auriceps*), long-tailed cuckoo (*Eudynamys taitensis*) and rifleman (*Acanthisitta chloris*) (all ranked as being in "*gradual decline*" in Hitchmough *et al*. (2007), see Appendix 3), New Zealand falcon (*Falco novaeseelandiae*) "*nationally vulnerable*"), Western weka (*Gallirallus australis australis* "*serious decline*"), South Island kaka (*Nestor meridionalis meridionalis* "*nationally endangered*") and South Island fernbird (*Bowdleria punctata* "*sparse*"). Most were associated with forest habitat though fernbirds occupied scrub and pakihi habitat, and weka were found in most habitats. Of these species falcon and kaka could be regarded as acutely threatened and rifleman are at risk, whilst all the other species are under chronic threat. Falcon, kaka and kereru are strong fliers and individuals range over large areas (many kilometres), whereas weka (a flightless rail) and the tiny rifleman occupy relatively small areas.

Threatened species were found in variable numbers: only a few falcon, kereru and long-tailed cuckoo were recorded, while kaka and kakariki were occasional and widespread, and fernbirds and riflemen were moderately common locally (i.e., localised, usually in higher-altitude beech forest for rifleman and dense scrubland and pakihi for fernbird). Weka were in low to moderate numbers throughout. Kaka were generally recorded as one or two individuals at a time heard flying over the area.

Research in other areas indicates the range of these populations of threatened birds, particularly kiwi, continues to contract from lower altitudes (perhaps because of higher predator density at lower altitudes. Other native species that may have been present in the area historically include blue duck (*Hymenolaimus malachorhynchos*, a river specialist sensitive to water quality).

In early European times Smith (1888) described birdlife at Lake Brunner (south of the Paparoa range) as including "*kokako approaching extinction, kakapo becoming rare, yellowhead and bush wren common, NZ thrush fairly numerous, red-crowned parakeet abundant and occasional flocks of 12+ saddlebacks*". All but parakeet are now extinct or critically endangered. Similar species may have been present at the Strongman site in much earlier times.

In general, forest areas were well represented by a range of common birds while scrubland and pakihi had fewer numbers and less diversity of species. Least numbers and lowest diversity of birds were encountered in the highly disturbed formerly mined areas (Buckingham 2008).

Pests

Rats, stoats and brushtail possums are the key predators of native birds. Browsers also affect native vegetation and may compete with native species. The main mammals influencing vegetation at the site are red deer, goats and possums. Rats and mice may also influence seed viability.

New Zealand has no native terrestrial mammals, with the exception of two species of bat. Mammals (a rat and a dog) were introduced by Maori within the last 1,000 years; however, the majority of introductions were associated with arrival of Europeans in the 18th and 19th centuries. The first farms in the Grey Valley were cleared of forest in 1858, with 3,000 ha cleared by 1869. Stoats were introduced to control rabbits in the 1870s, Buller reported Norway rats (*Rattus norvegicus*) had reached plague proportions in 1895 (Buller 1895), but these populations were later replaced by ship or black rats (*Rattus rattus*) in most mainland forests. The populations of ship rats, mice (*Mus musculus*) and their mustelid predators fluctuate in response to periodic mass flowering and fruiting of dominant native trees (known as ‘masting’). Rats and mustelids are expected to be present at Strongman.

Possums were introduced from Australia in the early 1900s to establish a fur industry. The population of the species has grown exponentially and it is now a significant national pest. The plant species most palatable to possums (including mistletoes (Sweetapple *et al.* 2004) were either not seen during the Strongman survey or only found occasionally (e.g., tree fuchsia). Buckingham (2008) noted several possums were seen during the nocturnal walking transect along the mine roads and possums were heard on 66.7% of kiwi listening station nights indicating that they are fairly common in the area despite annual poisoning in rehabilitation areas.

Buckingham (2008) found sign of deer and possums in forest and scrub, and hares (*Lepus europaeus*) were occasionally seen in open areas. Rabbits (*Oryctolagus cuniculus*) may also be present at the site.

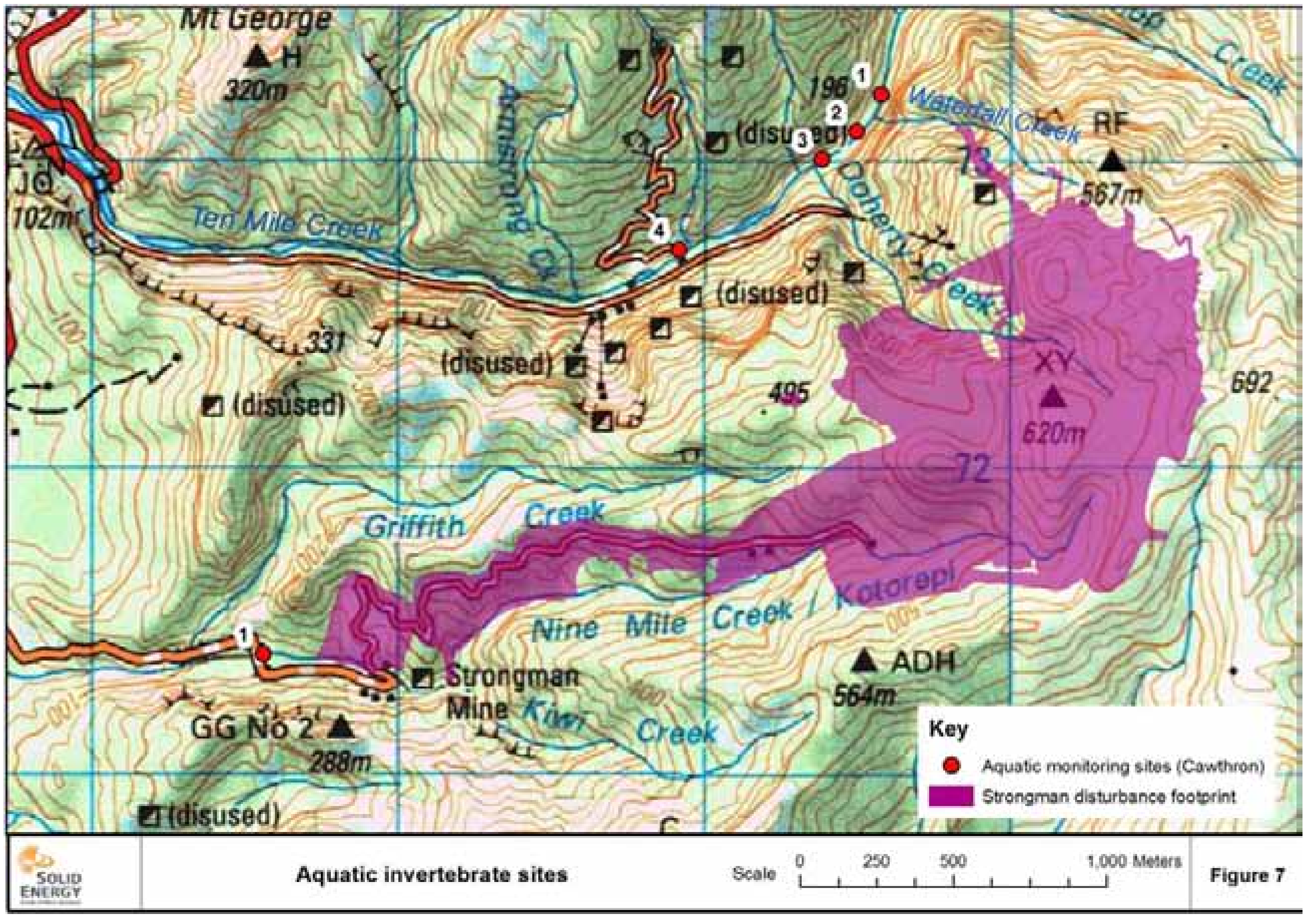
Red deer numbers in the Grey District peaked in the late 1940s. Deer are present at Strongman as evidenced by browse damage of one of their favoured large-leafed species broadleaf (*Griselinia littoralis*) below 2 m height in many of the forest plots. Large-leafed *Coprosma* species, another highly-preferred food, were only recorded in two of the nine forest plots. Goats are found in localised populations established from domestic populations in the gold mining days and persist around old gold digging sites (e.g., western Paparoa Ranges). However, goats have not been seen at Strongman for at least five years or so (pers. comm. R. Harrison). Browsed vegetation was observed patchily across rehabilitated areas with the nitrogen-fixer tutu (*Coriaria arborescens*), *Coprosma* spp, rushes (e.g., *Juncus effusus*) and native *Thelymitra* orchids most commonly affected. Rabbits (*Oryctolagus cuniculus*) may also be present at the site.

Control of possums using annual poisoning within the Strongman opencast FOOTPRINT began in June 2005 using cyanide bait. Two hundred and eleven possums were removed in July 2006. Only 13 possums were removed in September 2007 and the lower number was attributed partly to poor weather. An early summer operation in 2008 killed approximately 70 possums. Rats are often killed as a by-product of these operations. Deer are hunted recreationally but there is no targeted control programme. The main method used to control mustelids in New Zealand is intensive trapping, although many are probably killed by secondary poisoning during poison operations for rat or possum control. Mustelid trapping is not currently used at Strongman Mine.

2.2.3 Aquatic biology

The discharge from Strongman Mine enters Waterfall creek approximately 800 m upstream of its confluence with Ten Mile Creek. Waterfall Creek is difficult to access, so as part of the biological monitoring programme for the Strongman opencast mine site, sampling of periphyton, aquatic invertebrates and fish in Ten Mile Creek was conducted between 2003 and 2007 at the sites shown in Figure 7 (Olsen 2007). In 2007 these biological factors were also measured in nearby Nine Mile Creek by Olsen (2007). Harding and Niyogi (2008) sampled macroinvertebrates and water chemistry in Nine Mile Creek. Figure 7 also shows these survey site locations.

Figure 7: Aquatic invertebrate sites



Periphyton

The percentage cover of the stream bed by different categories of periphyton was assessed using Rapid Assessment Method 2. This involved estimating the periphyton percentage cover on single stones at five points across the river on four transects within a 100 m reach. From these data periphyton enrichment scores were calculated that reflect the enrichment conditions of the stream. The periphyton scores have been high (between 9.97 and 10.0 out of a possible 10) in all years. This, and the types of periphyton present (usually light brown, thin mats or films), is indicative of pristine (unenriched) conditions.

More extensive growths of periphyton were recorded from Nine Mile Creek in 2007 with periphyton covering the entire surface of most rocks and no rocks found without some periphyton attached. The periphyton enrichment score was 7.47 indicating poorer water quality there than in Ten Mile Creek.

Macroinvertebrates

Kick sampling using a 0.5 mm mesh D-net according to New Zealand's standard monitoring technique was used to capture stream dwelling invertebrates. Forty two taxa of macroinvertebrates are known from Ten Mile Creek. One measure of water quality, the number of environmentally sensitive Ephemeroptera (Mayflies), Plecoptera (Stoneflies) and Trichoptera (caddisflies) ('**EPT**') has exceeded 60% of the total taxa richness in Ten Mile Creek each year indicating a healthy aquatic environment. A second measure, the macroinvertebrate community index ('**MCI**') or its derivative the semi-quantitative MCI ('**SQMCI**'), has always exceeded 120 and 6.00 respectively in Ten Mile Creek, indicating that water and habitat quality within this stream are high. The EPT taxa score for Nine Mile Creek in 2007 was 57%, with a MCI value of 109 and SQMCI of 6.16. This MCI value is indicative of mild pollution, but the SQMCI indicates excellent water quality.

Harding and Niyogi (2008) used Surber sampling to collect a total of 31 taxa from six sites in Nine Mile Creek and calculated MCI values of 100 – 120 for each site and EPT scores of 12 –50%. MCI values in this range indicate mildly polluted water quality and a slightly degraded fauna, which is reflected in the low EPT scores. Water chemistry measurements showed that the creek had a neutral-slightly alkaline pH (7 – 8) with relatively high conductivity (360 – 600 μScm^{-1}) and dissolved metal concentrations that were not high by mine catchment standards. The survey of Harding and Niyogi was conducted in autumn (May) when the flow was very low, iron bacteria were prolific and the upstream creek was blocked by a number of log jams.

Fish

Electric fishing has been used by Olsen (2007) and others in Ten Mile and Nine Mile Creeks to record the fish present. Species recorded in Ten Mile Creek were the indigenous koaro (*Galaxias brevipinnis*), and long finned eel (*Anguilla dieffenbachia*) and the introduced salmonid, brown trout, (*Salmo trutta*). Koaro were found in Nine Mile Creek in 2007. Single pass electric fishing provides an indication of the fish that are present in a stream reach but does not provide accurate estimates of fish density and the failure to collect a particular species does not mean that it is absent from the site.

Overall, the aquatic surveys indicate that mining at Strongman has not significantly affected the abundance and diversity of periphyton, macroinvertebrates or fish species in the Ten Mile Creek during 2003 to 2007, and we therefore consider no offset is needed for the Ten Mile Creek. The 2007 results for Nine Mile Creek indicate somewhat degraded water quality and HABITAT characteristics.

2.3 Ecological context and information sources

The Strongman site lies in the Paparoa Range, in the Blackball Ecological District of North Westland. The Paparoa Range area forms a large, relatively continuous and intact forest block. The presence of near-complete altitudinal sequences of habitat, including lowland forests (which are grossly under-represented in the nationally protected network of reserves), and particularly podocarp / mixed broadleaf forests in a mosaic of habitats increases the value of this area with respect to fauna density and species assemblages (Morse 1981; Park and Bartle 1978).

New Zealand has a relatively small flora of about 2,400 vascular plants, but 889 of these are regarded as threatened to some degree and 100 species have insufficient data to establish the level of threat. Hitchmough *et al*. (2007) lists six species as becoming extinct since 1840. Given that work by Hitchmough *et al.* (2007) is acknowledged to be comprehensive and that it forms the basis of national conservation strategies it can be assumed that native vascular plants that are not listed in that document are not threatened. The main threats nationally are weed invasion (especially of low-stature plants such as those found in turf and cliff vegetation) and browsing or grazing by introduced animals (goats, deer, possums, rabbits, etc.). Threats to the species present in the forests and shrublands of the Strongman area include browsing which is believed to have caused severe depletion and possibly local extinction of mistletoes and reduction in the density of fuchsia and other palatable species, particularly in the seedling and shrub layers. Disease is an increasing threat, particularly root rots (*Phytopthera*), which are becoming established elsewhere in New Zealand. There are also concerns about the depletion and extinction of vertebrate pollinators and seed dispersers.

A key precursor to identifying local biodiversity is to determine the important ecosystem drivers. De Velice *et al.* (1988) assessed vegetation-environmental patterns in the adjacent Punakaiki Ecological District (also part of the coastal Paparoa Range) using gradient analysis of vegetation plots in the 'pristine' forests and identified the natural drivers of vegetation pattern in this steep, tectonically active LANDSCAPE as geology, temperature and topography. Geology and topography combine to control vegetation patterns through differences in fertility. The coal measures geology, characterised by mudstones and sandstones above the coal deposits, are less fertile than most other geologies, but within the coal measures at Strongman Mine the younger Goldlight Formation (the 'mpg' class on Figure 5) supports taller forests than the Rewanui Formation ('mpr' class) at similar altitude. Under the high leaching regime (between 3 and 5 m of rainfall annually) recent alluvial deposits on valley floors are more fertile than those lying on the slopes above – these alluvial deposits support the greatest densities of large trees, of which red beech (*Nothofagus fusca*) is dominant. Topography influences temperature (e.g., areas where cold air ponds), erosion and drainage. Where the geology is consistent, vegetation patterns are controlled by changes in temperature with altitude, with height and complexity decreasing and major canopy species changing from valley base to ridgeline.

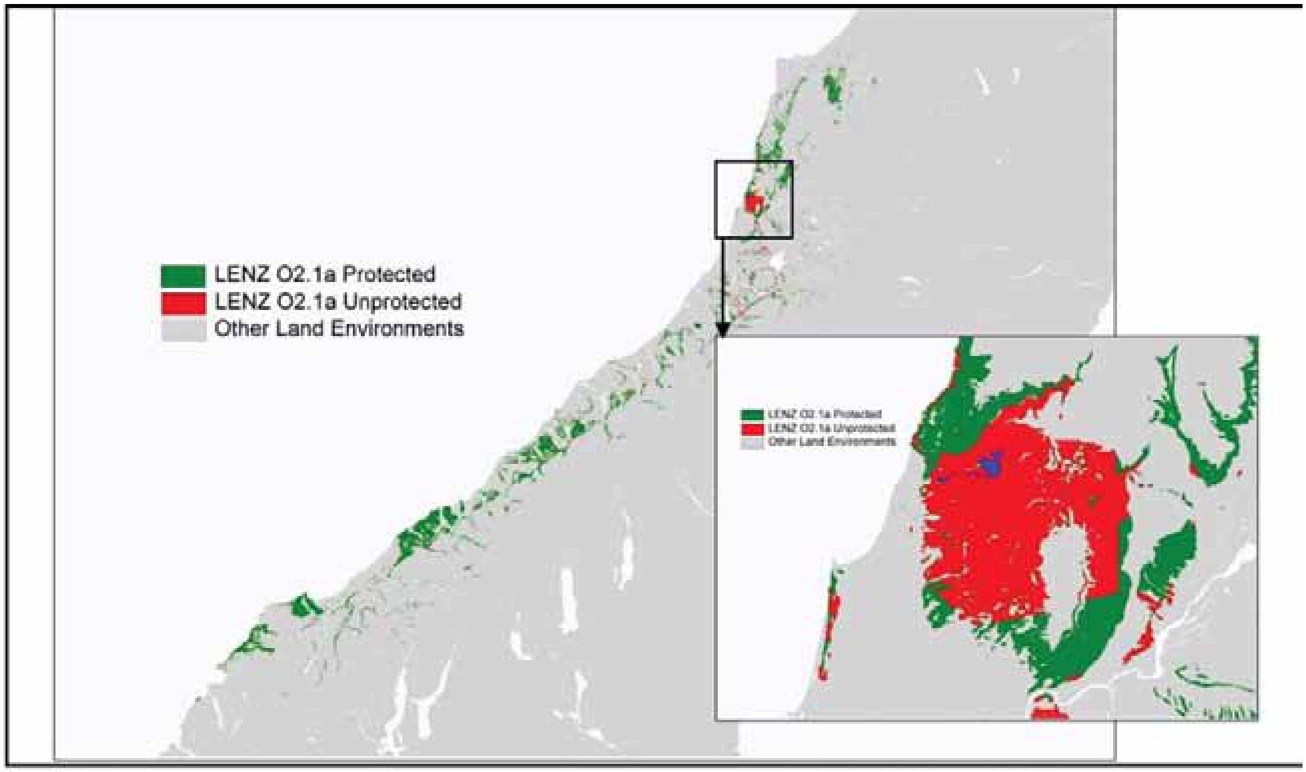
In the absence of comprehensive BASELINE studies of the site a literature review and search of the National Vegetation Survey Database ('**NiVS'** – a physical archive and computer databank containing records from approximately 77,000 vegetation survey plots covering exotic and indigenous plants in New Zealand's terrestrial ecosystems) was used to identify key ecosystems and compile a list of vascular plant species that could be present in the vicinity of the Strongman Mine. This list is provided in Appendix 4.

In addition to this database, PROXY data were collected from reference sites in the immediate vicinity. These sites were identified with reference to pre-mining aerial photography and GROUND-TRUTHING surveys.

The list was derived from the vegetation surveys carried out for this case study and from the sources described below.

The Land Environments of New Zealand ('**LENZ**') database (**www.landcareresearch.co.nz/databases/lenz/**) was searched to help identify similar large areas with similar ecosystems elsewhere in the region. The level 4 LENZ classification, useful to about 1:50,000 scale, shows two distinct environments present at the Strongman site as shown on Figure 8. 95% of the site is classified 02.1a – part of 161,000 ha on the West Coast of the South Island characterised by steep hills with moderately fertile, well-drained soils derived from tertiary mudstones and sandstones and with mild temperatures, low solar radiance and no annual water deficits. LENZ Class O1.1, comprised less than 5% (approximately 7.5 ha) of the Strongman footprint, being areas of the Nine Mile and Ten Mile Creek valleys with relatively high densities of very large and very tall trees, including red beech (which is characteristic of higher fertility and better-drained sites).

Figure 8: Distribution of LENZ level 4 Domain O2.1a in Westland, New Zealand (red and green areas)



SOLID ENERGY

Distribution of LENZ level 4 Doman O2.1a in Westland, New Zealand (red and green areas). The inset shows a closer view of the location in the Paparoa Range with the Strongman Mine identidied in blue

Figure 8

As Class O1.1 was a minor component at Strongman, but common on the West Coast (represented by 346,000 ha), only NiVS sites in class O2.1a were selected for interrogation. The NiVS plots selected are all in the Blackball Ecological District, and closest to the Strongman site (Appendix 5). Slope, elevation and rock class were identified by interrogating the underlying LENZ and New Zealand Land Resource Inventory layers. The NiVS data was collected as part of the Grey River 1967 – 68 survey and the Paparoa 1985 Survey. The Grey River survey was a resource inventory and vegetation typing survey to assess effects of browsing animals by Forest Research Institute (now Scion, Christchurch). The Paparoa 1985 Survey was carried out by the Department of Conservation (Hokitika) to test how direct and indirect gradient analysis methods could assist in nature reserve design. Six of the ten potential plots were used (four plots at low-altitude sites were not used).

The most comparable ecological data available are contained in the Upper Seven Mile report. The topography and LENZ classifications of Strongman and the Upper Seven Mile survey areas were used to identify comparable areas, since the Upper Seven Mile report includes higher ridges, with herbfield and scree vegetation associations not present at Strongman. The highest point at Strongman prior to mining was XY ridge at 620 m ASL. The Seven Mile Report generally identifies plants found below 600 m ASL so this is used as a cut-off-value for inclusion of species. The decision not to include all plants in the Seven Mile survey is supported by LENZ classification, as the peaks of the Upper Seven Mile area can be seen as ‘islands’ of alpine herbfields and low sub-alpine vegetation to the south of a more extensive plateau.

Relevant ecological information is also found in reports on reserves in the Blackball Ecological District, e.g., the Roaring Meg Ecological Area and Harbour Board Dryland Endowments (particularly Nine Mile). An ecological survey of the broader areas is recorded as underway by the Grey District Council (a Department of Conservation Protected Natural Areas Programme overview report (Wildlands Consultants 2004, pg 22)).

Overlying the natural influences on ecosystems patterns are fires and influences of introduced mammalian herbivores and carnivores. The southern half of the Blackball Ecological District is noted as having been previously devastated by fire and this has reduced the habitat value for birds (McEwen 1987). Fires from underground workings have affected vegetation at Strongman in very defined areas (as mapped in Figure 3); other areas appear to be unaffected by fire, with the possible exception of a ridgeline extending above the Strongman No1 portal which has a manuka shrubland cover. In contrast, fire appears to have stunted vegetation on the true left bank (left bank facing downstream) of Nine Mile Creek (outside the Strongman footprint). The influence of introduced mammals is described further in Section 2.2.2.

2.4 Quantifying ‘disturbance’

Impacts on biodiversity were quantified using the following process.

A disturbance score based on habitat integrity was derived that ranks impacts on a score from zero to ten. As the score increases the level of disturbance increases (i.e., 0 is a baseline habitat (no direct human impact but introduced herbivores and predators present)).

This is a qualitative measure of disturbance, however, the project assumes that the relationship between habitat quality and disturbance is linear.

As the score increases, the site stability, native plant richness and proportion of woody plants decreases, whilst the exotic plant species richness and abundance of herbaceous plants (especially those characteristic of open sites) increases. For forests an increasing score indicates that the height, diameter and structural complexity of the forest decreases.

Disturbed areas were then scored, relative to the undisturbed reference sites identified during the fieldwork as described in Section 2.2. The key criteria assessed were:

- Height relative to undisturbed vegetation.
- Canopy structure compared to undisturbed vegetation.
- Relative species richness – particularly presence of canopy seedlings >1 m tall.
- Intactness of ground layer (i.e., seed and seedling ‘banks’ for regeneration).
- Percentage of bare ground.

The vegetation was mapped in relation to its disturbance rating as shown on Figure 9. Table 3 sets out the extent of each disturbance rating, the vegetation plots that characterise the disturbance levels (see Appendix 1) and the equivalent area if plots were 100% disturbed.

Figure 9: Strongman disturbance footprint (aerial photography 2006)

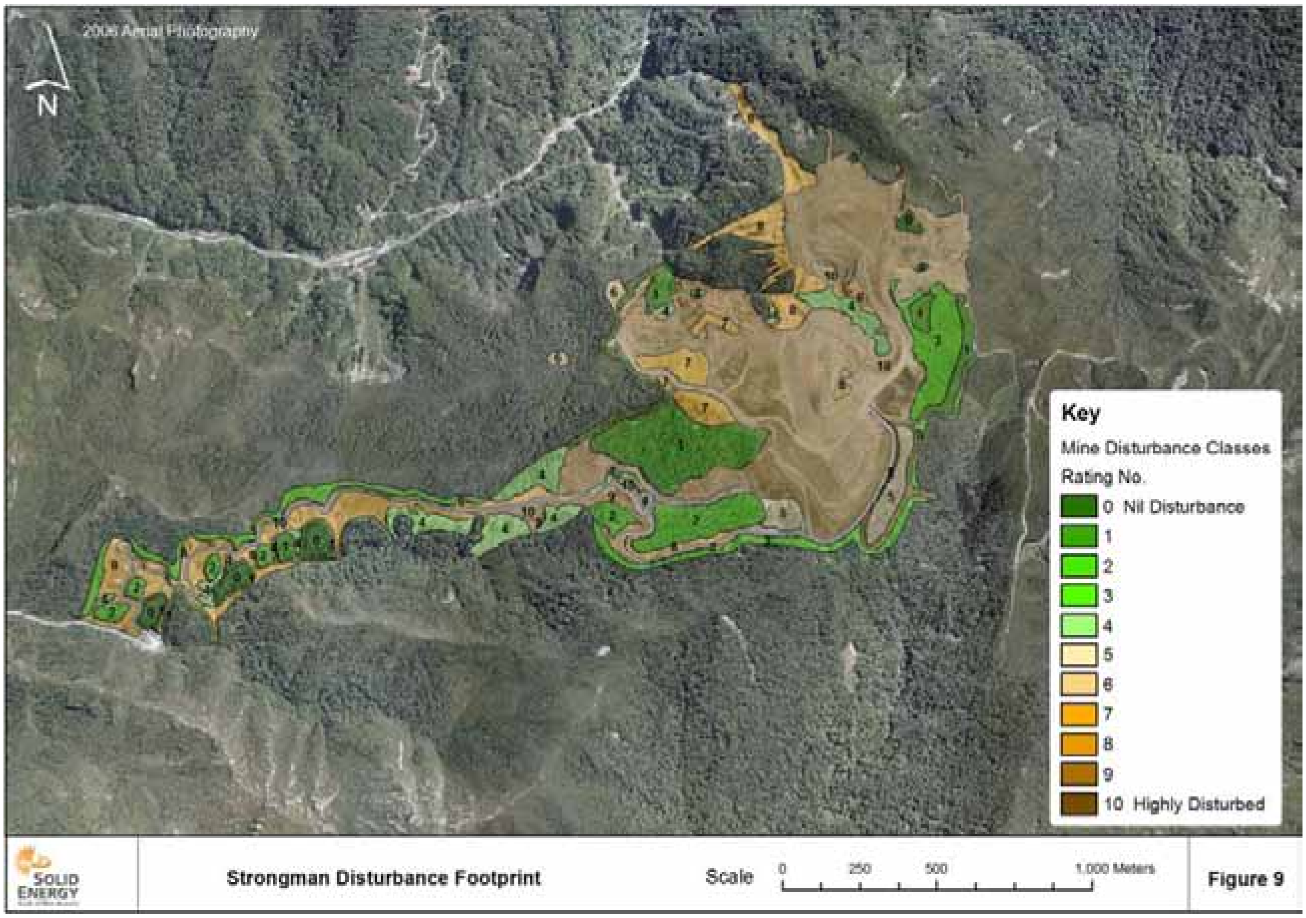


Table 3: Areas of vegetation rated against ten disturbance levels within the Strongman footprint

Rating	Description of disturbance class	Area (ha)	Plots	Multiplier		Disturbed equivalent area (ha)
		A		B	AxB	A-(AxB)
0	Undisturbed (although subjected to animal browse*)	6.6	1, 2, 3b, 4, 5, 6a, 9a, 9b, 10a, 10b, 12, 14		n / a	
1	Minor edge-affected with some windthrow, diverse and structured (e.g. along drill tracks)	15.8	8a, 8b, 3b	0.9	14.2	1.6
2		6.9		0.8	5.5	1.4
3	Structured canopy but affected such that forest is open, not intact, but diverse	14.1	11a, 11b	0.7	9.9	4.2
4	Large trees still alive / present, structured canopy with species characteristic of that association (e.g. Halls Totara)	9.2	13	0.6	5.5	3.7
5	Smoked or burnt canopy species at 1 – 5 m height diverse, greater woody species dominant	3.4	7a	0.5	1.7	1.7
6	Escarpment slip faces	0.9		0.4	0.4	0.5
7	High vegetation cover, sidecast, (diverse) 1 m tall canopy and ground layer species c. 10 years of rehabilitation growth (c. closure standard)	2.2	6b	0.3	0.7	1.5
8	Forest margin diverse, native, stable, low stature, weeds	21.2	3a, 3c	0.2	4.2	16.9
9	Sidecast with scattered (seral) native vegetation and weeds Sparse vegetation cover	1.5	6c, 7b	0.1	0.2	1.4
9.5&10	Contoured, stable, seedlings planted and / or oversown. Uncontoured, no soil, not revegetated	73.1		0.05		69.4
1 – 10	Disturbed to some extent	**148.3**				**106.0**
	Total area (0 – 10 inclusive)	**154.9**				

Note: evidence of browsing not used as an indicator of disturbance in this table.

The final column in Table 3 takes into account that there is a range of disturbance levels across the site – if just raw area were used there would be no value to remnant vegetation or ECOSYSTEMS on the site. The calculation takes the area disturbed and multiplies by the disturbance rating (converted into a number between 0.05 and 0.9, where 0.05 is disturbance level 0.5, and 0.9 is disturbance level 9. When subtracted from the disturbed area, this gives the equivalent area of undisturbed vegetation (A-(AxB)) The reason for doing this is to reflect that not all disturbed vegetation has the same ecosystem value, e.g., tall forest with level 8 disturbance rating has greater value than a rehabilitated area with 0, 0.5 or 1 disturbance rating.

Examples of the most disturbed areas are shown in Plates 2 – 4, including areas of sidecasting, areas that have been burned and areas that have been mined, recontoured and replanted (also refer to plot photographs in Appendix 1 that illustrate the level of disturbance). The loss of each area of the pre-mining vegetation types was calculated in relation to each disturbance rating as shown in Table 4.

Plate 2: Sidecast material on steep slopes below the mine area

Plate 3: Standing burned and / or gassed vegetation

Plate 4: Overburden slopes adjacent to Nine Mile Creek, disturbance rating 1. The overburden has been contoured, spread with soil, seeded with exotic grasses and planted with native woody seedlings

Table 4: Current area (ha) within the Strongman footprint of each vegetation type in each disturbance class

Disturbance rating	Vegetation type					
	Scrub to 2 m	Pine – manuka	Lowland forest	Rimu / beech forest	Rimu / beech / Halls totara forest	Total
0	1.4	1.0	0.9	2.6	0.7	6.6
1	0	1.7	6.4	6.7	1.0	15.8
2	0.1	0	0.2	6.6	0	6.9
3	0.1	1.2	0	7.4	5.4	14.1
4	0.12	0.8	0.2	6.7	1.4	9.2
5	0	0	0	3.4	0	3.4
6	0	0	0	0.9	0	0.9
7	0.4	0	0	0.6	1.2	2.2
8	1.2	2.2	1.0	11.6	5.2	21.2
9	0	0	0	1.5	0	1.5
10 high	17.3	15.8	0	24.7	15.3	73.1
Total	20.6	22.7	8.7	72.7	30.2	154.9
Total	**43.3**		**111.6**			

Note: there is remnant vegetation present on the site, with varying degrees of disturbance

The six vegetation types were simplified to two classes for the consideration of offsets and calculation of HABITAT HECTARES: tall forest and shrubland / podocarp forest. Tall forest comprises rimu and beech forest at mid altitudes, lowland rimu beech forest and rimu, mountain beech and Hall's totara forest at higher latitudes on mpr lithology. The shrubland type comprises pine manuka scrub and shrubland of similar species composition. These COMMUNITY TYPES occur as a mosaic across large areas depending on the factors described earlier (including geology and altitude) and the classes mapped represent a finer detail than can be used in derivation of the offset and in the identification of candidate offset sites. They make up an ecosystem complex that the use of two classes adequately represents.

When the ecosystems are grouped into the two types to be used for selection of offsets, there are:

- 43.3 ha of scrub-type ecosystem.
- 111.6 ha of forest-type ecosystem.

3. Assessing Biodiversity Impacts

3.1 Determining site boundaries

The site boundaries were determined as the Strongman 2 underground and opencast FOOTPRINT and the footprint of the access road that leads up the valley of the Nine Mile Creek from the Strongman 1 Underground Mine entrance. Figure 10 shows the pre-mining (1985) vegetation at the site, including significant areas of subsidence and erosion scars attributed to underground mining in the adjacent 10 Mile Creek. Figure 11 shows the existing (2006) mine footprint which includes the access road.

Figure 10: Pre-mining aerial photography (1985)

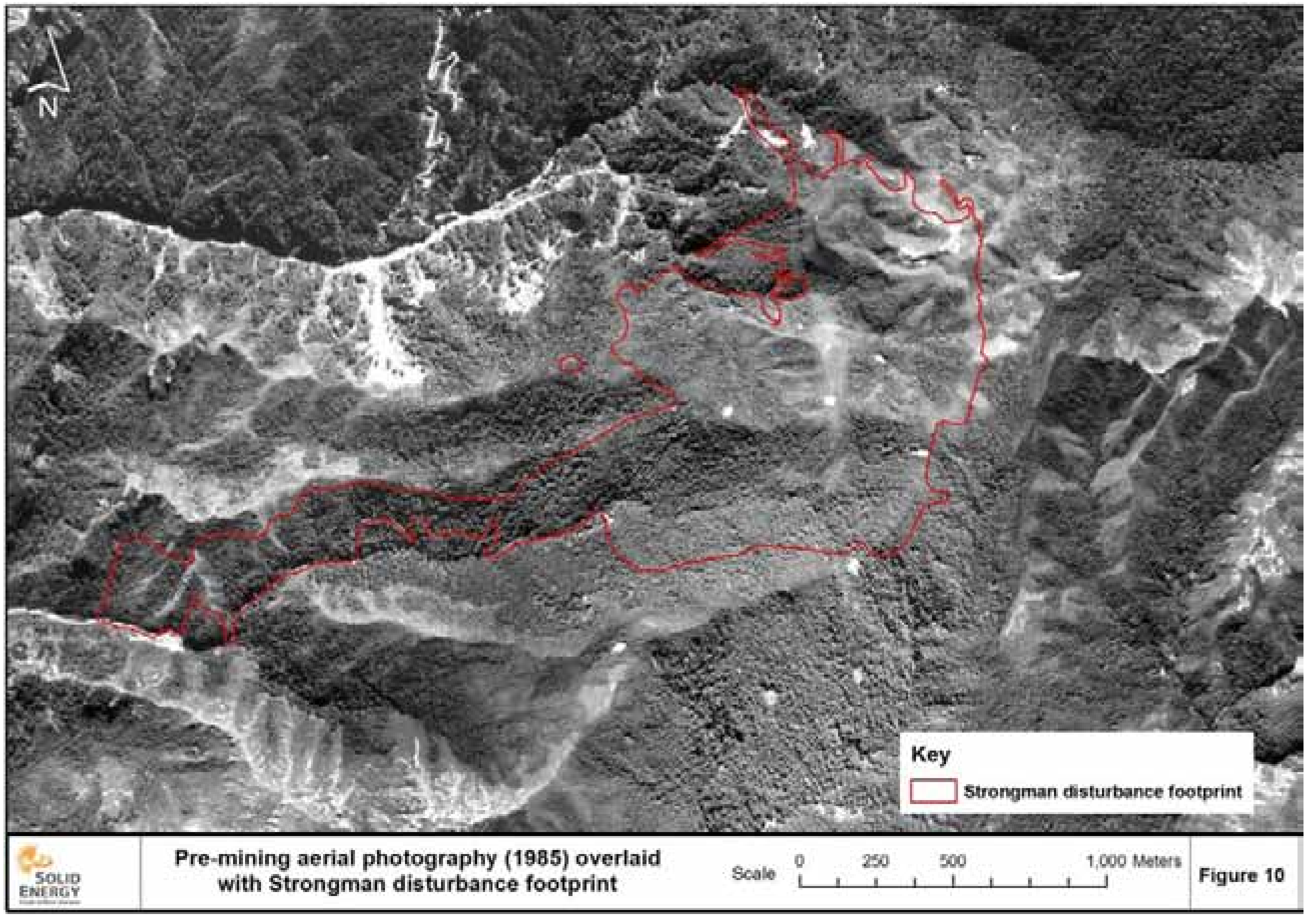
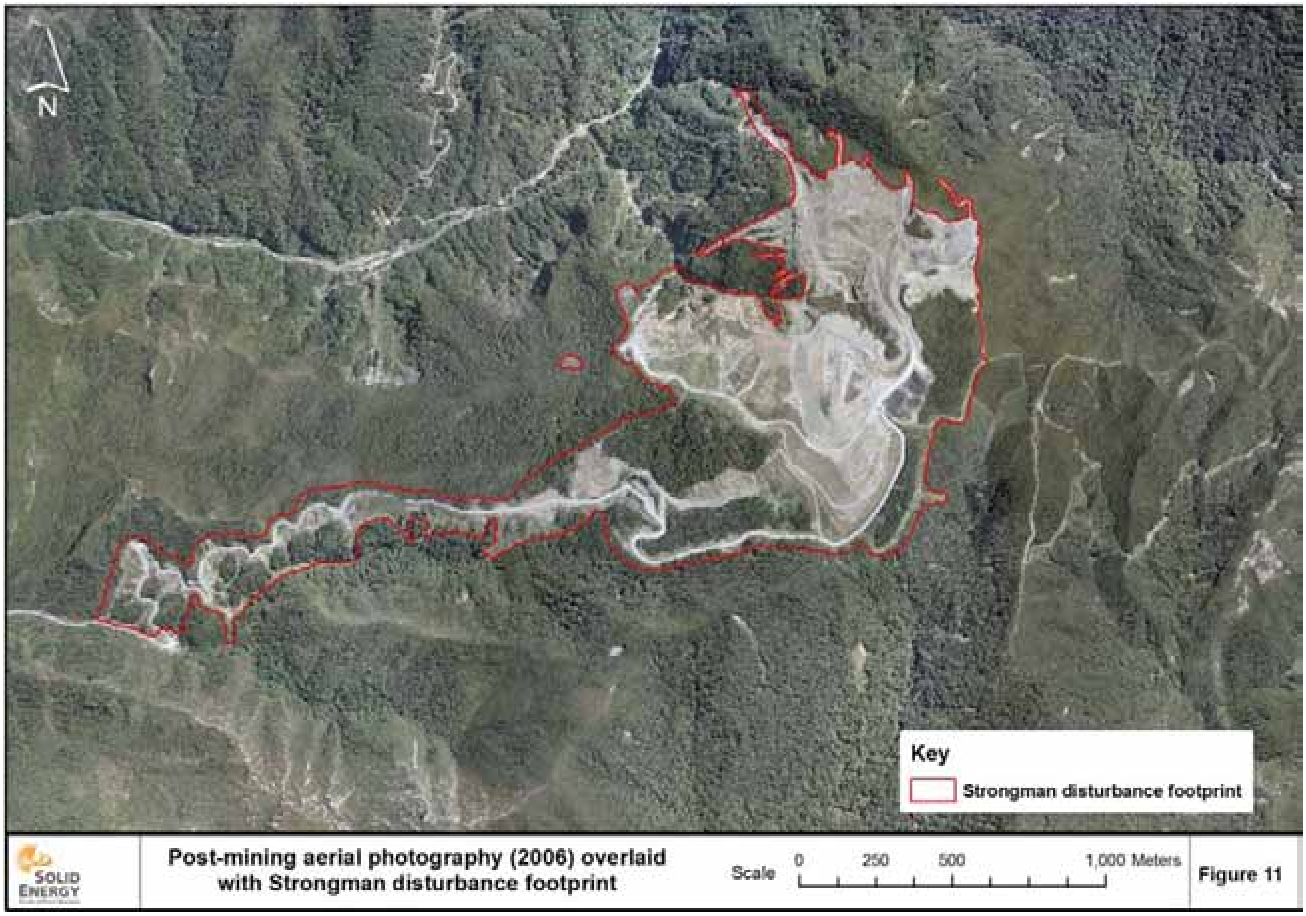


Figure 11: Post-mining aerial photography (2006) overlaid with opencast mine areas



This footprint includes all of the disturbed land associated with the Strongman 2 underground and opencast area. Edge effects were estimated based on field surveys of tall forest, scrub and shrubland communities. In tall forest, edge effects were estimated at 50 m, in scrub 10 m or less and in shrubland 1 m or less (much of this vegetation is very dense). For the purposes of determining boundaries for this project a conservative edge effect distance of 50 m was assumed for the entire site. Along the access road sidecasting (the casting of rock and vegetation material excavated from the road line into the adjacent gully) created a disturbed slope along much of the route and sidecast materials also entered stands of forest that remained standing. This was taken into account in establishing the final area. Considerable disturbance to adjacent vegetation occurred during construction of this road, which was developed specifically to access the coal reserves.

The eastern boundary of the footprint was defined as the loop road (to the east extension). We have excluded the road leading eastward to a separate prospective mining area, the ‘Liverpool’ or ‘Seven Mile’ area (not yet developed). Strongman 1 underground workings are present to the west of the project area however there are no discernable features present at the surface that have changed the ecosystem. This is because underground mining occurred at great depth and surface deformation is negligible. The pre-mining landscape shown in Figure 10 shows no significant earthworks or tracks ‘uphill’ (north) of Strongman 1, except distinct and discrete drill sites (some of which are now revegetated).

The road to Strongman 2 underground was constructed in 1993. The 2006 (post-mining) aerial photograph (Figure 11) was used to delineate the extent of earthworks and associated erosion because there have been no earthworks since then that would alter boundaries. These mine boundaries were digitised and overlaid on the 1985 aerial photograph.

This ‘immediate’ footprint was extended to incorporate:

- The road above the Strongman 1 underground portal to Strongman 2 portal (which was not originally mapped).
- Sidecasts and associated erosion.
- Edge effects, particularly into tall forest, where trees adjacent to abrupt edges are more susceptible to windthrow, and undergrowth exposed to greater light and wind (lower humidity) and potential invasion of weeds.
- Areas affected by burning, hot substrate and smoke.
- Impacts on aquatic systems / streams which are summarised in Section 2.2.3. Four annual surveys (2004 to 2007) indicate that the Nine and Ten Mile Creeks have not been impacted by Strongman Mine operations. Headwater tributaries (e.g., Waterfall Creek) are very short in this mountainous landscape, so are largely encompassed within the mapped Strongman footprint.
- Impacts on the ranges of kiwi (not yet available).

3.2 Identifying ‘reference’ or ‘benchmark’ sites

3.2.1 Benchmark sites

BENCHMARK sites are areas considered to have biodiversity equivalent to that which was present before mining began. It was not possible to identify pristine or well-conserved examples of ecosystems and biodiversity components at the site, as recommended by the BBOP guidance, since the creation and maintenance of such examples in the New Zealand context nearly always requires long-term, broad-spectrum control of mammals to very low densities, and this has not occurred at any site near the Strongman Mine. Benchmark sites were selected using the BBOP habitat hectares approach, where the first step is to assess the site in context of the broader area. This includes a BASELINE ecological assessment to identify the site boundaries, the KEY BIODIVERSITY COMPONENTS, locating and identifying reference sites for vegetation assessments and assessing the level of disturbance. This information was presented in Sections 2.2 – 2.4.

3.3 Key biodiversity components

The key biodiversity components considered in the development of the habitat hectares matrix are provided in Table 5.

Table 5: Key biodiversity components (pre-mining)

Biodiversity	INTRINSIC VALUES	USE VALUES	CULTURAL VALUES
Animal species Avifauna, which includes threatened* (and iconic) species such as kiwi, New Zealand pigeon, kakariki, long tailed cuckoo, rifleman, New Zealand falcon, western weka, South Island Kaka, South Island fernbird (and others)	Presence of threatened species	No direct commercial value; all indigenous bird species listed are absolutely protected under the Wildlife Act	Special dispensation can allow Maori to collect some culturally important species, (e.g., New Zealand pigeon) for ceremonial purposes that are protected by the Wildlife Act; some bird species are considered *taonga* (treasured)
Plant species Threatened species *Peraxilla tetrapetala*; five species at southern limit and five species ENDEMIC to or of localised distribution known to be present to the east of the site	Presence of threatened species in the general area	No commercial or other use	Some plant species have medicinal value but no known current use of the area by Maori
Habitats Tall forest of rimu and beech Upland forest of rimu, beech, Hall's totara Podocarp forest (yellow-silver and pink pine dominated) characteristic of coal measures Podocarp-manuka shrubland characteristic of coal measures but some fire-induced	Known habitat for listed threatened animal species, potential habitat for other listed threatened plant species found outside of the site	Recreational hunting (all cultures); possum trapping. The area is 'State Coal Reserve' and thus has national economic value	Habitat for plants and species of cultural importance (food fibre and medicinal) considered *taonga*
ECOSYSTEM SERVICES Sediment control, stability maintenance, protection of water quality of Nine Mile and Ten Mile catchments	Landscape and ecosystem valued for AMENITY	Functions include: water catchment sediment control, assists stability of steep land, carbon sequestration	Natural water quality is valued by Maori and pakeha for cultural, recreational and amenity qualities

* Refer to Appendix 3 for Hitchmough *et al*.'s (2007) hierarchy of threat status adopted in New Zealand.

3.4 Applying the mitigation hierarchy

3.4.1 Avoid, minimise and rehabilitate

Biodiversity offsets are a commitment to compensate for significant residual adverse impacts on biodiversity identified after appropriate AVOIDANCE, minimisation and REHABILITATION measures have been taken according to the MITIGATION HIERARCHY (i.e., avoid, remedy, mitigate as outlined in the Resource Management Act 1991). Offsets cannot provide a justification for proceeding with projects for which the

RESIDUAL IMPACTS on biodiversity are unacceptable. In this case the mitigation hierarchy has not been applied as the mining activities have already occurred and thus this project deals with a post-hoc offset.

During mining and rehabilitation the company attempted to remedy the effects of its activities (fire effects, vegetation removal, habitat impacts). In 2003 Solid Energy publically acknowledged that the efforts to avoid and remedy the impacts at Strongman 2 had fallen short of appropriate standards. This in turn triggered the initiative to develop a series of 'offsetting activities' including this BBOP project.

That said, Solid Energy has continued rehabilitation of the site (which is its normal practice) with the objective of returning it to a cover of indigenous vegetation in the medium term as set out below.

3.4.2 Rehabilitation

The total footprint of the Strongman Mine (about 150 ha) is relatively large in comparison to the area from which coal was extracted (about 40 ha) for two key reasons: first, the very steep topography especially in relation to the North-West pit margins increased the risk of surface erosion from the edges of bluffs, and the slips tended to travel relatively long distances to the base of the valleys – long, narrow slip scars are typical, also overburden material was disposed of in adjacent undisturbed areas during the initial mine development. Second, most of the pit, and nearly all the access road, abuts tall forest which is vulnerable to edge effects (the disturbance estimate generally used a 50 m buffer) – only the north-east part of the mine abutted shrubland where the low, extremely dense plants meant edge effects are likely to be only several metres.

The degree and longevity of impact are expected to vary across the site, according to vegetation type, species present and context of the disturbance, as illustrated in the disturbance map (see Figure 9). In disturbance classes 9 and10 the pre-mining vegetation and soils were completely removed and / or buried. Rehabilitation activities have been applied to most of these areas, with the exception of some sidecasts.

The 10 year aim for rehabilitated areas is the establishment of a vegetation cover that promotes succession to a resilient native forest and shrub cover with low medium-term management input. The short term rehabilitation aims of stability and protection of water quality have been met over the majority of the site, and sediment ponds are expected to be decommissioned and planted in 2009.

Rehabilitation outcomes are tracked using permanent photo points (photographed annually), supported by the recording of native and exotic vegetation cover and height along 50 m permanent transects that are representative of areas with similar rehabilitation (e.g. similar age, substrate and aspect). Release of a performance bond is linked to progress towards 75% native plant cover greater than or equal to 1 m height.

Accessible areas from which vegetation was completely removed have been contoured, covered with a growth substrate (stockpiled soils) and revegetated. Much of the site was seeded with exotic grass species to provide short-term stabilisation of re-spread soils. This decision was taken on the basis that soil conservation and minimisation of impacts on surrounding vegetation are crucial in the short term and in the long term the development of an indigenous ecosystem will succeed the exotic grass species (there are many examples in New Zealand of regenerating indigenous vegetation completely succeeding and replacing such exotic grasses). Solid Energy is prepared to intervene to remove exotics if necessary, once the indigenous vegetation is providing those ecosystem services.

Since 2002, 11 woody and herbaceous native seral plant species have been successfully established using planting of nursery-raised seedlings at an average density of 5000 seedlings/ha, some native seeding and small areas of transplants from areas before stripping. The dominant planted species have been karamu

(*Coprosma robusta*), koromiko (*Hebe salicifolia*), mountain flax (*Phormium cookianum*), manuka (*Leptospermum scoparium*), broadleaf (*Griselinia littoralis*) and toetoe (*Cortaderia richardii*). The majority of planting was completed between 2002 and 2007. Maintenance activities include annual possum control to reduce browsing of planted areas, weed control (using herbicides), limited fertilising and maintenance of the main access roads. About 10 ha of the 155 ha site remains to be rehabilitated, excluding the main access road (about 4.5 ha) that will remain indefinitely. The 10 ha includes minor access roads (about 4 ha), areas where fire suppression activities are in progress, several structures (water tanks and implement sheds) and small stockpiles used for road maintenance and fire-fighting/grouting. About 5 ha of this area are expected to be planted in spring 2009.

On most sites covered with respread topsoil, the native seedlings planted exceed 0.5 m height within 5 years. The majority of planted areas should achieve the performance bond standard within 10 years. This is equivalent to disturbance rating 7 (described in Section 2.6, Table 3).

In relation to the "value" of rehabilitated areas, in the HABITAT HECTARES calculation a value of zero was attributed, as rehabilitation is at such an early stage and biodiversity values have not yet been replaced.

3.5 Offsetable nature of impacts

The presumption of 'LIKE-FOR-LIKE' offsets is one of the most effective means to achieving 'no net loss' except in cases where 'TRADING UP' to a higher conservation priority BIOTOPE – an 'out-of-kind' offset – is justified. In New Zealand the best PROXY MEASURE for ecosystem or HABITAT TYPE is provided by the LENZ framework (Figure 8), with the caveat that it is not suitable for small, dispersed ecosystems such as rock outcrops. The LENZ framework is useful at a scale of about 1:50,000 because it covers the whole of New Zealand, and uses national climate surfaces, soil, slope and geology information. It allows comparison of present native ecosystems (using national land cover databases derived from satellite imagery) and probable past native ecosystems, thus providing an estimate of the representativeness of ecosystems and their vulnerability to depletion. The national threat classification assessments highlight ecosystems with less than 30% of their original area. Decisions relating to trading up' are dealt with on an ad hoc basis and there are no prescribed rules for this in New Zealand. The Strongman ecosystems are regionally well represented, consequently trading up is a viable option that has been explored.

In summary, the ecosystems at Strongman are considered to be offsetable due to the large residual area of similar forest under conservation management. The regeneration processes acting on seral forests today are unlikely to result in the vegetation pattern previously present, particularly in the presence of deer, which even at low densities remove highly palatable species, and to a lesser extent the presence of possums and rats.

The presumption is that 'like–for-like' offsets can be applied at a species level. The BBOP framework requires that no species undergoes EXTINCTION or a negative change in its conservation status as a result of the development project. This requires identification of the species present at the IMPACT SITE prior to the activity being undertaken. As the Strongman offset is being assessed at the cessation of mining, and pre-mining information did not include detailed species assessments, lists of 'likely' species have been created. Species lists for fish and aquatic invertebrates are likely to be most accurate, as annual measurements from 2004 to 2007 (during mining) at sites upstream and downstream of the mine indicate no discernable change in biota. The inventory of bird species in the wider area is also likely to be little changed given the nature of the topography and short life of the mine. Many of the native birds are threatened due to slow population decline (i.e. chronic threats due to predation); South Island kaka have the highest conservation status of the birds recorded at the site, followed by New Zealand falcon. Great spotted Kiwi, whilst iconic and charismatic, have a lower threat ranking but may have greater conservation significance due to their location and density. None of these species are likely to have increased their threat ranking at a national scale as a result of the mining activity. As a result of this uncertainty in information the use of species as a measure of value and impact has been rejected and proxies developed to replace them. These include specific INDICATORS for the health of faunal populations.

In this case study the key biodiversity components and their context have been described in some detail. Rather than undertaking analysis of effect and determining offsets based on the species level, proxy measures have been developed that encapsulate the habitat characteristics that determine species health. It is considered that analysing on a multiple species basis is redundant where suitable proxies can be identified. This is further explored in Section 3.7.

3.6 Developing the attributes used in calculations

Central to the BBOP methodology is quantifying the pre-project and post-project biodiversity CONDITION using ecosystem ATTRIBUTES. The attributes are SURROGATES for the amount and quality of biodiversity and reflect the success or otherwise of a project in minimising residual impacts on biodiversity. Attributes used in other BBOP pilot projects include:

- Forest canopy cover and forest condition class (various methods are also used in New Zealand to quantify impacts of browsers).
- Measures of suitable habitat, e.g., density of streams / ha, tree snags (or cavities) / ha, rock piles / ha, and large diameter trees / ha.
- Measures of animal abundance or diversity, e.g., stream invertebrate species and abundance, number of home ranges overlapping the project area.

In this case study raw presence or absence is not used. The draft attributes are similar for both forest and scrub ecosystems; the scrub attributes being a subset of the forest attributes and indicated by*. The attributes were selected to minimise cross correlation but areas where there is correlation are also identified below.

- **Canopy cover (%)*.** Undisturbed (reference plot) forest and scrub are characterised by >90% (canopy+emergent) canopy cover. Nearly all surfaces are vegetated unless large boulders or recent wind-thrown trees are present. The canopy cover parameter is a surrogate for land stability, strongly linked to erosion, and is also included as it needs to be tracked as a criterion indicating success of rehabilitation. Prior to mining, there would have been near 100% cover. At full canopy closure weed invasion is reduced.
- **Emergent cover (%).** Forests with a podocarp component are characterised by the presence of emergent trees. This criterion may be deleted, as it overlaps to some extent with canopy cover and is an artefact of the species present as well as forest age, being less pronounced in beech forest with a low density of podocarps. Emergent cover is chosen to reflect age (full maturity) of vegetation. Large tree girth or dbh, presence of epiphytes and tree cavity habitat for some bird and bat species are further characteristics.
- **Shrub understorey (1 to 4 m height) cover (%).** A shrubland understorey develops only after the canopy has thinned and reached a ‘mature’ height, so this attribute is a measure of the maturity and complexity of a site. Shrubland (scrub) does not support an understorey, as light levels are too low. This is also an indicator of the abundance of deer and goats.
- **Ratio browsed: unbrowsed plants*.** This is a measure of the impact of exotic browsing animals, since it has been established through exclosure plots and research in the West Coast forests that both deer and possums have a preference for certain species (Nugent *et al*. 2000, Parkes and Forsyth 2008, Payton *et*

al. 1997, Pekelharing *et al.* 1988, Sweetapple 2003). This criterion may be replaced by 'the density of large-leafed (palatable) species in 0.5 to 2 m layer', reflecting the impact of deer on understorey and future canopy species.

- **Ratio of native to non-native vascular plant species*.** This attribute is a measure of the intactness of native flora. Degraded sites generally have a high number of exotic species and intact native ecosystems have no exotic plant species. A simpler alternative measure is the % cover of exotic species.
- **Proportion of kiwi home ranges with juvenile kiwi.** The great spotted kiwi is a species of high conservation and CULTURAL VALUE. The presence of juveniles indicates a healthy population, as these long-lived birds are highly vulnerable when small, but when >800 g (approximately) are relatively resilient to stoats (their key predator). The use of kiwi home ranges incorporates a measure of population density. Stoat density has not been used, as densities are notoriously variable and difficult to measure as they depend on environmental factors not under the control of the project.
- **Small native bird species occupancy*.** Occupancy of small birds is heavily influenced by the impact of rats, a key predator of small birds, invertebrates and seeds. This indicator is included to counterbalance the impact of a criterion on kiwi, as an exclusive focus on kiwi predators (stoats) can increase abundance of rats. The methodology for this indicator needs to be refined. At its simplest, the measure is the proportion of bird species present pre- mine (or at the benchmark sites) that are found to be present at a site. More sophisticated (and complex) versions take bird abundance into account.

The modified habitat hectares approach requires giving each attribute a value reflecting its condition before and after the project (before rehabilitation). When summed, these provide the 'habitat quantum' (or hectares) that must be offset. Each LIKE-FOR-LIKE ecosystem or species offset is assessed for the habitat quantum that can be generated.

Table 6 provides estimated values for each of the above attributes. The benchmark condition is the condition that can be attained under current intensive management like that applied on mainland islands. The pre-project status is based on the condition of the reference plots and 1985 aerial photography. Post-project condition is based on fieldwork carried out in 2008 in which disturbance was characterised. The post project condition is calculated based on the areas (hectares) of different levels of disturbance within the Strongman FOOTPRINT and with equal WEIGHTING of values.

Table 6: Attributes used to characterise biodiversity condition at the Strongman site

Forest attribute	Benchmark condition	Pre-project 1985	Post-project 2008
Canopy cover	90%	90%	8%
Emergent cover	20%	5%	1%
Shrub understorey (1 to 4 m) cover	50%	40%	15%
Palatable species: unpalatable species	100%	40%	1%
Intactness of flora: native: non-native plants	100%	90%	24%
Ranges with juvenile kiwi	30%	20%	0%
Small bird species occupancy	100%	50%	5%

The benchmark column indicates the percentage cover of the parameter in the absence of introduced browsers, grazers and predators (i.e., pre-European settlement).

Calculation of offsets

A conservative footprint of Strongman Mine as reflected in vegetation and rated by level of disturbance, was mapped onto a 2005 aerial photograph. Areas were then calculated for each of the 9 levels of disturbance. This gave a total footprint with any level of vegetation disturbance of 148 ha. It also enabled calculation of an equivalent 'bare-land' area of 102 ha, recognising that ecological values increase as the level of disturbance decreases (Table 3). As described in the text below that table, to calculate the 'disturbed area equivalent' the area disturbed in each disturbance class is multiplied by the disturbance rating (converted into a number between 0.05 and 0.9, where 0.05 is disturbance level 0.5, and 0.9 is disturbance level 9 – a linear scale is used to adjust for the effects of disturbance. Other scales could be used to 'stress test' the model. This is a crude and simple measure of habitat hectares.

The modified habitat hectares approach was used, as illustrated in the following tables, and following the approach used in the BBOP methodology appendix, using ECOSYSTEM attributes to more fully characterise the state of biodiversity. Table 7 shows the steps used to calculate a loss of 41.3 habitat hectares associated with impacting 111.6 ha of forest ecosystems in the Strongman footprint. The pre-project habitat hectares is the (pre-project condition) multiplied by the weighting value. In this case each criterion has been given the same weighting; so with 7 criteria the weighting is $\frac{1}{7}$ (0.143). The post-project habitat hectares are similarly calculated by dividing the post-project condition by the pre-project condition and multiplying this by the weighting value. The net loss (column C) is the pre-project habitat hectares per hectare (column A) minus post-project habitat hectares per hectare (column B), and the habitat hectares lost is the forest area impacted by the project (111.6 ha) multiplied by net loss (refer to Treweek *et al*. 2008 a & b).

Table 7: Calculation of biodiversity loss as habitat hectares for forest ecosystem at Strongman Mine

Attribute	Benchmark conditions (%)	Pre-project condition (%)	Post-project condition (%)	Pre-project habitat hectares / ha	Post-project habitat hectares / ha	Net Loss of habitat hectares / ha	Habitat hectares lost
				A	B	(A-B = C)	111.6 x C
Canopy	90	90	8	0.143	0.013	0.130	14.5
Emergent cover	20	5	1	0.036	0.007	0.029	3.2
Understorey	60	40	15	0.095	0.036	0.060	6.7
Palatable plants	100	5	1	0.007	0.001	0.006	0.7
Native flora	100	100	24	0.143	0.034	0.109	12.2
Kiwi	30	0	0	0	0	0	0
Small birds	100	30	5	0.043	0.007	0.036	4.0
Total						0.370	**41.3**

Note: The weighting was the same for all attributes (i.e., 0.143) so is not included as a column.

Table 8 shows the steps used to calculate a loss of 24.8 habitat hectares associated with impacting 43.3 ha of scrub ecosystems in the Strongman footprint.

Table 8: Calculation of biodiversity loss as 'habitat ha' for scrub ecosystems at Strongman Mine

Attribute	Benchmark condition (%)	Pre-project condition (%)	Post-project condition (%)	Pre-project habitat hectares / ha	Post-project habitat hectares / ha	Net loss of habitat hectares / ha	Habitat hectares lost
				A	B	(A-B=C)	43.3 x C
Canopy	90	90	7	0.25	0.019	0.231	10.1
Small birds	100	50	7	0.125	0.018	0.108	4.7
Native flora	100	100	7	0.25	0.018	0.233	10.0
Kiwi	30	0	0	0	0	0	0
Total						0.571	**24.8**

Note: The weighting was the same for all attributes (i.e., 0.25) so is not included as a column.

Sensitivity assessment

To assess the sensitivity (or robustness) of the habitat hectares approach to the ATTRIBUTES selected, an estimation of biodiversity GAINS was undertaken for an offset project scenario focusing exclusively on achieving optimum kiwi survival through intensive pest (stoats) control. This offset scenario would increase the proportion of kiwi with juvenile birds in their home range from around 0 to 30%, by using captive rearing in years when stoat densities are expected to be high, or mortality has delivered below-target numbers of juveniles. In this scenario there is no benefit to the vegetation attributes, and no impact on small bird occupancy. This offset would produce a net gain of 0.143 habitat hectares / hectare in like-for-like forest ecosystems and 0.25 habitat hectares / ha for scrub ecosystem. With equal weighting for all ecosystem attributes, the number of attributes selected is important. Few attributes in the scrub ecosystem mean gains in any single attribute add more value than if they occurred in the forest ecosystem described by more attributes. The value given to an offset also depends on its chosen weight. Both the number and weighting of attributes are subjective.

Offsets that deliver substantial rapid improvements in post-project condition, such as kiwi enhancement, or revegetation of sparsely-vegetated orphan mine sites are favoured, as are offsets that can deliver multiple benefits, such as predator control. Although structure is an important characteristic of forests, because emergent trees and dense shrub layer are generally slow to develop, these attributes are unlikely to be the target of offset actions. This is unfortunate, as deer browsing is recognised as having a major impact on long term forest sustainability.

The relationship between the attribute and the overall state of biodiversity affects the estimated value of the offset where there is more than one way to increase the attribute value. For example, kiwi juveniles (as above) can be increased by pest control or by artificial rearing, but only pest control gives wider biodiversity benefits.

Time discounting

Time discounting is important where long-lived vegetation is involved. Although a vegetation cover approximating to that present prior to mining may eventually be restored, there will have been a lag of many years between the original loss of native vegetation and its return. This case study has not at this stage included a time discount step but this will be considered during the development of the offset.

Table 9 gives the anticipated ecosystem criteria for vegetation at 10 years of age. Large increases in canopy cover, presence of palatable species and native intactness are predicted, a moderate increase in the occupancy of small native birds, but no change in criteria that reflect a forest structure (as the rehabilitated areas are too young to have an emergent canopy or shrub understorey). The response of kiwi is likely to be controlled by predation as in the absence of intensive predator control successful breeding is unlikely. At this moderate to low altitude site, kiwi are at the margin of a much larger population centred in the upland Paparoa Range. Predator numbers are smaller in this colder, damper high altitude HABITAT of the range.

Table 9: Attributes used to characterise biodiversity condition at the Strongman site pre-project, immediately post-project and estimated for rehabilitated forest ecosystems meeting the closure criteria (approximately age 10 years)

Forest attribute	Pre-project 1985	Post-project 2008	Condition at closure	Residual loss*	Temporal loss
Canopy cover	90%	8%	80%	10%	72%
Emergent canopy cover	5%	1%	1%	4%	0%
Shrub understorey (1 to 4 m) cover	80%	15%	15%	65%	0%
Palatable species: unpalatable species	40%	1%	20%	20%	19%
Intactness of flora – native: non-native plants	90%	24%	50%	40%	26%
Ranges with juvenile kiwi	20%	0%	0%	20%	0%
Small bird species occupancy	50%	5%	20%	30%	15%

***** Residual loss = pre-project – closure condition; temporal loss = closure condition – post-project

Note: The immediate post-project condition is calculated based on the hectares of different levels of disturbance.

An additional time-discount is relevant to the Strongman project, as a BBOP principle is to establish an offset, and achieve biodiversity gains, before the negative biodiversity impact of a project occurs. In the case of Strongman Mine, biodiversity losses occurred before the offset can be implemented – the access road to the underground mine was constructed in 1993, and the majority of impact occurred with overburden stripping for the opencast mine from 2002 to 2005. A time discount should take this 'gap' into account.

3.7 Identifying offset options

3.7.1 Types of offset

Offsets can be described as follows:

- Like-for-like offsets, OUT-OF-KIND offsets.
- Species-specific offsets, ecosystem offsets (AVERTED RISK), social offsets.
- Ecosystem enhancement (i.e. pest or weed control, revegetation, or species introductions) vs. addition of protected land under 'standard' management of 'benign neglect'.

The focus of offset projects was to deliver ecological and / or species-based benefits. Both like-for-like and out-of-kind offsets were explored, with most of these also including ecosystem enhancement.

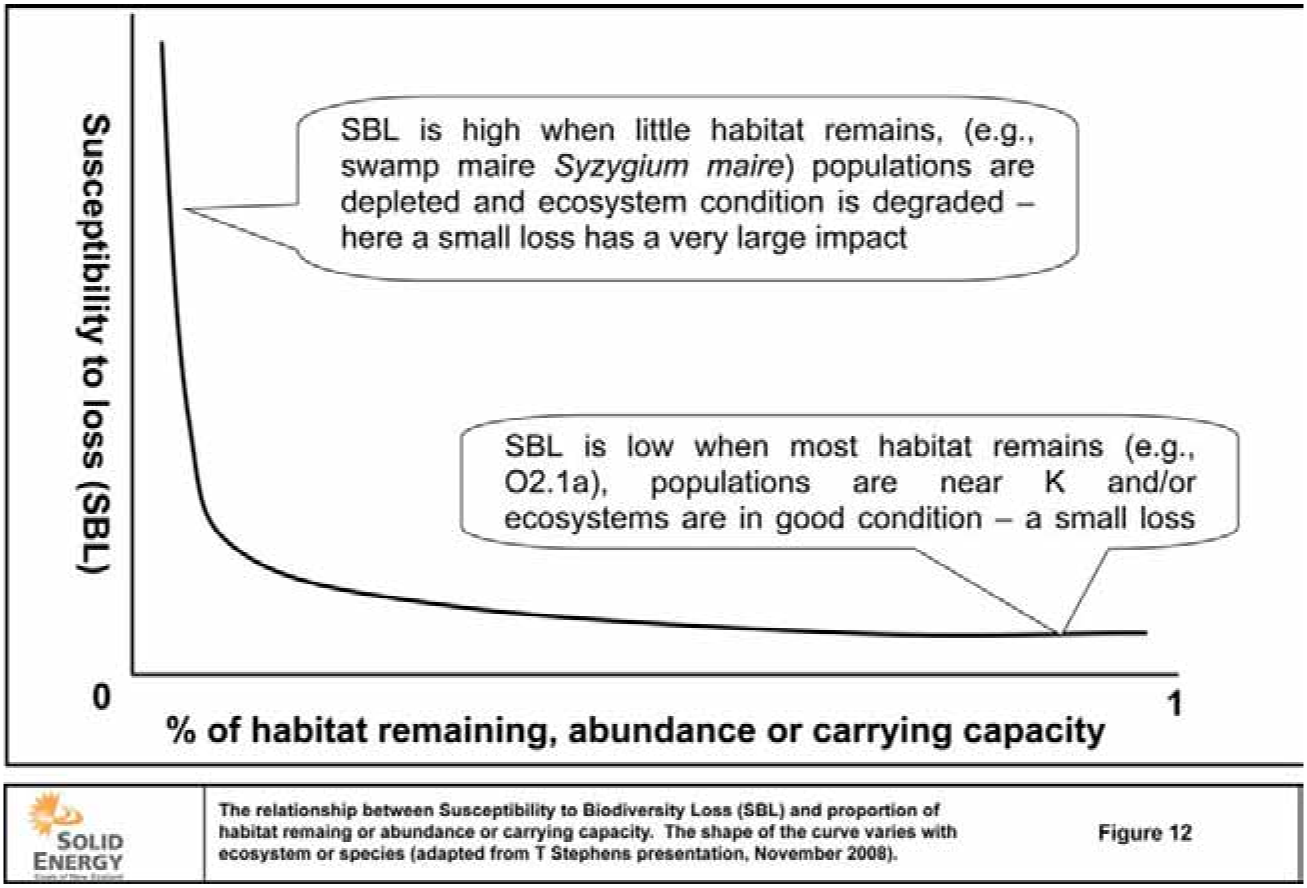
3.7.2 Potential new offset projects

Ecosystem benefits can be delivered in a variety of ways with varying levels of certainty. For a like-for-like offset the addition of protected land to achieve ecosystem benefits would, under the current normal management of 'benign neglect', need very large offset areas (thousands of hectares) to achieve ecosystem benefits because the rate of background loss of this ECOSYSTEM TYPE is slow. In contrast, protection of only small areas (<100 ha) of highly threatened 'not-like' ecosystems could achieve large ecosystem benefits, and the area could be further reduced with management that delivers ecosystem enhancements, for example, effective predator control. These analyses are described in the following examples.

The location of potential LIKE-FOR-LIKE ecosystem offsets was initially identified by mapping Land Environments of New Zealand class O2.1a and overlaying land ownership as shown in Figure 8. This was regarded as useful given the relatively large area of the O2.1a class (143,000 ha), despite the LENZ amalgamating both Strongman forest and shrubland ecosystems. Areas of particular value were considered to be large areas, areas contiguous with land owned or managed by the Department of Conservation, and areas within the Blackball Ecological District and Grey District. The latter areas had a higher likelihood of containing similar ecosystems and of achieving acceptance by the local community and conservancy.

The Department of Conservation owns or manages the majority of this LENZ class (Figure 8). Only very small areas of O2.1a, mostly contiguous with Department of Conservation land, are in private ownership. The majority of land not managed by the Department of Conservation is also Government-owned, but administered by MED for mineral extraction. Since the land is not privately owned, purchase of land for an offset is not possible. Transfer of land to the Department of Conservation is a political process, likely to take considerable time, which would delay any offset benefits. The ecosystem benefits of transferring ownership from MED to Department of Conservation under the dominant existing management regime of benign neglect are neither large nor certain as ecosystem decline is gradual (Figure 12) and mining is still possible on land administered by the Department of Conservation. That is, a huge area would need to be legally protected to avert equivalent loss and this is neither cost effective nor feasible, nor does it align with SENZ conservation aspirations. Therefore the averted risk value of procuring such land for Department of Conservation in a like-for-like, ecosystem offset is not preferred.

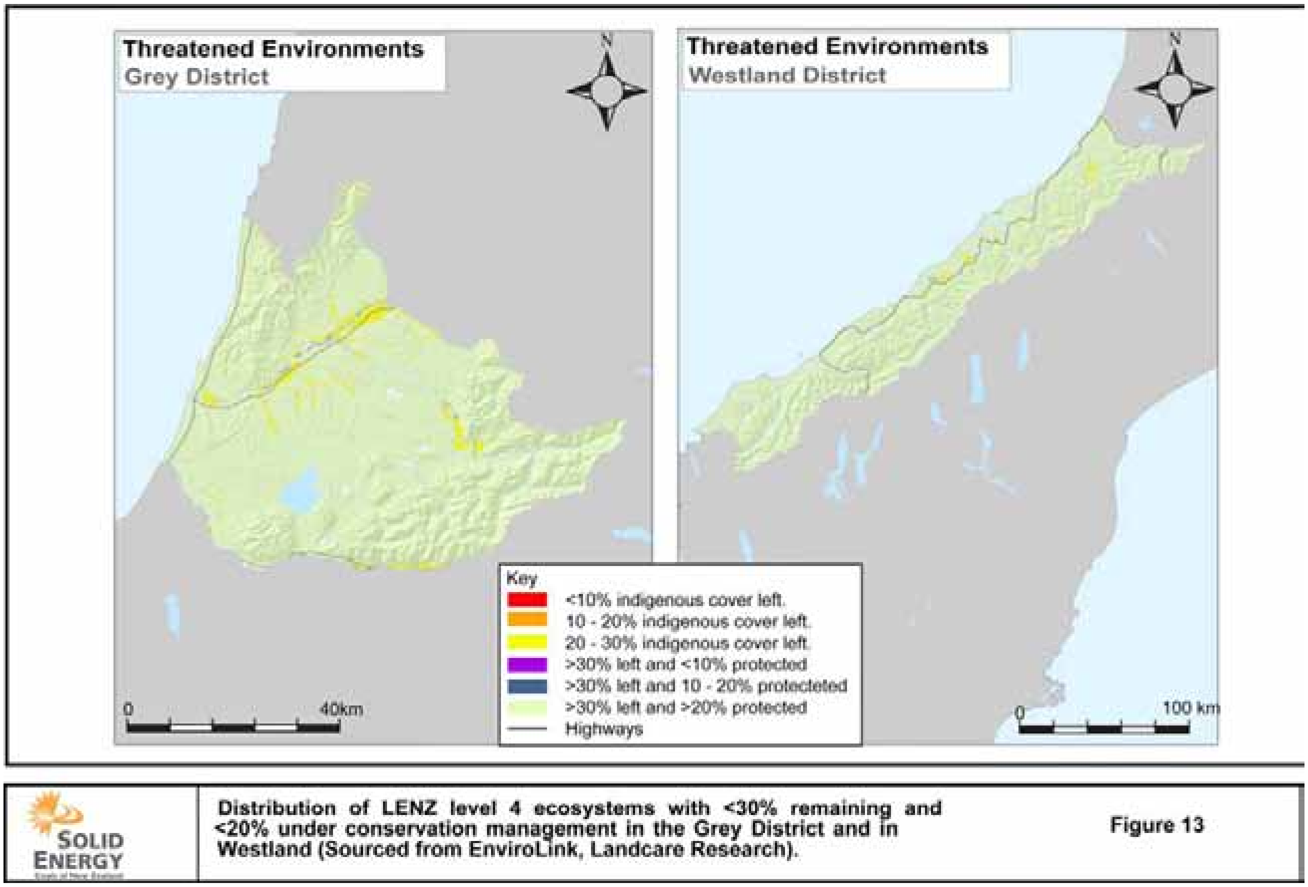
Figure 12: The relationship between Susceptibility to Biodiversity Loss (SBL) and proportion of habitat remaining or abundance or carrying capacity



An averted risk offset was explored for out-of-kind ecosystems by overlaying LENZ classes that (i) cover less than 30% of their original area (the remainder being cleared or otherwise severely altered) with land ownership boundaries, and (ii) identifying those that are less than 20% administered by the Department of Conservation. Both (i) and (ii) are ecosystems with a high susceptibility to BIODIVERSITY LOSS (on the far left in Figure 12), as the conservation significance of each land unit increases as the total number of units decreases.

The maps identified alluvial lowland river terrace ecosystems as the most threatened in the Grey District, with the largest areas in the Grey River Valley (Figure 13). Forests have been cleared, and wetlands drained by gold dredging and farming. Many unpublished reports dating from the 1970s, and more recently, identify these areas and the coastal plains as under-protected and under threat. In consultation meetings, remnant forest of the podocarp matai (*Prumnopitys taxifolia*) on these alluvial soils was identified by local Department of Conservation staff as the highest priority for protection because the understorey is often grazed, cleared and / or drained as dairy farming intensifies. Staff also noted that applications by Department of Conservation over the last few years for conservation funding to buy such forest remnants have been unsuccessful. This provides an opportunity to complement, rather than substitute for, government funding.

Figure 13: Distribution of LENZ level 4 ecosystems with <30% remaining and <20% under conservation management in the Grey District and in Westland



This out-of-kind ecosystem offset could deliver significant benefits, particularly if it contributed to a wildlife corridor across the Grey Valley to sustain / recreate genetic links between fauna in the large indigenous forest reserves on either side of the Grey Valley, as has been recommended in several reports. The Queen Elizabeth 2nd Open Space Trust ('**QE2 Trust**') was developed for such situations; under the aegis of the Trust a perpetual covenant is placed over valuable ecological components and livestock are excluded from the covenant area. Ownership can remain with the individual and the remainder of the land is retained for its current use. The land can also be purchased by the QE2 Trust and made a reserve. Such an offset requires significant initial capital for land purchase and fencing (to exclude stock), ongoing maintenance to control weeds and pests, and potentially revegetation to create dense buffer zones. This type of offset provides additional benefits through 'ecosystem enhancement'.

Ecosystem enhancement offsets

The most cost effective ecosystem offsets are achieved using ecosystem enhancement through pest control of existing land because without active intervention most New Zealand ecosystems are doomed to a continual, gradual decline in species biodiversity and abundance. At present only very small areas are being managed to slow this biodiversity decline. Despite its relative paucity New Zealand's biodiversity is of international importance – most native terrestrial plant and vertebrate species are found nowhere else. More than 50 million years of isolation means many have ancient lineages and no near relatives. Evolution in primarily forested environments in the absence of mammals favoured the evolution and PERSISTENCE of native bird and insect species that are ground-dwelling, flightless, unusually large, slow, and long-lived with slow or very slow breeding rates. These are highly vulnerable to introduced mammalian predators, particularly the three ‘virulent predators’ that hunt by scent: rats, brush-tailed possums and mustelids (stoats and ferrets) (Young 2004). Introduced mammalian herbivores (deer, goats and possums) also pose a serious threat to the conservation of indigenous biodiversity in New Zealand’s forests because they have the potential to radically and permanently change the vegetative structure and composition of many of those ecosystems (Nugent *et al.* 2001). The benefits of effective control of alien / exotic vertebrate pests and predators have been well demonstrated in New Zealand (for example Innes *et al*. 2004; Powlesland *et al*. 2003; Saunders and Norton 2001).

Ecosystem enhancement is therefore a preferred option for ecosystem offset for the Strongman Mine where large O2.1a land areas are already in the Department of Conservation estate (i.e., ‘protected’ and hence the ecosystem is not threatened by land use change). Ecosystem enhancement can also deliver species-specific benefits. Clearly interventions must include a mechanism for delivering gains in PERPETUITY. In New Zealand this is commonly done via a Trust Fund set up specifically for this purpose.

Species enhancement offsets

The text below discusses species-led offset programmes for great spotted kiwi (a like-for-like offset for a single species) and *Powelliphanta* snails (an out-of-kind offset for a single species) and two ecosystem offset programmes that have a variety of potential ecosystem enhancement methods.

Species selected for like-for-like species offset programmes are those either present in or near the Strongman area at the time mining began (see Appendix 4). The lists are derived from field surveys at Strongman and lower altitude areas of the Upper Seven Mile Creek, databases such as the National Vegetation Survey, and literature reviews described in Section 2.3.

Great spotted kiwi is the most iconic vertebrate species present in the site environs. Although an estimated 22,000 birds remain, this kiwi is in gradual and chronic decline with some populations having disappeared altogether, particularly in lowland areas where stoats are most abundant. Furthermore control of kiwi predators also protects other forest birds such as kaka, which are more threatened (this offset does not offset damage done to the vegetation and invertebrate communities by ungulates).

The kiwi population near Strongman is at the periphery of a larger, high altitude population in the southern Paparoa Range. Predator control, if carried out regularly and effectively, is recognised as an effective method of increasing kiwi populations, and can be complemented with artificial hatching and raising of chicks until they reach a size at which they are resistant to stoats. A kiwi-focused, enhancement offset could be achieved by expanding an existing programme in the south-eastern Paparoa Range. Increasing existing areas can be more cost effective than starting a new programme because edge effects and the size of the affected area are important, especially as kiwi are territorial and have large home ranges (20 to 50 ha), so juveniles need to disperse to areas within the predator control area. An alternative is to begin a programme based around the Strongman site. The potential for both sites to increase the abundance and range (area inhabited) of kiwi needs to be assessed. Both sites have the potential to offer additional ecosystem benefits, if the number of predator species targeted is expanded (particularly to include rats), and if herbivores (particularly deer) are eliminated.

The kiwi-call survey indicated a minimum of four and probably five pairs of great spotted kiwi, and a single male in the 350 ha survey area centred on the Strongman site. The survey indicated that territories include parts of the current Strongman footprint, and that they include scrub and forest ecosystems. As scrub and forest areas within the footprint appear to be part of existing ranges, the Strongman area conservatively removed 100 ha from great spotted kiwi ranges (disturbance classes 6 to 10, Table 4). Although the survey method used cannot specify territory size (this would require using kiwi tracking dogs to capture the birds), the density of birds indicates that 100 ha could have supported two or three pairs of great spotted kiwi – six potential pairs were recorded in the 350 ha survey area (which included 100 ha within the Strongman footprint that is not kiwi habitat), that is, the home ranges cover approximately 40 ha each. The highly territorial nature of kiwi means displaced birds are unlikely to survive where the adjacent territories are occupied. It should be noted that the kiwi carrying capacity of the adjoining area is not well understood and the displaced individuals may well have established territory within the surrounding areas. The number of pairs impacted may have been greater if mining made parts of adjacent kiwi territories non-viable.

An offset should mitigate the impact on great-spotted kiwi and their potential offspring from the beginning of surface disturbance through to the time when kiwi would be likely to utilise the rehabilitated site. Great spotted kiwi calling rates were similar to those on the Mount William Range. Breeding success of that population was estimated at a maximum of 0.125 juveniles/pair/year without stoat control. The current situation at Strongman has yet to be determined.

Powelliphanta gagei were considered because even though they were not present at the site prior to mining, it is probable that in the absence of predators their range would have extended further than it currently does. This species has the highest threat status of an invertebrate species, although it's taxonomic and conservation status has not been confirmed due to the small number of individuals, patchy distribution and remote location of the population. The greatest threats to the snail are likely to be predation and habitat disturbance associated with open-cast mining and associated infrastructure (especially roads), since it appears to favour coal measures outcrops and ridgetops. An out-of-kind biodiversity offset for the snail would be relatively high-risk, as it would not be on land administered by MED, and benefits of pest control are both unproven and resource-intensive to quantify for snails because little is known about this snail's natural abundance and distribution. Although this offset could have national benefits, because no other conservation programmes exist for the species, this species-led offset is not recommended because the risk of non-achievement is considerable.

Two ecosystem enhancement programmes that the Department of Conservation is already carrying out (these are not BBOP projects) are an existing OUT-OF-KIND programme in the Maruia Valley and a LIKE-FOR-LIKE programme in the Blackball Ecological District (described in Appendix 6). The enhancement methods include intensive predator control, removal of pest browsers, weed control, and rehabilitation of disturbed areas within the general offset area. Department of Conservation staff have encouraged companies considering offsets (e.g., Globe Mine) to contribute to and expand the Maruia Valley predator control programme. This site contains no kiwi and is a beech-forest ecosystem, so would not be a like-for-like offset for the Strongman project. The Maruia and like-for-like Paparoa great spotted kiwi programme could be enhanced by increasing the area treated, or expanding the programme to cover a greater range of pests. Focusing only on predators of kiwi (mustelids and dogs), or removal of only possums, can mean the populations of small birds are negatively affected because rat numbers are likely to increase in the absence of mustelids, and rats eat birds. Research in the Paparoa Range, on the West Coast, and nationally has identified the impact of specific browsers on different plant species and forest ecosystems, and their potential for recovery on removal of the browsers.

If weeds are present at offset sites, their removal (an enhancement gain), and the prevention of new populations of ecological weeds establishing (an averted risk gain) can be of great value. Most of the potential offset programmes described have few weed issues, however, if an offset for great spotted kiwi was started in the Strongman area, weed control with removal of deer would be beneficial, given the presence of weeds along many existing access roads and at drill sites. Securing the Strongman area from invasions of bird-dispersed weeds (e.g., cotoneaster) should involve control of weeds down to the coastal strip and along the coastal road to minimise further weed invasions into Nine and Ten Mile Creek Harbour Board Endowment land (managed by the Department of Conservation). However, actions preventing future decline are often less favoured for such projects because they are prophylactic, the effects take some time to be noticeable and are therefore more difficult to explain to the lay public; whereas actions such as predator control and, to a lesser extent, herbivore removal provide a more visible gain. From a corporate perspective the latter provides more demonstrable benefits.

3.8 Quantifying gains from offset options

The gains from potential offsets calculated using the HABITAT HECTARES approach have only been modelled for a combined species-based (kiwi) and like-for-like ecological enhancement. The criteria used may vary depending on the project selected, because some projects are already measuring biodiversity outcomes using their own methods. The aim of the selected offset is to ensure that biodiversity benefits from the proposed offset(s) substantially outweigh the biodiversity impact of the Strongman Mine, and that the risks are low, or have clear 'fall-back' remedies to ensure success if the methodology selected fails to deliver the anticipated gain (for example, ecosystem enhancement projects). In the situation where proven offset methodologies already exist (as is the case for predator control in New Zealand) this reduces the need for expensive fieldwork to quantify the magnitude of benefits. There must still be an underlying logic and measurement process to demonstrate that the selected offset does provide benefits that substantially outweigh the biodiversity impact of the given project. However in situations or economies where quantification is difficult or expensive, or resources are limited, the 'smother' approach (so much gain that there is clearly no net loss) may be the most effective way to manage an offset process.

3.9 Finalising offset site(s) and activities

A range of potential offset projects has been identified including threatened species, like-for-like and 'not-for-like' ecosystem enhancement projects. Several small MITIGATION projects have been running for several years and the expectation is that these will continue. Solid Energy is supporting a potentially substantial social mitigation project, the South Paparoa Walkway. The priority for an offset project is therefore to provide ecosystem offsets, and projects that can be readily expanded may be preferable. Like-for-like ecosystem offsets and great spotted kiwi offsets are best gained by ecosystem enhancements, through controlling a range of introduced pests including predators (to achieve kiwi and native bird success criteria) and herbivore and / or weed removal to achieve forest health criteria. Two projects could build on existing biodiversity enhancement projects: the out-of-kind Maruia Valley pest control programme and Paparoa kiwi programme. The Strongman ECOSYSTEMS are well represented in the Department of Conservation estate, hence the AVERTED RISK project proposed is for a highly-threatened, not-for-like forest ecosystem (a specific site has not been identified).

It is proposed to generally estimate gains from projects once a shortlist of two or three projects has been agreed by Solid Energy and consulted parties, particularly the Department of Conservation and the Ministry of Economic Development, since most proposed offsets are on Government-owned land. Biodiversity GAINS, the likely time taken to reach targets, the risk of not achieving targets, the availability of 'fall-back options' to achieve targets, certainty that the targets accurately reflect biodiversity gains, the capital and maintenance costs of projects, legal constraints, and input of collaborators will be assessed for shortlisted projects.

4. Project Outcomes

We are satisfied that the measurement of the impact undertaken to date fairly represents the nature and scope of this retrospective pilot project. The design of an offset is now under way and consultation with stakeholders has been initiated. Solid Energy currently intends to complete this project as described in this document and looks forward to any feedback on this pilot study.

5. Conclusions / Closing Statement

This pilot BBOP study involves a retrospective assessment of impacts associated with a now closed coal mine. Due to the extensive database we are confident that an accurate assessment of biodiversity loss has been possible. The offset will involve both ecosystem (averted risk) and species led components, the latter focussing on great spotted kiwi.

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Appendix 1: Vegetation Plot Data

PLOT 1: Low tangle-fern, manuka and pine vegetation

Veg class:	Manuka-dominated shrubland to 2 m
Site class:	Undisturbed reference site (0)
Grid reference:	E2368050 N5871604
General location:	West of spur above the road, unaffected by mining activities
Geology:	mpd
Slope:	45° (either side of spur)
Aspect:	NW-SE trending spur
Canopy height:	30-50cm, occasionally 1.5m
Canopy cover:	100%
Ground cover:	*Gleichenia dicarpa* 70%, *Leptospermum scoparium* 10%

Species in height classes;

0 – 30cm	30cm – 1.5m
Gleichenia dicarpa	*Coprosma colensoi*
Lycopodium laterale	*Cyathodes fasciculata*
Phormium cookianum	*Olearia arborescens*
Empodisma minus	*Dracophyllum longifolium*
Celmisia semicordata	*Leptospermum scoparium*
Blechnum procerum	*Weinmannia racemosa*
Epacris alpina	*Phyllocladus alpinus*
Leptospermum scoparium	*Lepidothamnus intermedius*
Blechnum novae-zealandiae	*Metrosideros umbellata*
Pentachondra pumila	*Halocarpus biformis*
Schizaea bifida	*Pseudopanax crassifolius*
Lepidothamnus intermedius	*Gahnia procera*

Notes:

An adjacent band of taller yellow-silver and pink pine occurs between this and adjacent taller beech forest. Vegetation includes canopy species yellow silver pine (45%), pink pine (40%), mountain beech (5%), rimu (5%). *Gahnia xanthocarpa*, *Dracophyllum traversii*, *Phormium tenax*, *Pittosporum rigidum*, *Coprosma colensoi*, *Coprosma rhamnoides*, *Gahnia procera*, *Empodisma minus*, *Sticherus cunninghamii* make up a tangled ground layer.

Photos 22, 23

Plot 1 and Plot 2

PLOT 2: Same spur, 50m to the north

Veg class: Manuka-dominated shrubland to 2 m
Site class: Undisturbed reference site (0)

General location: Crest of spur above (north of) the road, unaffected by mining activities
Geology: mpd
Slope: 30° (either side of spur)
Aspect: NW facing slope
Canopy height: 40cm- 1.1m
Canopy cover: 100%
Ground cover: *Gleichenia dicarpa* (70%), *Dracophyllum longifolium* (10%), *Leptospermum scoparium*, *Gahnia procera*.

Species in height classes;

0 – 30cm	30cm – 1.1m
Gleichenia dicarpa	*Lepidothamnus intermedius*
Empodisma minus	*Leptospermum scoparium*
Celmisia sp.	*Dracophyllum longifolium*
Cyathodes juniperina	*Gahnia procera*
Lycopodium laterale	*Dracophyllum uniflorum*
Leptospermum scoparium	
Weinmannia racemosa	
Metrosideros umbellata	
Lepidothamnus intermedius	
Epacris alpina	
Coprosma colensoi	

Notes:
Nearby, also noted were *Quintinia acutifolia*, *Coprosma colensoi*, *Celmisia parva*

Plot 3a: Margin of tall rimu/beech forest (29.7.08)

Veg class: Seral (not mapped)
Site class: Disturbed site (8)

General location: Northern road edge, spoil heaps, on forest margins; slopes rise above to cliffs
Geology: mpd
Slope: Hummocky margins, overall 5°
Aspect: South facing
Canopy height: 10 cm to 1.5 m
Canopy cover: 40% but variable
Canopy dominants: Nil, mixed colonizers

Species present:

Weinmannia racemosa	*Metrosideros diffusa*
Blechnum discolor	*Paesia scaberula*
Nothofagus solandri	*Pseudopanax colensoi*
Nothofagus menziesii	*Grammitis billardierei*
Olearia avicenniaefolia	*Dracophyllum longifolium*
Nothofagus fusca	*Cortaderia richardii*
Epacris alpina	*Gunnera prorepens*
Astelia solandri	*Hebe salicifolia*
Baumea tenax	*Uncinia uncinata*
Blechnum novae-zelandiae	*Archeria traversii*
Coprosma colensoi	*Nertera depressa*
Coprosma lucida	*Celmisia graminifolia (check sp.)*
Coprosma grandifolia	*Griselinia littoralis*
Coprosma tayloriae	*Cyathodes juniperina*
Deudrobium cunninghamii	*Gahnia pauciflora*
Juncus articulatus	*Gahnia xanthocarpa*
Metrosideros parkinsonii	

Notes: Disturbed hummocky ground, abundant micro-sites.
Photos 29, 30, 31

Plot 3a forest margin

PLOT 3b: Rimu and beech forest

Veg class:	Rimu/beech forest
Site class:	Undisturbed reference site (0)
General location:	North side of road, slopes rise above to cliffs, 10 m in from forest edge
Geology:	mpd
Slope:	10-15°
Aspect:	South facing
Canopy height:	8-15m
Canopy cover:	100%
Canopy dominants:	*Dacrydium cupressinum, Nothofagus fusca.*

Species in height class:

8-15m	**0-1m continued**
Dacrydium cupressinum	*Coprosma foetidissima*
Halocarpus biformis	*Cyathodes fasciculatus*
Nothofagus fusca	*Elaeocarpus hookerianus*
Nothofagus solandri	*Gahnia pauciflora*
Nothofagus menziesii	*Libertia micrantha*
	Lindsaea trichomanoides
1-8m second tier	*Neomyrtus pedunculata*
Dracophyllum traversii	*Pittosporum rigidum*
Lepidothamnus intermedius	*Prumnopitys ferruginea* (Miro)
Metrosideros umbellata	*Sticherus cunninghamii*
Pseudopanax crassifolius	Seedlings of spp in taller previous tiers.
Quintinia acutifolia	
Weinmannia racemosa	
0-1m third tier	
Astelia solandri	
Blechnum procerum	
Coprosma colensoi	
Coprosma tayloriae	
Phormium tenax	

Notes:
Also seen in forest nearby *Myrsine salicina, Coprosma lucida.*
Photos 29, 30, 31.

Plot 3 b: tall forest edge

PLOT 4: Rimu/beech forest

Veg class:	Rimu/beech forest
Site class:	Undisturbed reference site (0)
General location:	North side of road, 70 m in from forest edge, sloping up to cliffs
Geology:	mpd
Slope:	15°
Aspect:	SW facing slope
Canopy height:	20m
Canopy cover:	80%
Canopy dominants:	*Nothofagus fusca, Nothofagus solandri*

Species in height class

15-20m *Dacrydium cupressinum* **2-15m** *Quintinia acutifolia* *Weinmannia racemosa* *Halocarpus biformis* *Myrsine salicina* *Dracophyllum traversii*	**0-2m** *Gahnia xanthocarpa* *Sticherus cunninghamii* *Metrosideros diffusa* *Nothofagus solandri* *Lindsaea trichomanoides* *Blechnum discolor* *Grammitis billardierei* *Coprosma colensoi* *Hymenophyllum demissum* *Hymenophyllum multifidum* *Coprosma tayloriae*

Notes:
Also seen nearby *Podocarpus hallii, Coprosma rhamnoides, Phyllocladus alpinus, Tmesipteris tannensis, Libertia micrantha, Coprosma foetidissima, Neomyrtus pedunculata, Myrsine divaricarta.* No photos.
Rimu dbh= 51cm
Red beech dbh=42cm

PLOT 5: Rimu and beech forest

Veg class: Lowland forest
Site class: Undisturbed reference site (0)

General location: South side of 9 mile creek, huge blocky square-sided rocks on forest floor, boulders and colluviums on lower slopes
Geology: mpg
Slope: 12-15°
Aspect: NE
Canopy height: 40m
Canopy cover: 80% (multi-layered)
Canopy dominants: *Nothofagus fusca, Nothofagus menziesii, Dacrydium cupressinum.*

Species in height class

30-40m	0-10m
Nothofagus fusca *Nothofagus menziesii* *Dacrydium cupressinum* **10-30m** *Nothofagus menziesii* *Myrsine salicina* *Weinmannia racemosa* *Metrosideros umbellata* *Nothofagus fusca* *Quintinia acutifolia* *Dracophyllum traversii* *Cyathea smithii* *Ripogonum scandens* *Coprosma grandifolia*	*Blechnum discolor* *Ripogonum scandens* *Metrosideros diffusa* *Podocarpus hallii* *Astelia nervosa* *Blechnum procerum* *Coprosma foetidissima* *Coprosma colensoi* *Grammitis billardierei* *Metrosideros parkinsonii* *Gahnia xanthocarpa* *Gahnia pauciflora* *Libertia micrantha* *Sticherus cunninghamii* *Prumnopitys ferruginea* *Polystichum vestitum* *Podocarpus alpine* *Quintinia acutifolia* *Cyathodes fasciculatus* *Pseudopanax colensoi* *Lindsaea trichomanoides* *Tmesipteris tannensis* *Pseudopanax crassifolius* *Metrosideros diffusa* *Hymenophyllum demissum* *Hymenophyllum dilatatum* *Dendrobium cunninghamii* *Earina mucronata*

Note:
Freycinettia baueriana subsp *banksii* common nearby.
Rimu dbh=870mm
Red beech dbh=750mm
Photos 15, 18, 19, 21

Plot 5: tall forest

PLOT 6a: Tall forest of rimu, silver beech, rata, pink pine, yellow-silver pine.

Veg class:	Lowland forest
Site class:	Undisturbed reference site (0)
Grid reference:	
General location:	Between (below) road and 9 Mile Creek, remnant forest patch
Geology	mpd
Slope:	30°
Aspect:	East facing
Canopy height:	35-40m
Canopy cover:	100%
Canopy dominants:	*Dacrydium cupressinum, Nothofagus menziesii, Metrosideros umbellata*

Species in height class:

35-40m	**0-1m**
Dacrydium cupressinum	*Sticherus cunninghamii*
Nothofagus menziesii	*Lepidothamnus intermedius*
Metrosideros umbellata	*Coprosma rhamnoides*
	Coprosma colensoi
5-35m	*Dianella nigra (?)*
Lepidothamnus intermedius	*Metrosideros diffusa*
Weinmannia racemosa	*Myrsine salicina*
Podocarpus hallii	*Lindsaea trichomanoides*
Nothofagus menziesii	*Pittosporum rigidum*
	Pseudopanax colensoi
1-5m	*Metrosideros parkinsonii*
Metrosideros umbellata	*Trichomanes reniforme*
Pseudopanax simplex	*Tmesipteris tannensis*
Coprosma colensoi	*Uncinia uncinata*
Quintinia acutifolia	*Blechnum procerum*
Dacrydium cupressinum	*Phyllocladus alpinus*
Lepidothamnus intermedius	*Leptospermum scoparium*
Dracophyllum traversii	*Phormium tenax*
Coprosma rhamnoides	*Dracophyllum traversii*
Nothofagus menziesii	*Gahnia pauciflora*
Gahnia xanthocarpa (?)	*Dendrobium cunninghamii*
Phyllocladus alpinus	*Earina autumnalis*
Podocarpus hallii	
Pseudopanax crassifolius	

Notes:
Rimu dbh=450mm
Silver beech dbh=290mm
Rata dbh=440mm
Photos 17, 18?

Plot 6: Tall forest

Plot 6b: Side-cast toe vegetation on riparian flat, 9 Mile Creek. Disturbed ground, natural regeneration.

Veg class: Seral (not mapped)
Site class: Disturbed site (7)

Grid reference:
General location: Between Plot 6a and 9 Mile Creek
Geology: Sidecast broken rock (mpd)
Slope: <5°
Aspect: East facing
Canopy height: 1-2 m
Canopy cover: 90%
Canopy dominants: Mixed shrub, fern and sedge vegetation

Species in height class:

0-2m	*Earina mucronata*
Cortaderia richardii	*Earina autumnalis*
Gahnia rigida	*Dracophyllum longifolium*
Blechnum novae-zelandiae	*Ulex europaeus*
Nothofagus menziesii	*Paesia scaberula*
Leptospermum scoparium	*Metrosideros umbellata*
Weinmannia racemosa	*Myrsine salicina*
Griselinia littoralis	*Carex coriacea*
Coprosma grandifolia	*Gahnia xanthocarpa*
Dacrydium cupressinum	*Uncinia uncinata*
Carpodetus serratus	
Blechnum discolor	

Photo 19

Plot 6c: Side-cast slope

Veg class: Seral vegetation (not mapped)
Site class: Disturbed site (9)

Grid reference:
General location: Between (below) road and 9 Mile Creek, adjacent to Plot 6a remnant forest patch
Geology sidecast broken rock (mpd)
Slope: 25°
Aspect: East facing
Canopy height: 10cm – 1 m
Canopy cover: 20%
Canopy dominants: Seedlngs and saplings of tree and shrubs, sedges, ferns

Species in height class

0-2m *Contaderia richardii* *Gahnia rigida* *Leptospermum scoparium* *Weinmannia racemosa* *Blechnum discolor* *Metrosideros umbellata* *Dracophyllum longifolium* *Agrostis tenuis*	*Nothofagus fusca* *Nothofagus menziesii* *Hebe salicifolia* *Empodisma minus* *Uncinia uncinata* *Polystichum vestitum* *Quintinia acutifolia* *Cyathodes juniperina* *Nothofagus solandri* *Olearia avicennaefolia*

Photo 20

Plot 7a: Burned/ gassed area above road (31.7.08)

Veg class:	Remnant and regenerating forest, burned and gassed area (not mapped)
Site class:	Disturbed site (5)
General location:	Above road
Geology:	mpg
Slope:	12-15°
Aspect:	North west facing
Canopy height:	Variable, regrowth to 5 m
Canopy cover:	Vegetation cover 100%
Canopy dominants:	Mixed regenerating species, *Histiopteris* common

Species present:

0-5m	*Phormium cookianum*
Phyllocladus alpinus	*Pseudopanax colensoi*
Coprosma rhamnoides	*Dacrydium cupressinum*
Coprosma colensoi	*Coprosma foetidissima*
Weinmannia racemosa	*Histiopteris incisa*
Quintinia acutifolia	*Astelia nervosa*
Griselinia littoralis	*Metrosideros parkinsonii*
Blechnum procerum	*Pseudopanax simplex*
Blechnum novae-zelandiae	*Cordyline indivisa*
Dracophyllum traversii	*Uncinia uncinata*
Myrsine divaricata	*Podocarpus hallii*

Notes:
Dead trunks, a few live trees, re-growth to 5m, tangled *Histiopteris* and shrubs form ground layer. Much deer faeces on grassy fire break nearby.

Plot 7a: Burned and gassed remnant

Plot 7b: Northern burned area (by shed):

Veg class: Burned and/or gassed forest (not mapped)
Site class: Disturbed site (9)

General location: Lower end of track
Geology: mpr
Slope: 12°
Aspect: South east facing
Canopy height: 30 cm
Canopy cover: 80%
Canopy dominants: *Histiopteris*

Species present:

0-30cm	*Nertera depressa*
Histiopteris incisa	*Nothofagus solandri*
Exotic grasses	*Blechnum procerum*
Dracophyllum traversii	*Dacrydium cupressinum*
Weinmannia racemosa	*Astelia nervosa*
Griselinia littoralis	*Leptospermum scoparium*
Phyllocladus alpinus	
Gahnia (?) procera	

Notes:
Values lower than the large area above road. Shrub and tree species colonising beneath dead trunks in lower area, but elsewhere *Histiopteris* and *Carex coriacea* dominates. All growth is <30cm tall.
Photos 10, 11

PLOT 8a: Tall rimu and silver beech forest

Veg class:	Rimu/beech-Hall's totara
Site class:	Disturbed site (1)
General location:	Adjacent to track west of main mine area
Geology:	mpg
Slope:	12-15° (hummocky)
Aspect:	West-facing slope
Canopy height:	30m
Canopy cover:	70%
Canopy dominants:	*Nothofagus menziesii (25m), Dacrydium cupressinum (30m)*

Species in height class:

25-30m *Nothofagus menziesii* *Dacrydium cupressinum* **5-30m** *Myrsine salicina* *Weinmannia racemosa* *Pseudopanax simplex* *Nothofagus menziesii* **1-5m** *Pseudopanax simplex* *Cyathea smithii* *Myrsine salicina* *Weinmannia racemosa* *Quintinia acutifolia* *Coprosma rhamnoides* *Coprosma grandifolia*	**0-1m** *Astelia nervosa* *Blechnum discolor* *Blechnum procerum* *Coprosma colensoi* *Coprosma rhamnoides* *Cyathea smithii* *Histiopteris incisa* *Hymenophyllum demissum* *Libertia micrantha* *Luzuriaga parviflora* *Metrosideros fulgens* *Microlaena avenacea* *Myrsine divaricata* *Nertera villosa* *Nothofagus menziesii* *Phymatosorus pustulatus* *Phyllocladus alpinus* *Quintinia acutifolia* *Rumohra adiantiformis* *Uncinia rupestris* *Uncinia uncinata* ***Epiphytes*** *Asplenium flaccidum* *Astelia nervosa* *Dianella nigra* *Earina sp.* *Griselinia littoralis* *Hymenophyllum demissum* *Metrosideros fulgens*

Notes:
Also present on track nearby *Coprosma tayloriae, Elaeocarpus hookerianus, Juncus gregiflorus, Coprosma grandifolia*

Plot 8: Tall forest near old track

PLOT 8b: Rimu and silver beech forest

Veg class: Rimu/beech forest
Site class: Disturbed site (1)

General location: Lower end of track
Geology: mpg
Slope: <5°
Aspect: West-facing
Canopy height: 30m
Canopy cover: 70%
Canopy dominants: *Dacrydium cupressinum (30m), Nothofagus menziesii (15-20m)*

Species in height class:

15-30m	**0-3m**
Nothofagus menziesii *Dacrydium cupressinum* **3-15m** *Weinmannia racemosa* *Myrsine salicina* *Phyllocladus alpinus* *Dracophyllum traversii* *Griselinia littoralis* *Nothofagus menziesii*	*Quintinia acutifolia* *Myrsine salicina* *Cyathea smithii* *Blechnum procerum* *Nothofagus menziesii* *Pseudopanax simplex* *Myrsine divaricata* *Nothofagus solandri* *Microlaena avenacea* *Nertera villosa* *Nertera depressa* *Coprosma foetidissima* *Metrosideros parkinsonii* *Neomyrtus pedunculata* *Libertia micrantha* *Dacrydium cupressinum* *Grammitis billardierei* *Polystichum vestitum* *Earina autumnalis* *Earina mucronata* *Coprosma colensoi* *Uncinia uncinata*

Notes:
Rimu dbh= 50+cm
Beech dbh =20-30cm (80 cm near plot).

PLOT 9a: Manuka and pine shrubland

Veg class:	Manuka-dominated shrubland to 2 m
Site class:	Reference site (0)

Grid reference:	E2370637 N5872604
General location:	Highest altitude area on Rewanui coal measures
Geology:	mpr
Slope:	15- 20°(steep rounded ridges)
Aspect:	NNE facing
Canopy height:	To 1.8m variable
Canopy cover:	100%
Canopy dominants:	*Lepidothamnus intermedius (30%), Halocarpus biformis (30%), Leptospermum scoparium (40%).*

Species in height class:

50cm-1.8m	**0-50cm**
Lepidothamnus intermedius	*Gahnia pauciflora*
Halocarpus biformis	*Lycopodium laterale*
Leptospermum scoparium	*Nothofagus solandri*
Dracophyllum longifolium	*Lepidothamnus intermedius*
Metrosideros umbellata	*Halocarpus biformis*
Pseudopanax linearis	*Leptospermum scoparium*
	Empodisma minus

Notes:
Photos 33, 34

PLOT 9b: Manuka-pine shrub-land

Veg class: Manuka-dominated shrubland
Site class: Reference site (0)

General location: 50m from plot 9a on spur
Geology: mpr
Slope: 15°
Aspect: North
Canopy height: 50-60cm
Canopy cover: 70-80%

Species in height class:

40-60cm	0-40cm
Lepidothamnus intermedius	*Leptospermum scoparium*
Halocarpus biformis	*Empodisma minus*
Leptospermum scoparium	*Pentachondra pumila*
Dracophyllum longifolium	*Gentiana ? spenceri*
Nothofagus solandri	*Cyathodes juniperina*
	Lycopodium laterale

Notes:
Also seen nearby, *Earina mucronata* and *E autumnalis* growing in mossy ground near log. Photo shows general vicinity of Plots 9a and 9b..

PLOT 10a: Manuka shrub-land

Veg class:	Manuka-dominated shrubland
Site class:	Reference site (0)
Grid reference:	E2370576 N5872767
General location:	Just below crest
Geology:	mpr
Slope:	8°
Aspect:	West facing
Canopy height:	1.1-1.5m
Canopy cover:	100%
Canopy dominants:	*Leptospermum scoparium (70%)*

Species in height class:

1.1-1.5m	0-1.1m
Leptospermum scoparium	*Gleichenia dicarpa*
Pseudopanax linearis	*Empodisma minus*
Nothofagus menziesii	*Lycopodium laterale*
Metrosideros umbellata	*Cyathodes empetrifolia*
Lepidothamnus intermedius	
Gleichenia dicarpa	
Dracophyllum longifolium	
Halocarpus biformis	
Quintinia acutifolia	
Nothofagus solandri	

Notes:
Noted nearby, *Oreobolus strictus*, on open ground. Ground very mossy.
Photo 35

PLOT 10b: Pine and manuka scrub and shrubland

Veg class: Pine-dominated scrub
Site class: Reference site (0)

Grid reference: E2370538 N5872734
General location: Slope below ridge.
Geology: mpr
Slope: 12°
Aspect: N
Canopy height: 3-5m
Canopy cover: 100%
Canopy dominants: *Halocarpus biformis, Lepidothamnus intermedius, Leptospermum scoparium.*

Species in height class:

3-5m	*Quintinia acutifolia*
Halocarpus biformis	*Dracophyllum longifolium*
Lepidothamnus intermedius	*Elaeocarpus hookerianus*
Leptospermum scoparium	
	0-50cm
50cm to 3m	*Gahnia pauciflora*
Dracophyllum traversii	*Myrsine divaricata*
Myrsine divaricata	*Empodisma minus*
Pseudopanax simplex	*Coprosma colensoi*
Weinmannia racemosa	*Quintinia acutifolia*
Pseudopanax linearis	*Podocarpus hallii*
Phyllocladus alpinus	*Cyathodes juniperina*
Halocarpus biformis	*Leptospermum scoparium*
Lepidothamnus intermedius	*Carpha alpina*

Photos 37, 38

PLOT 11a: Rimu and broadleaved forest remnant

Veg class: Rimu/beech-Halls totara forest
Site class: Disturbed site (3)

Grid reference: E2370471 N5872263
General location: Remnant forest stand affected by wind-throw and edge effects (3
Geology: mpr
Slope: 15°
Aspect: West facing
Canopy height: 15-20m
Canopy cover: 80%

Species in height class:

15-20m	**0-1.5m**
Dacrydium cupressinum	*Blechnum procerum*
Metrosideros umbellata	*Coprosma foetidissima*
Nothofagus solandri	*Coprosma tayloriae*
Phyllocladus alpinus	*Cyathea smithii*
Podocarpus hallii	*Dracophyllum longifolium*
Weinmannia racemosa	*Dracophyllum townsonii*
	Elaeocarpus hookerianus
1.5-15m	*Gahnia pauciflora*
Coprosma colensoi	*Grammitis billardierei*
Coprosma tayloriae	*Griselinia littoralis*
Dracophyllum traversii	*Histiopteris incisa*
Myrsine divaricata	*Hymenophyllum multifidum*
Phyllocladus alpinus	*Libertia micrantha*
Pseudopanax colensoi	*Luzuriaga parviflora*
Quintinia acutifolia	*Metrosideros diffusa*
Weinmannia racemosa	*Metrosideros parkinsonii*
	Microlaena avenacea
	Myrsine divaricata
	Neomyrtus pedunculatus
	Nertera depressa
	Nertera villosa
	Nothofagus solandri
	Phormium cookianum
	Pittosporum rigidum
	Podocarpus hallii
	Pseudopanax anomalus.
	Pseudopanax colensoi
	Pseudopanax crassifolius
	Quintinia acutifolia
	Rumohra adiantifolia
	Tmesipteris tannensis
	Uncinia uncinata

Notes: The remnant stand is affected by wind-throw and edge effects and thus the area rates 7 but the plot itself appeared undisturbed, could be considered as a reference site.
Dacrydium cupressinum is emergent with dbh's of 32, 27 and 29cm.

Plot 11 a and b: Remnant forest

PLOT 11b: Rimu broadleaved forest remnant

Veg class: Rimu/beech-Hall's totara forest
Site class: Disturbed site (3)

Grid reference: E2370471 N5872263
General location: Gently sloping area above mine. 70 m from plot 11A
Geology: mpr
Slope: 15°
Aspect: W
Canopy height: 15-20m
Canopy cover: 80%

Species in height class:

15-20m *Dacrydium cupressinum* *Metrosideros umbellata* *Podocarpus hallii* *Weinmannia racemosa* *Phyllocladus alpinus* *Nothofagus solandri* **1.5-15m** *Dracophyllum traversii* *Myrsine divaricata* *Phyllocladus alpinus* *Weinmannia racemosa* *Quintinia acutifolia* *Metrosideros parkinsonii* *Pseudopanax simplex* *Pseudopanax linearis* *Coprosma tayloriae*	**0-1.5m** *Griselinia littoralis* *Coprosma colensoi* *Hymenophyllum demissum* *Neomyrtus pedunculata* *Pittosporum rigidum* *Elaeocarpus hookerianus* *Polystichum vestitum (?)* *Grammitis billardierei* *Blechnum procerum* *Cyathea smithii* *Dracophyllum traversii* *Gahnia pauciflora* *Phyllocladus alpinus* *Pseudopanax linearis* *Quintinia acutifolia* *Histiopteris incisa* *Nertera villosa* *Dacrydium cupressinum* *Myrsine divaricata* *Phormium cookianum* *Metrosideros parkinsonii* *Metrosideros diffusa* *Astelia sp. (check n+r-L)* *Luzuriaga parviflora* *Uncinia (?) sp.* *Coprosma foetidissima* *Coprosma rhamnoides* *Coprosma tayloriae*

PLOT 12: Yellow-silver and pink pine forest

Veg class: Pine-dominated forest
Site class: Reference site (0)

General location: Western edge of mining area
Geology: mpr
Slope: 5°
Aspect: West facing
Canopy height: 8-15m variable
Canopy cover: 70%

Species in height class:

8-15m	*Quintinia acutifolia*
Lepidothamnus intermedius	*Weinmannia racemosa*
Halocarpus biformis	*Metrosideros diffusa*
	Leptospermum scoparium
1-8m	*Phyllocladus alpinus*
Lepidothamnus intermedius	*Dracophyllum traversii*
Halocarpus biformis	*Tmesipteris tennensis*
Dracophyllum longifolium	*Grammitis billardierei*
Leptospermum scoparium	*Griselinia littoralis*
Quintinia acutifolia	*Coprosma colensoi*
	Gleichenia cunninghamii
0-1m	*Lycopodium laterale*
Myrsine salicina	*Cyathodes juniperina*
Metrosideros parkinsonii	*Myrsine divaricata*
Gahnia procera	*Dianella nigra*

Notes:
Pink pine dbhs =12, 18, 27, 32. Yellow silver pine tends to be multi-trunked. Photos 41, 42

PLOT 13: Rimu-broad-leaved forest remnant

Veg class: Rimu/beech-Hall's totara forest
Site class: Disturbed site (4)

Grid reference: E2370323 N5872354
General location: Very steep slope above escarpment
Geology: mpr
Slope: 10-35°
Aspect: WSW
Canopy height: 18-20 m
Canopy cover: 35%
Canopy dominants: Scattered rimu, totara and beech

Species in height class:

Canopy *Dacrydium cupressinum* *Nothofagus menziesii* **Sub-canopy** *Podocarpus hallii* *Weinmannia racemosa* *Halocarpus biformis* *Dracophyllum traversii* *Nothofagus solandri* *Myrsine divaricata* *Cyathodes fasciculate* *Metrosideros umbellate*	**Around margins** *Pseudopanax simplex* *Griselinia littoralis* *Astelia nervosa* *Quintinia acutifolia* *Coprosma robusta* *Myrsine salicina* *Phyllocladus alpinus* *Gahnia pauciflora* *Metrosideros parkinsonii* *Histiopteris incisa* Other ferns around edge

Notes:
Fallen rimu dbh= 41cm.
Photos 1, 2, 3, 4, 12 (30-31.7.08)

PLOT 14: Rimu and silver beech forest. (31.7.08)

Veg class: Rimu/beech forest
Site class: Reference site (0)

General location: Above and south of access road.
Geology: mpg
Slope: 15°
Aspect: NNW facing
Canopy height: 35+m
Canopy cover: 80%

Species in height class:

25-35m *Dacrydium cupressinum* *Nothofagus menziesii* *Prumnopitys ferruginea* **3-20m** *Weinmannia racemosa* *Myrsine salicina* *Quintinia acutifolia* *Metrosideros umbellata* **50cm-3m** *Coprosma foetidissima* *Myrsine salicina* *Coprosma colensoi* *Coprosma rhamnoides* *Weinmannia racemosa* *Nothofagus menziesii* *Quintinia acutifolia* *Pseudopanax crassifolius* *Pseudopanax colensoi* *Gahnia pauciflora*	**0-50cm** *Nothofagus solandri* *Griselinia littoralis* *Blechnum procerum* *Nothofagus menziesii* *Blechnum discolor* *Coprosma robusta* *Coprosma rhamnoides* *Coprosma colensoi* *Libertia micrantha* *Pittosporum rigidum* *Asplenium flaccidum* *Luzuriaga parviflora* *Lindsaea trichomanoides* *Metrosideros parkinsonii* **Epiphytes** *Phymatosorus pustulatus* *Hymenophyllum dilatatum* *Tmesipteris tannensis* *Earina mucronata* *Earina autumnalis*

Photos 13, 14 (30-31.7.08)

Plot 14: Tall forest

Appendix 2: Birds Recorded in the Strongman Mine Area

Native Birds		IUCN Status*	New Zealand Threatened Status**
Great spotted kiwi	*Apteryx haastii*	Vulnerable	Gradual Decline
Australasian harrier	*Circus approximans*	Least concern	Not threatened
NZ bush falcon	*Falco novaeseelandiae*	Near Threatened	Nationally vulnerable
Western weka	*Gallirallus australis australis*	Vulnerable	Serious decline
Kereru	*Hemiphaga novaeseelandiae*	Near Threatened	Gradual Decline
South Island Kaka	*Nestor meridionalis meridionalis*	Endangered	Nationally endangered
Kakariki	*Cyanoramphus auriceps*	Near Threatened	Gradual Decline
Long-tailed cuckoo	*Eudynamys taitensis*	Least concern	Gradual Decline
Morepork	*Ninox novaeseelandiae*	Least concern	Not threatened
Rifleman	*Acanthisitta chloris*	Least concern	Gradual Decline
Welcome swallow	*Hirundo tahitica*	Least concern	Coloniser
New Zealand pipit	*Anthus novaeseelandiae*	Least concern	Not threatened
Fernbird	*Bowdleria punctata*	Least concern	Sparse
Brown creeper	*Mohoua novaeseelandiae*	Least concern	Not threatened
Grey warbler	*Gerygone igata*	Least concern	Not threatened
Fantail	*Rhipidura fuliginosa*	Least concern	Not threatened
South Island Tomtit	*Petroica macrocephala macrocephala*	Least concern	Not threatened
Silvereye	*Zosterops lateralis*	Least concern	Not threatened
Bellbird	*Anthornis melanura*	Least concern	Not threatened
Tui	*Prosthemadera novaeseelandiae*	Least concern	Not threatened
Introduced Birds			
Dunnock	*Prunella modularis*	Least concern	
Blackbird	*Turdus merula*	Least concern	
Song thrush	*Turdus philomelos*	Least concern	
Chaffinch	*Fringilla coelebs*	Least concern	
Redpoll	*Carduelis flammea*	Least concern	
		*IUCN classification Ver. 3.1	**Hitchmough *et al.* 2007

Appendix 3: Hitchmough *et al*. (2007) Threat Categories

Explanation of Threat Categories in New Zealand

Hitchmough, Cromarty and Bull (2007) assessed the risk of extinction for New Zealand mammals, birds, reptiles, amphibians, fish, invertebrates and plants. By identifying threatened or potentially threatened species they were able to compile lists of threatened taxa according to the New Zealand Threat Classification System (Molloy *et al*. 2002). The lists are regularly updated (every three years) to reflect improved knowledge or changes in status.

The process involves consultation with experts, derivation of a list and then circulation of the draft list to expert panel members and Department of Conservation conservancies before final lists are published. The categories are:

Extinct
Beyond all reasonable doubt no individuals of the species remain

Data Deficient - Where information is so lacking that an assessment is not possible, the taxon is assigned to the Data Deficient category.

Not Threatened - Taxa that are assessed and do not fit any of the Threatened categories.

Threatened Categories:

Acutely threatened

Acutely threatened species are facing a very high risk of extinction in the wild. There are three sub-categories:

Nationally Critical – those with a very small population or a very high rate of decline

Nationally Endangered – those with either a small population with a moderate to high recent or predicted decline or a small to moderate population with a high recent or predicted decline.

Nationally Vulnerable - Small to moderate population and moderate recent or predicted decline.

Chronically threatened

Chronically threatened species are facing extinction, but are buffered slightly by either a large population or a slow rate of decline. This includes two categories:

Serious Decline – either a moderate to large population and moderate to large predicted decline, or a small to moderate population and small to moderate predicted decline.

Gradual Decline - Moderate to large population and small to moderate decline.

At Risk

Taxa that are not threatened (i.e. do not meet the criteria for Acutely Threatened or Chronically Threatened categories) but have either restricted ranges or small scattered sub-populations, are described as being "At Risk" and are listed in one of two categories:

Sparse - Taxa with very small, widely scattered populations.

Range Restricted - These taxa occur in a small geographic area, are restricted to a particular habitat, or require very specific substrates, and for colonial breeders, have fewer than 10 subpopulations.

Appendix 4: Strongman Plant List

Table 1. Vascular Plant Species recorded at the Strongman site, their location, conservation status and growth form.

Species	CS	F	Strongman sites						
			Manuka	Podocarp	Forest mpg	Forest mpr	Forest mpd	NVS Plot no.	7 Mile, <600 m
Agrostis capillaris	X	MH							√
Abrotanella linearis		DH							√
Androstoma empetrifolia		TS	√ mpr						√
Aporostylis bifolia		O							√
Asplenium bulbiferum		F							√
Alseuosmia pusilla		TS							√
Archeria traversii		TS						61-3	√
Asplenium flaccidum		F			√				√
Astelia fragrans		MH							√
Astelia nervosa		MH			√	√	√	61-3	√
Astelia solandri		MH					√	74	
Baumea sp.		MH							
Blechnum discolour		F			√		√	61-6, 74 87 88	√
Blechnum chambersii		F							√
Blechnum colensoi		F							√
Blechnum fluviatile		F						61-3,6	√
Blechnum nigrum		F							√
Blechnum novae-zealandiae		F	√					61-6, 74 87	√√
Blechnum penna-marina		F							√
Blechnum procerum		F	√		√	√	√	74 87 88	√
Blechnum vulcanicum		F							√
Brachyglottis rotundifolia		TS							√
Carex coriacea		MH							√
Carpha alpine		MH		√					√
Carpodetus serratus		TS							√
Celmisia Cass.		DH						74	
Celmisia semicordata		DH	√						√
Cirsium vulgare		DH							√
Clematis paniculata		DC							√
Coprosma australis		TS						74 87	
Coprosma ciliate		TS							√
Coprosma colensoi		TS	√	√	√	√	√	61-3,6 87 88	√
Coprosma foetidissima		TS			√	√	√	61-3,6 74 87 88	√
Coprosma grandifolia		TS			√				√
Coprosma lucida		TS					√	74 87 88	
Coprosma parviflora var. *dumosa*		TS						87 88	√
Coprosma pseudocuneata		TS						61-3,6	√
Coprosma rhamnoides		TS	√			√		74 88	√
Coprosma tayloriae		TS				√	√		

Coriaria arborea		TS							
Cordyline indivisa		TS							
Cortaderia richardii		MH							?
Corybas acuminatus		O							?
Ctenopteris heterophylla		F							?
Cyathea colensoi		F						61-3,6	?
Cyathea smithii		F			?	?			?
Dacrydium cupressinum		TS	?		?	?	?	74 87 88	?
Dendrobium cunninghamii		O			?			87	?
Dianella intermedia		MH		?			?	74 87	
Dicksonia squarrosa		F						87	?
Dracophyllum longifolium		F	?	?		?		88	?
Dracophyllum townsonii		F				?		87 88	?
Dracophyllum traversii		F	?	?	?	?	?	61-3,6	?
Dracophyllum uniflorum		F	?						
Drosera spathulata		DH							?
Earina autumnalis		O	? mpr					87	?
Earina mucronata		O	? mpr		?				?
Elaeocarpus hookerianus		TS		?		?	?	87 88	?
Empodisma minus		MH	?	?					?
Epacris alpine		TS	?						?
Freycinettia banksii		MC			?			74	
Fuchsia excorticata		TS							
Gahnia pauciflora		MH	? mpr	?	?	?	?		?
Gahnia procera		MH	?					74 87 88	
Gahnia rigida		MH		?					
Gahnia xanthocarpa		MH	?		?			74	
Gaultheria antipoda		TS							?
Gentiana ?spenceri		DH	? mpr						?
Gentiana townsonii		DH							?
Gleichenia cunninghamii		F		?				87	
Gleichenia microphylla		F							?
Gleichenia dicarpa		F	?						?
Grammitis billardierei		F		?	?	?	?	61-3,6 87 88	?
Griselinia littoralis		TS		?		?	?	61-3 74 87 88	?
Gunnera prorepens		DH							
Halocarpus biformis		TS	?	?		?	?		?
Hebe mooreae		TS							
Hebe odora		TS							
Hebe salicifolia		TS						74	
Hedycarya arborea		TS						74	
Histiopteris incise		F			?	?			?
Holcus lantanus	X	MH							?
Hymenophyllum armstrongii		F						87 88	?
Hymenophyllum demissum		F			?	?	?	61-6 88	?
Hymenophyllum dilatatum		F			?				
Hymenophyllum flabellatum		F						88	?
Hymenophyllum lyallii		F						87 88	?
Hymenophyllum multifidum		F				?	?		?
Hymenophyllum peltatum#		F							?
Hymenophyllum rarum#		F							?
Hymenophyllum revolutum		F						88	?

Hymenophyllum rufescens		F							?
Hymenophyllum sanguinolentum		F							?
Hymenophyllum villosum#		F							?
Juncus acuminatus	X	MH							
Juncus effuses		MH							?
Juncus gregiflorus		MH							?
Juncus novae-zelandiae		MH							?
Kunzea ericoides		TS							
Lepidosperma australe		MH							?
Lepidothamnus intermedius		TS	?	?			?	88	?
Leptocephala juniperina		TS	?	?				87 88	?
Leptopteris superba		F							?
Leptospermum scoparium		TS	?	?			?	87	?
Leucopogon fasciculata		TS	?		?	?	?	74 87 88	
Leycesteria formosa	X	TS							
Libertia micrantha		MH			?	?	?		
Libertia pulchella		MH						61-3 88	?
Libocedrus bidwillii		TS							?
Lindsaea cuneata		F						74 87	
Lindsaea trichomanoides		F			?		?		?
Luzuriaga parviflora		DH							?
Lotus pedunculatus	X	DH							?
Luzula rufa		MH							?
Luzuriaga parviflora		TS			?	?		88	
Lycopodium australianum		F							
Lycopodium laterale		F	?	?					?
Lycopodium ramulosum		F							
Lycopodium scariosum		F							?
Lycopodium varium		F						87	?
Lycopodium volubile		F						88	
Melicytus ramiflorus		TS							?
Metrosideros diffusa		TS		?	?	?	?		?
Metrosideros fulgens		TS						61-6 74	?
Metrosideros parkinsonii		TS		?	?	?		88	?
Metrosideros perforata		TS						74	
Metrosideros umbellata		TS	?		?	?	?	61-3,6 74 87 88	?
Microlaena avenacea		MH			?	?			?
Myrsine australis		TS						74	
Myrsine divaricata		TS		?		?	?	87 88	?
Myrsine salicina		TS		?	?		?	74 88	?
Neomyrtus pedunculata		DH				?	?	74 87 88	
Nertera depressa		DH				?		87	?
Nertera dichondrifolia		DH						61-3 88	
Nertera villosa		DH			?	?			?
Nothofagus fusca		TS			?		?	61-6	?
Nothofagus menziesii		TS	?mpr		?	?	?	61-1,3,6 87 88	?
Nothofagus solandri		TS	?			?		61-3 74 88	?
Nothofagus solandri var. *cliffortioides*		TS						61-6 87	

Nothofagus truncata		TS						74	
Olearia arborescens		TS	?					61-6	?
Oleara avicenniifolia		TS						74	
Olearia colensoi		TS							?
Olearia ilicifolia		TS							?
Oreobolus stricta		DH							?
Paesia scaberula		F							?
Parsonsia sp.		DC							?
Pentachondra pumila		TS	?						?
Peraxilla tetrapetala	GD	DH							?
Phormium cookianum		MH	?			?		74	?
Phormium tenax		MH	?				?		
Phyllocladus alpinus		TS	?	?	?	?	?	61-3,6 87 88	?
Phymatosorus pustulatus		F			?				?
Pimelea longifolia		TS							?
Pittosporum colensoi		TS						74	
Pittosporum rigidum		TS	?			?	?		?
Podocarpus hallii		TS		?	?	?	?	61-6 74 88	?
Polystichum vestitum		F			?	?		61-6	?
Prumnopitys ferruginea		TS			?		?		?
Pseudopanax colensoi		TS			?	?		61-6, 74 87 88	?
Pseudopanax crassifolius		TS	?		?	?	?	74 88	?
Pseudopanax linearis		TS	? mpr	?		?		61-3	?
Pseudowintera colorata		TS							?
Pterostylis venosa		O							?
Quintinia acutifolia		TS	? mpr	?	?	?	?	61-3,6 74 87 88	?
Raukaua simplex		TS				?	?	61-3,6 87 88	?
Ripogonum scandens		DC			?				?
Rubus cissoids		DC							?
Rumohra adiantiformis		F			?	?			?
Rytidosperma sp.		MH							?
Sagina procumbens	X	DH							?
Schefflera digitata		TS							?
Schizaea bifida		F	?						
Schoenus pauciflorus		MH							?
Sticherus cunninghamii		F	?		?		?		?
Thelymitra sp.		O							??
Tmesipteris tannensis				?	?	?	?	88	?
Trichomanes reniforme		f						61-6 74 88	?
Ulex europaeus	X								?
Uncinia rupestris					?			87 88	?
Uncinia uncinata					?	?		61-3 88	?
Weinmannia racemosa			?	?	?	?	?	74 87 88	?

Key

CS = Conservation status using the New Zealand Threat Classification System (Hitchmough et al. 2007): Nationally Endangered, Nationally Vulnerable, Serious Decline, Gradual Decline, Sparse, Range Restricted
Form: F = fern or fern ally, O = orchid, TS = tree or shrub, DC = dicot climber, MC = monocot climber, DH = dicot herb, MH = monocot herb.
Plants found only on MPR geology have mpr in box.

Notes on the list of vascular plants likely present at Strongman Mine

All species identified as present below 600 m in the Upper Seven Mile survey area are listed as it is likely they are present at the Strongman site given the similar geologies, close proximity and overlapping altitude range. The NVS plots are all in LENZ level 4 O2.1a, in the Blackball Ecological District, and closest to the Strongman site (Table 2, Fig 1). Slope, elevation and rockclass were identified from interrogating the underlying LENZ and NZLRI layers. The plot data was collected in the Grey River 1967-68 Survey, plots 61-1, 61-3 and 61-6, and the Paparoa 1985 Survey, plots 74 (140 m ASL), 87 (380 m ASL) and 88 (470 m ASL). Plots 28, 31 and 74 have not been used as they lie below 110 m ASL (plot 89 is not in LENZ O2.1a and is at 600 m ASL). ED30 was not used as it contains lowland species, including some not found at Strongman or other sites, e.g., *Cyathea medullaris, Griselinia lucida* and *Blechnum discolor*

The species list does not include bryophytes and liverworts and includes only relatively undisturbed ecosystems, hence all exotic species present are not listed. Exotic species are identified by “X”. One of the assessment criteria uses a ratio of exotic to native species, so a list of exotic species can be generated after the first survey of the rehabilitated sites.

Acknowledgement

We acknowledge the use of data drawn from the Landcare Research National Vegetation Survey Database (NVS).

References

Hitchmough R., Bull L. and Cromarty P. (comp.) 2007: New Zealand Threat Classification System lists. Department of Conservation, Wellington. 194 p.

Overmars F 1997: Past and present distribution of mistletoes on the West Coast pp 65-69 In: *New Zealand’s loranthaceous mistletoes: proceedings of a workshop hosted by Threatened Species Unit, Department of Conservation, Cass, 17-20 July 1995*. de Lange P and Norton D (eds). Department of Conservation, Wellington, NZ.

Appendix 5: NiVS Table and Maps

Table 1. NVS plots in the Blackball Ecological District and LENZ level 4 O2.1A. Bolded plots were used to cross-check potential vascular plant species for the Strongman site.

NIVS Description	RockClass	Slope	Elevation
61 1 GREY RIVER 1967-68 FOREST - Recce inventory	Hs	16	900
61 3	**Hs**	**18**	**759**
61 6	**Hs**	**25**	**530**
ED 28 PAPAROA 1985 FOREST - Recce inventory	Hs	26	108
ED 30	Hs	29	113
ED 31	Hs	25	70
ED 73	Hs	19	50
ED 74 PAPAROA 1985 FOREST - Recce inventory	**Hs**	**18**	**127**
ED 87	**Ss**	**16**	**373**
ED 88	**Ss**	**23**	**439**

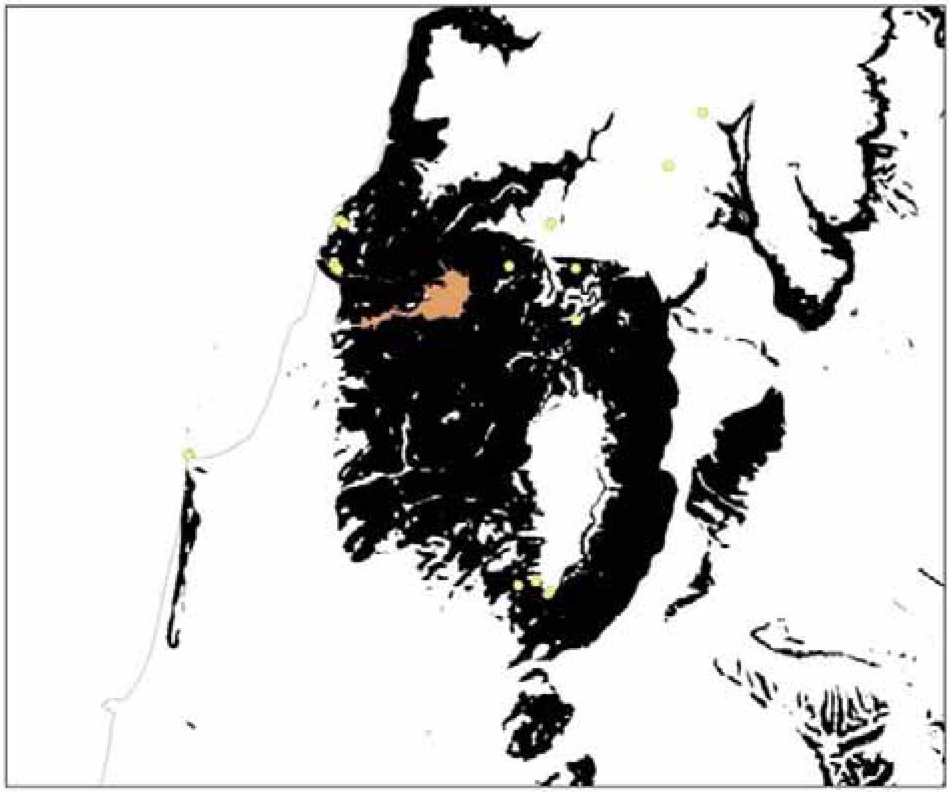

Figure 1. Location of LENZ level 4 Domain O2.1a in Central Westland, overlaid with NiVS plots (yellow dots) and the Strongman Mine (orange) (map generated by Fraser Morgan, Landcare Research, November 2008).

Appendix 6: Existing Mitigation Projects (as Distinct from Offsets)

Existing Mitigation Projects

Solid Energy is currently carrying out two mitigation projects (that were not designed as offsets under BBOP): revegetation of the Hall Ridge orphan coalmine; and contribution towards public walkways in the Paparoa Range.

Hall Ridge is a small site occupying a broad knoll above the Spring Creek Mine (owned by Solid Energy) and is surrounded by relatively unmodified manuka shrubland grading into forest. The pre-mining vegetation was manuka shrubland on very infertile coal measure geology, similar to that on the highest parts of Strongman. Vegetation and soils were removed from about 4 ha of coal outcrop (430 m asl) around 1980 by a private company that left the site un-rehabilitated. Both the access road and the site developed a partial cover of introduced gorse. In 2005/06 Solid Energy applied approximately 6 tonnes/ha nodulised stacker dust to raise the substrate's pH and has since planted about 5000 native woody and herbaceous plants/ha (with fertilisation at planting) and controlled gorse to speed revegetation to a native-dominated cover. Plant survival to date is estimated at 75%. Planting over the 4 ha was completed in October 2008 when 7800 plants were established. Plate 1 shows the site in December 2008 looking towards the south. Weed and occasional possum control is continuing along the access road and on the Hall ridge site. This is a small, like-for-like, shrubland ecosystem enhancement prpoject (rehabilitation, weed and pest control).

Plate 1: Hall Ridge offset site, December 2008.

Two public walkways are included as part mitigation for the effects of activities at mitigation. The Mount Davy Road is a popular local walk and 4WD route. Solid Energy has managed weeds along the road for the last four years to ensure continued access for vehicles and people. Gorse and Himalayan honeysuckle would otherwise block access because both species can reach 2 to 3 m in height and width. Solid Energy has indicated it will contribute to a new public track – the South Paparoa Walkway, which is currently being planned. Both projects are considered out-of-kind social offsets, however, there is potential for delivery of some ecosystem and amenity benefits on the Mount Davy Road if weed control is extended so that native species replace the adventive weeds, which are generally limited to the road margin and its sidecasts.

To learn more about the BBOP principles, guidelines and optional methodologies, go to:

www.forest-trends.org/biodiversityoffsetprogram/guidelines