[Year]

Mt Shamrock Quarry Rehabilitation Report

Thomas Fee

Naturelinks

[Date]

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General Information

Site Location: Holcim Mt Shamrock Quarry Mt Shamrock Rd, Pakenham Upper, Vic,

Client: Matt Dodd – Mine Manager. Mt Shamrock Quarry, Holcim

Contact: 0413 700 816

Project Manager: Thomas Fee 0477 938 249

Team leader: Andrew Clarke 0477 086 784

Report Scope

This report addresses all re-vegetation works carried out by Naturelinks over the period of May 2015 through to the current period of July 2016 and the maintenance works undertaken on these restoration areas to date (May 2018). As part of the Mt Shamrock re-vegetation works multiple areas were direct seeded and planted with indigenous understorey species as well as with mid and upper strata tube-stock plants as specified in the Landscape & Rehabilitation Management Plan (LRMP). The areas rehabilitated are outlined below along with processes undertaken species quantities and species composition. As well as detailing restoration works, this report outlines management activities undertaken in order to promote the success of the rehabilitation efforts along with detailing issues encountered, successes and management challenges discovered on site throughout the rehabilitation process.

Extraction Area Rehabilitation Works 2015

The area referred to as Extraction re-vegetation refers to the first rehabilitated area within the Mt Shamrock quarry area undertaken by Naturelinks and is 4Ha in total (Figure 1). Works undertaken included direct seeding using a sterile cover crop and native seed mix and the planting of 1812 tube-stock of mid and upper strata species and the planting of understorey species that were unviable to

be direct seeded into the site. All species selected appear in the EVC 16 List of species for Lowland Forests located within the Gippsland Plains Bioregion (refer to Table 1 &2).

Figure 1: 2015 Mt Shamrock 'Extraction' Re-vegetation area (4Ha).

Table 1: Species list and quantities for upper and mid-strata species planted in Extraction re-vegetation area (4Ha).

Upper/Mid-strata Species	Common Names	Number of Individuals Planted
Eucaylptus viminalis	Manna Gum	60
Eucalyptus globoidea	White Stringybark	60
Eucalyptus obliqua	Messmate	60
Eucalyptus radiata ssp. radiata	Narrow-leafed peppermint	60
Eucalytpus fulgens	Green Scentbark	12
Acacia melanoxylon	Blackwood	120
Acacia dealbata	Silver Wattle	120
Acacia myrtifolia	Myrtle Wattle	60
Leptospermum lanigerum	Wooly Tea-tree	600
Epacris impressa	Common Heath	180
Hakea nodosa	Yellow Hakea	240
Pultenea gunnii	Golden Bush-pea	180
Cassinia aculeata	Dogwood	60

Total		**1812**

Table 2: Understorey species planted in 4Ha Extraction Re-vegetation area.

Understorey Species	Common Names	Number of Individuals Planted
Lomandra longifolia var. longifolia	**Spiny-headed Mat rush**	**16,000**
Dicondra repens	**Kidney Weed**	**4200**
Total		**20,200**

Firstly, site preparation was undertaken by Holcim in the form of spreading top-soil across the re-vegetation site (Figure 2). Naturelinks then undertook weed control works in the form of two non-selective spray runs throughout the site in order to minimise the presence and spread of invasive species in the area. Following these spray works, hydro-seeding was undertaken in two parts; with 2Ha carried out in May 2015 and the remaining 2Ha seeded in July 2015. Direct seeding was carried out by Hydrograss Pty Ltd. using a native and sterile Rye seed mix embedded within a liquid mulch applied directly to the bare earth. Table 3 refers to the seed mix and proportions for each species along with sowing rates, all native seed is sown at 40kg/Ha in conjunction with the cover crop of Sterile Rye Corn sown at a rate of 100kg/Ha. Combined 140kg/Ha of seed was sown on site.

Figure 2: Part of the extraction area to be rehabilitated after topsoil was spread over the site.

Table 3: Native seed mix, sowing rates and proportions for Extraction Re-vegetation area.

Species	Common Name	Sowing Rate	Percentage of Seed	Total Seed
Themeda triandra	**Kangaroo Grass**	**12kg/Ha**	**30%**	**48kg**
Rytidosperma caespitosum	**Common Wallaby-grass**	**16kg/Ha**	**40%**	**64kg**
Microlaena stipoides	**Weeping Grass**	**12kg/Ha**	**30%**	**48kg**

Proceeding this all tube-stock species were planted along with stakes and guards in early spring (September 2015) at a planting density of 5m². Following the senescence of the sterile Rye species in the understorey and the subsequent opening of inter-tussock spaces the understorey species of *Dicondra repens* and *Lomandra longifolia var. longifolia* were planted in the following winter (July 2016). The above works detail the initial activities undertaken in order to re-vegetate this area and establish a functioning Lowland Forest Eco-system in the future. Species planted on-site were supplied locally where possible, with details of our plant suppliers and provenance detailed below.

Naturelinks has partnered with a local not-for-profit indigenous nursery located in Beaconsfield Upper. Green Circle Plant nursery is largely run by volunteers from the local community and supplies the bulk of the mid to upper strata species and some of the understorey species. Green Circle operate using only locally sourced seed and cut materials for propagation found within a 10km radius of Upper Beaconsfield including the areas of Dewhurst, Berwick, Beaconsfield, Officer and Pakenham (Simmons, Sue, Personal Communication, 2018). Green Circle also propagate individuals from seed and cut materials sourced directly from site where appropriate (particularly in regards to The Net Gain area). Lomandra species are supplied by Alliance seeds using seed collected from Bunyip State Park.

Due to the high volume of seed required for our hydro-seeding operations it is difficult to ensure local provenance of these seeds and still provide for the large quantities of seed required to carry out the rehabilitation works. Hydrograss notes that bulk of seeds sourced for Mt Shamrock come from a single supplier, with *Themeda triandra* seed sourced locally from Laverton, *Microalaena stipoides* from Atwood and *Rytidosperma spp*. Sourced from Sydenham and Tarneit. Where required volumes of seed were bolstered using other seed suppliers.

Phase B 2015 Non-Quarry Operational Area Re-vegetation Works

The Phase B planting area refers to the ERM Non-Quarry Operation Area: Landscape Plan Drawing: L3a. This area was re-vegetated in 2015 using the species outlined in table 6. Preparatory works included spraying of high threat weeds and establishing planting areas for upper and mid storey species. Individuals were then planted, staked and guarded and areas re-vegetated for Upper and mid strata species only.

Phase B Planting Species	Common Names	Number of Individuals
Eucalyptus viminalis	**Manna Gum**	**170**
Eucalyptus radiata	**Narrow-leaved Peppermint**	**170**
Eucalyptus obliqua	**Messmate**	**230**
Eucalyptus fulgens	**Green Scentbark**	**120**
Acacia melanoxylon	**Blackwood**	**230**
Acacia dealbata	**Silver Wattle**	**120**
Cassinia aculeata	**Dogwood**	**60**
Total		**1100**

Mt Shamrock 2016 Rehabilitation works

Extraction Area Extension

Re-vegetation works undertaken by Naturelinks in 2016 were located in an area directly adjacent to the 2015 works (Figure 2). Works carried out in 2016 were similar to those of 2015 with some slight variation in species numbers and seed proportions (Tables 4&5). Hydro-seeding was again undertaken in May of 2016 following preparatory spray works with mid/upper strata species planted, staked and guarded in July of 2016 along with additional understorey species (*L. longifolia and D. repens*).

Figure 3: 2016 1Ha Re-vegetation area at Mt Shamrock Quarry.

Table 4: Revised seed proportions for 2016 1Ha re-vegetation area at Mt Shamrock quarry.

Species	Sowing Rate	Percentage of Seed	Total Seed
Themeda triandra	6kg/Ha	15%	6kg
Rytidosperma caespitosum	28kg/Ha	70%	28kg
Microlaena stipoides	6kg/Ha	15%	6kg

Table 5: mid and upper strata species list and number of individuals planted

Upper/Mid-strata Species	Common Names	Number of Individuals
Eucaylptus viminalis	Manna Gum	30
Eucalyptus globoidea	White Stringybark	30
Eucalyptus obliqua	Messmate	30
Eucalyptus radiata ssp. radiata	Narrow-leafed peppermint	30
Eucalytpus fulgens	Green Scentbark	10
Acacia melanoxylon	Blackwood	40
Acacia dealbata	Silver Wattle	40
Acacia myrtifolia	Myrtle Wattle	40
Leptospermum lanigerum	Wooly Tea-tree	100
Epacris impressa	Common Heath	50
Hakea nodosa	Yellow Hakea	100
Cassinia aculeata	Dogwood	20
Total		520

Phase C Scattered Planting Rehabilitation works

Phase C re-vegetation works undertaken by Naturelinks to Non-Quarry Operational Area: Landscape Plan Planting Phase C (L4a). These areas were planted with 1080 over-storey species only at an average stocking density of 18m squared per plant. Stock proof fencing was erected by Holcim for a total of 150 species planted in grazing areas and all remaining individuals were staked and guarded (see Table 6 for species numbers). Preparatory works were undertaken to spray out and remove biomass in planting areas prior to planting.

Figure 4: Phase C 2016 Scattered planting Areas.

Table 6: Over-storey species planted in Phase C 2016 Re-vegetation area.

Tree Species	Common Names	Number of Individuals
Eucalyptus obliqua	**Messmate**	**360**
Eucalyptus radiata ssp. radiata	**Narrow-leaved Peppermint**	**360**
Eucalytpus fulgens	**Green Scentbark**	**180**
Acacia melanoxylon	**Blackwood**	**180**
Total		**1080**

Rehabilitation Maintenance Works

Maintenance Works Undertaken in the operation extraction planting areas have largely centred on tree guard maintenance, weed control and brushcutting of biomass around plants. Brushcutting around trees and shrubs was undertaken in order to form a natural mulch layer around the plants using natural biomass (particularly over the winter months) during the plant establishment period of 52 weeks prior to planting. Due to the high rainfall experienced by the Pakenham area and the location of the Mt Shamrock Quarry within agricultural and grazing land, invasive exotic species are

an ongoing issue on site that require constant efforts in regards to management and control. These threats are predominantly targeted towards the understorey species and pose a real threat of outcompeting native grasses. Although germination of Rytidosperma species has been very successful, site conditions favour invasive perennial grasses like *Paspalum sp* and *Phalaris aquatica* which outcompete Rytidosperma particularly in areas with higher soil moisture due to variations in water movement throughout the site. Similarly, as coverage of the annual Rye Corn cover crop reduces, inter-tussock spaces open up allowing for the germination and persistence of a variety of weed species. Table 7 details high threat weeds found on-site that require ongoing maintenance

Table 7: List of high threat weed species found on 5Ha re-vegetation area.

High Threat Weeds	Common Name
Arctotheca calendula	Cape Weed
Brassica fruticulosa	Twiggy Turnip
Bromus sp	Bromus species
Conyza sp.	Fleabane sp
Cirsium vulgare	Spear Thistle
Cynodon dactylon var. dactylon	Couch
Dittrichia graveolens	Stinkwort
Dactylis glomerata	Cocksfoot
Cortaderia selloana	Pampas Grass
Helminthotheca echioides	Ox-tongue
Holcus lanatus	Yorkshire Fog
Hypochaeris radicata	Cat's Ear
Malva nicaeenis	Mallow-of-Nice
Onopordum acanthium ssp. acanthium	Scotch Thistle
Paspalum dilatatum	Paspalum
Phalaris aquatica	Toowoomba Canary-grass
Plantago lanceolata	Ribwort
Polygonum arenastrum	Wireweed
Raphanus raphanistrum	Wild Radish
Solanum nigrum s.l	Black Nightshade
Sonchus asper ssp. asper	Rough Sow-thistle
Sonchus oleraceus	Sow-thistle
Rubus fruticosus spp. agg.	Blackberry
Silybum marianum	Variegated Thistle

Weed management practices undertaken by Naturelinks predominantly centre on selective and non-selective herbicide application delivered by either high pressure quick spray units or knapsack spray works for more sensitive areas. Selective herbicide runs utilising broadleaf only herbicides is often undertaken as large areas can be sprayed at a time using Quicksprays without damage occurring to the native grass dominated understorey. This cannot occur when targeting grassy weeds using a non-selective herbicide like Weedmaster Duo as damage would occur to the native grasses. Where weed control targeting perennial exotic grasses occurs, knapsack only spraying is undertaken to avoid any off target damage occurring (Figure 5). Whilst this is a slower process it is necessary to maintain the condition of native vegetation present in the understorey whilst controlling invasive weeds.

Figure 5: Non-selective knapsack spray works undertaken at Extraction planting area

Supplementary planting of trees and shrubs has occurred in all areas excluding Phase C (due to near 100% planting success rates) with numbers varying between zones due to differing site conditions discussed below. Within the extraction rehabilitation area rates of planting senescence have varied from between 10-30% depending on factors such as soil depth, slope, aspect and soil moisture. Natural

Observations, Successes and Management Issues

Initial high germination rates of *Rytidosperma spp.* From 2015 direct seeding and very low germination rates of *T. triandra* and *M. stipoides* led to a change in seed proportions for the native component of the seed mix (Table 4). However, as site conditions changed and canopy cover and soil moisture increased conditions favoured the germination of *M. stipoides.* Consequently, areas with higher soil moisture and shaded areas from canopy cover or dense grass cover (>95% cover) resulted in an increase in germination of *M. stipoides,* often presenting 1-2 years after initial sowing. In other areas topsoil appeared to be spread at a comparatively shallow depth, resulting in poor tree growth and tree death (>30%), here no *M. stipoide*s or *T. triandra* germinated, however *Rytidosperma* species

have had good success and invasive grass numbers are relatively low compared to more moist and shaded areas. It is also worth noting that cover of exotic perennial grasses has increased in areas with higher canopy cover and soil moisture and is significantly reduced when compared to areas with reduced depth of topsoil.

Rates of tree and shrub growth across the site have been varied and patchy. As is the case with the increased presence of weed species as discussed above, areas with increased soil moisture and soil depth appear to promote superior growth rate in trees and shrubs when compared to areas with less soil depth (as evidenced by figures 6&7). Growth rates and survival rates in Phase C non-extraction area plantings have surpassed those planted in the extraction area. This likely due to a more intact layer of top-soil existing due to a lack of disturbance from mining operations.

Figures 6&7: Sloped areas with increased soil depth and soil moisture (water flow) showing high growth rates of trees.

Re-vegetated areas located within the extraction zone of the mine have seen some natural recruitment processes occur with Table 8 depicting indigenous species that have colonised the site through natural seed dispersal

Table 8: Species naturally recruiting on-site.

Species	Common Name	Life-form
Ozothamnus ferrugineus	Tree Everlasting	Small tree/shrub
Aceana Novae-zealandiae	Bidgee-widgee	Groundcover

Figures 8&9: Areas with less soil depth exhibiting reduced rates of tree growth compared to above.

Notes for Ongoing Management

It is apparent that an increase in soil depth and soil moisture increases growth rates for most trees and shrubs when compared to areas with little topsoil depth and flat areas. Each different area brings with it different challenges in regards to maintenance, with areas of low soil depth seeing a decrease in weed numbers and species present along with a reduced rate in tree and shrub growth rates and an increase mortality. These areas require less frequent efforts regarding weed control but will likely require weed control efforts for a longer period of time due to a delay in plant establishment and canopy cover when compared to other areas of the extraction rehabilitation areas. In contrast to this, areas with higher rates of growth see a more diverse number of weed species present at higher numbers than some surrounding areas. These areas require more intensive management during the development of a tree canopy. However, given the context of the site, which is surrounded by agricultural land and exposed to high winds bringing with it weed seed and high rainfall, ongoing weed management of this site is essential if indigenous vegetation is to dominate the site. This is of particular importance for understorey species as these are most vulnerable to competition from invasive species.