Centennial Coal

Rehabilitation Plan

Bore 8 Dewatering Facility

Springvale Colliery

March 2013

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Rehabilitation Plan

Bore 8 Dewatering Facility

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Summary

The potential impacts from vegetation clearing of the Bore 8 pipeline corridor can be minimised through the implementation of a number of actions. These actions centre around avoiding removal of vegetation and disturbance of topsoil where stems of Persoonia hindii are recorded.

The key mitigation measure being implemented is the realignment of the pipeline within the corridor to significantly reduce the number of *Persoonia hindii* stems being directly impacted upon. With the implementation of recommendations to avoid complete removal of the plants, minimising topsoil disturbance, clear demarcation of the plants and the work area the impact to *P. hindii* can be kept to a minimum.

The successful rehabilitation of the pipeline corridor will be reliant on the implementation of the above actions as well as the rehabilitation recommendations. The rehabilitation recommendations involve the implementation of erosion control measures and the reinstatement of the plant material and woody debris over the site. If all the above measures are implemented it is foreseen that the pipeline corridor should satisfactorily revegetate itself. Examples of this being the case can be seen in pipeline corridors previously constructed by Springvale Coal Mine in the locality.

The methods to be used in the rehabilitation of the Bore 8 Compound will be applied based on the conditions that occur on the site at the time of rehabilitation. Because of this, not all recommended methods are likely to be required. The methods concentrate on the storage and care of topsoil stockpiles. A hierarchy of revegetation methods that prioritises the use of natural revegetation followed by direct seeding or the planting of tubestock only if natural revegetation does not occur, and the use of organic matter to assist with revegetation success and erosion control.

Monitoring will initially involve regular visual inspection followed by a formalised monitoring program. Initial visual monitoring will allow for any problems to be detected and measures to rectify them to be implemented. Once revegetation has reached a stage where it can confidently be considered to be established the formalised monitoring program will be implemented to determine how the rehabilitation is progressing and to establish when it has reached a stage that it can be considered to be complete.

1.0 Introduction

As part of the Bore 8 Project Springvale Coal Mine Pty Ltd has requested RPS to complete a Rehabilitation Plan for the Bore 8 pad and pipeline corridor to satisfy section 19B of the Notification of Modification. The Bore 8 Project will require clearing of approximately 4 ha of vegetation within a 120 m x 120 m drill pad at Bore 8 (see Appendix 2) and along the access track; however 2.34 ha of the cleared area will be partially rehabilitated following completion of construction (see Appendix 3 and 4). One threatened flora species, *Persoonia hindii*, which is listed as endangered under the TSC Act, was identified during the field survey in the Study Area. A total of 93 individual *Persoonia hindii* stems occur within the Project Application Area, due to mitigation measures initiated by Springvale Coal there will be a reduction in the number of stems that are now likely to be directly impacted upon by the project.

Bore 8 will be a semi–permanent feature in the landscape until the infrastructure is no longer required to ensure the safe progression of underground mining activities at Springvale. Bore 8 will be rehabilitated to an end land use of open forest. Upon completion of construction and commissioning of Bore 8, the drill pad will be partially rehabilitated to the minimum area required for the operational phase, anticipated to be a 0.32 ha platform, as well as a 20 m wide Asset Protection Zone around the final footprint. During operation of Bore 8 the fuel load within the Asset Protection Zone will be kept reduced. Once no longer needed, Bore 8 will be decommissioned and full rehabilitation of the site will be undertaken in accordance with the Occupation Permit, and to Forest NSW's standard and satisfaction.

Rehabilitation works will involve decommissioning of all surface infrastructure, grouting and sealing of boreholes, dozer trimming the area to facilitate appropriate drainage of surface runoff. Rehabilitation will be undertaken to ensure the final landform is commensurate with the surrounding topography and will be free-draining. A rehabilitation plan is required to detail how re–spreading of topsoil, re–seeding of the disturbed area with endemic native species will be undertaken to achieve a final land use of open forest. In addition details will be provided on how impacts to *P. Hindii* will be reduced, how the success of the rehabilitation activities will be monitored and a timeline for these activities to occur will be included. For circumstances where impacts to P.hindii can not be avoided, the removal and ongoing management of P.hindii shall be in accordance with the research program titled "Persoonia hindii: species, distribution and security on the Newnes Plateau" that is administered by Centennial Springvale.

2.0 Pipeline Corridor Rehabilitation

The installation of the pipeline will result in the removal of vegetation along a 3.5km corridor. The fact that the corridor will be placed adjacent to an existing track and that it will be progressively rehabilitated following installation of the pipeline will result in a minimal long term impact to the vegetation. Springvale Mine has also altered their pipeline layout to detour around the biggest concentrations of *P. hindii* thereby minimising their impact to the *P. hindii* population and native vegetation even further. Recommendations to further reduce the impact on *P. hindii* and measures to rehabilitate the corridor are detailed below.

2.1 Vegetation removal

During the removal of vegetation within the corridor to allow for installation of the pipeline it is recommended that a number of control measures are implemented:

- As per Centennial Coal Springvale's proposed mitigation measures, realignment of the pipeline onto the access road should be undertaken wherever possible to reduce the number of *P. hindii* individuals to be impacted upon. For the approximate location of the proposed realignment see Appendix 2;
- The corridor should be clearly demarcated to ensure all works remain within the nominated corridor, this will ensure no unnecessary vegetation is removed and that any *P. hindii* plants not within the pipeline corridor are damaged;
- All individual *P. hindii* have already been marked, but this should be rechecked and redone as required;
- During clearing the removal of vegetation should be limited to above ground parts as much as possible, this will enable any vegetation that is able to resprout once works are completed to do so and will also assist with stabilization of topsoil to minimise erosion/soil loss;
- During clearing all efforts should be made to ensure the damage to individual *P.hindii* is kept to a minimum. Clearing should be supervised by a spotter to communicate plant locations to the excavator operator;
- All vegetation should be windrowed between the trenching and the surrounding vegetation. This windrowing will act as erosion and siltation control as well as a short-term refuge to any animals fleeing from removed vegetation; and
- The removal of topsoil should be kept to a minimum and only occur where necessary. Ensuring topsoil is left undisturbed as much as possible will greatly increase the likelihood of natural regeneration and the speed that it occurs.

2.2 Trenching

A progressive trencher will be used to construct the pipeline trench. This method results in soil being placed directly adjacent to the trench. The advantage of this process is that disturbance is kept to a bare minimum. It is recommended that:

- The locations of *P. hindii* be remarked following clearing;
- The exact locations that individual *P. hindii* occurred should be avoided during the trenching process whenever possible. By minimising the amount of disturbance upon the locality that *P. hindii* occurred it will greatly increase the likelihood that it will resprout from any remaining rhizomes;
- For circumstances where impacts to P.hindii can not be avoided, the removal and ongoing management of P.hindii shall be in accordance with the research program titled "Persoonia hindii: species, distribution and security on the Newnes Plateau" that is administered by Centennial Springvale.

- The mixing of topsoil and trenched material should be avoided whenever possible. The ecological value of the topsoil and the likelihood of success of natural regeneration will be dependent upon this occurring; and
- A spotter should be present to communicate the locations of *P. hindii* to the equipment operators as this will increase the effectiveness of these recommendations.

2.3 Erosion Control Measures

The following site specific erosion control measures will be implemented on the pipeline corridor.

- The backfilled trench will be thoroughly compacted to avoid settlement / subsidence of the fill material and inadvertent channelization of water. The top 150 mm of fill may subsequently be scarified or roughen (if required) to assist topsoil adhesion and vegetation establishment.
- Topsoil and forest litter will be respread over the trench area. Logs and windrowed timber will be randomly scattered over the topsoiled areas. However, care will be taken to ensure that any large logs are placed parallel to the contour to avoid the concentration of overland flows.
- As the pipeline corridor follows a ridge along its entire length the running surface of the access track will be constructed with a crown so that runoff water sheds to both sides of the track.
- Mitre drains will be constructed periodically to direct runoff away from the track and will be done so to reduce the likelihood of concentrated water flowing over the rehabilitation.

For further detailed information refer to the dedicated Erosion and Sediment Control Plan - Bore 8 Dewatering Facility (Appendix 5).

2.4 Rehabilitation

The pipeline corridor is a narrow linear site with minimal disturbance occuring during clearing and trenching. The corridor will be progressively rehabilitated and it is anticipated that backfilling and reinstatement of the service corridor shall be completed within a three week period from opening the service trench.

Being a narrow linear feature the distance for propagules to disperse and recolonise the site from surrounding vegetation will be minimal. In addition, as the vegetation and topsoil will only be stockpiled for a short period of time, seeds and the soil flora and fauna are unlikely to have degraded to a significant degree during that time. Because of this, if the previous recommendations are implemented where practical during clearing and trenching a minimal amount of active rehabilitation will be required. This approach has proven successful on other Springvale pipeline installations with *P. Hindii* recolonising the pipeline easement adjacent to Beecroft Trail and Sunnyside Ridge Rd, see Plate 1 and 2.

Plate 1 Rehabilitated Pipeline Easement along Beecroft Trail (Roger Lembit 2013)

Plate 2 View of Pipeline Easement along Sunnyside Ridge Rd with *P. hindii* in foreground (Roger Lembit 2013)

3.0 Bore 8 Dewatering Compound Site Rehabilitation

3.1 Methodology

The number and type of methodologies employed will be determined by site conditions that occur at the time of rehabilitation (i.e. vegetation condition, site condition, and season). The preferred revegetation method for the Bore 8 Compound is natural revegetation with other methods only applied if this does not occur. The need for additional measures will be assessed and the resulting methods to be used will be decided upon at the time of rehabilitation.

3.1.1 Weed Treatment

Any listed noxious weeds infestations identified should be treated. This should include any that are deemed to be deleterious to the revegetation effort, or are likely to spread during the course of the rehabilitation work. Herbicides should be used with due consideration to environmental knock on effects. Any weeds that germinate from the seed bank in the topsoil stockpile should also be treated to prevent outbreaks that pose an ongoing liability.

3.1.2 Topsoil Stockpiling

3.1.2.1 Biological Aspects of stockpile handling

Stripping and stockpiling of topsoils followed by re-spreading for revegetation is regarded as best practice rehabilitation in the mining industry. The use of topsoil in this regard has three main advantages as a source of seeds (seed bank), soil microbial organisms, and as a physical covering for dispersive subsoils. Biologically, the value of stockpiled topsoil is largely determined by the length of time that soil will be stockpiled and the physical shape of the stockpile (Kiepert et al. 2002).

Topsoil can be used as a seed source, however this depends on the quality and composition of the vegetation previously established and the target community to be re-established. That is, native vegetation can provide an excellent seed source if that is the revegetation target, whereas exotic pasture species will not aid in the re-establishment of native ecosystems.

The majority of soil micro and macro flora and fauna reside in topsoil. The organisms residing here are instrumental in nutrient cycling, soil structure and plant survival. A key component of the soil microbial community is the endomycorrhizae. These are obligate symbiotic fungi (they must infect plant roots to survive) that form associations with the majority of all plant species. They are slow to re-colonise a disturbed area taking tens of decades to disperse, and are severely disrupted by stripping and stockpiling; their spores degrade within six months of stockpiling. Stockpiling of topsoil needs to be considered in the light of two conflicting requirements.

Stockpiles generally are constructed to minimise surface area to volume ratios. That is, they are constructed as high and as steep as possible. This reduces the total disturbance footprint and restricts the surface area for weeds to become established. However, stockpiles can become anaerobic within six months, leading to death of beneficial microbes and the degradation of seeds and spores, therefore the anticipated duration the soil will be stockpiled will determine how it will need to be treated before it can be used for rehabilitation purposes (Table 2).

3.1.2.2 Recommendations

To maximise the preservation of the biological aspects of topsoil, stockpiles should be constructed as low and spread out as possible, preferably <2m in height (Kiepert, *et al,* 2002). This does increase the footprint and provides greater surface area for weed colonisation. Seeding with target vegetation species as soon as possible on the stockpile itself will reduce weed infestation and erosion. The roots will assist in maintaining a viable microbial community and the plants will provide organic matter after re-spreading. Depending on the length of time stockpiling occurs, some species may even set seed thereby replacing the original seed bank which can deteriorate and become unviable over time. Stockpiled topsoils are to be treated for any noxious weed infestations prior to being respread over the site.

Excavated topsoil and subsoil should be stockpiled away from drainage lines, with installation of sediment control fencing where deemed appropriate.

Table 1 Topsoil stockpile requirements.

Soil Type	Time Since Stripping	Action
Topsoil	Duration <6months	Normal erosion controls Shape to reduce disturbance of surrounding area
	Duration >6months	Normal erosion controls Shape to reduce biological impact of stockpiling
Subsoil	Duration not as critical	Normal erosion controls Seed with native grass species to reduce weed infestations Replace in reverse order of removal

3.1.3 Revegetation

Revegetation of the Bore 8 Compound requires consideration of a range of factors which can influence the establishment success of the target vegetation. Revegetation generally requires site preparation and direct seeding, and may also involve other methodologies such as brush matting, and planting with tubestock. All seed and tubestock should be of a local provenance and sourced locally to ensure they are acclimatised to the climatic conditions that occur at the site.

3.1.3.1 Site Preparation

Site preparation will involve the following steps;

- Assess the site and identify potential weeds, erosion issues and other important site specific information. Identify potential resources that can be used for the rehabilitation process (i.e. native vegetation and topsoil availability).
- Treat weeds with herbicide and remove these if viable seed is present.
- Identify the dominant target species from site surveys and further species known to occur within the locality. This data will be collated and used to create a site specific table from which groundcover and shrub species (if present) can be selected. These species are detailed in Appendix 1.
- Reshape and spread topsoil across site.
- Contour rip the topsoil to ameliorate the effects of compaction from heavy machinery. Ripping should not occur below the depth of the re-spread topsoil. Mixing and de-compaction of underlying dispersive subsoils can increase dispersion;

3.1.3.2 Direct Seeding

Revegetation using seed is less expensive than planting with tubestock, however, disadvantages include the potential for desiccation of seed due to harsh micro-site conditions; and a loss of seed due to insect or bird harvesting.

The potential for the desiccation of seed can be reduced by correct site preparation (see section 3.1.4). If it becomes necessary seeds can be coated in insecticides such as Coopex™ which has been found to discourage ant harvesting. Coopex™ discourages ants from removing seed, but at low doses does not kill the ants (Campbell & Gilmour, 1979). Seed coating adds to the cost and handling of seed, but on bare ground such as rehabilitated sites, ants can harvest up to 99% of broadcast seed (M. Cole, C. Castor & Y. Nussbaumer, University of Newcastle, pers. comm.).

The viability of seed can also be increased by coating the soil with microbial inocula (common practice with many agricultural legumes). Small seeded species can be physically limited in the quantity of inocula which is able to adhere. This can reduce the effectiveness of inocula application (Stephens & Rask, 2000).

3.1.3.3 Species Selection

A selection of suitable native grass, tree and shrub species that may be used is presented in Appendix 1. Recommendations are based on the species present on site and those that are commercially available. If additional species are required, seed collection may be required. Generally, seeding mixes of native species should be applied at between at 5-10kg/ha. The composition of seed mix should be determined by species availability and the target community.

3.1.3.4 Tubestock

The use of tubestock to rehabilitate a site has some advantages and disadvantages over direct seeding.

Advantages include;

- Better control over composition and density;
- Fewer plants are required to be planted (as compared to seed);
- Increased survival rates when compared to broadcast seed (So *et al.* 2011). This can be attributed to;
  - Greater size and rate of development of the plant, especially the roots;
  - Requirement for tree-guarding which improves the micro-climate and reduces herbivory;
  - Problems associated with seed dormancy already overcome;
  - Increased ability to compete with weeds due to size;
  - Ability to inoculate and determine success of inoculation with multiple microbial symbionts such as rhizobia, mycorrhizae and plant growth promoting bacteria prior to planting.

Disadvantages include;

- It is more costly than direct seeding, mainly as it is more labour intensive;
- Rates of herbivory can be very high if not protected by tree-guards or fencing, adding to costs;
- Requires six months' notice to propagating nurseries. Most species will not be available at short notice;
- Requires increased site preparation and watering. A number of products are available that can be added to water to assist with plant health, water loss, and root establishment and should be considered as they will increase the likelihood of success.

3.1.4 Site Preparation

3.1.4.1 Landform and Topsoil

Site preparation will include dozer trimming of the area to facilitate appropriate drainage of surface runoff. Rehabilitation will be undertaken to ensure the final landform is commensurate with the surrounding topography and will be free-draining. Topsoil will be respread across the site and contour ripped to ameliorate the effects of compaction from machinery.

3.1.4.2 Brush matting

Brush matting involves the spreading of harvested stems, seed pods and seeds en mass over the targeted area. This method requires the source site to be in reasonable proximity and the harvested plant material must have seeds at the correct phase of development to be viable. Proximity is important as brush is generally a high volume, low bulk product making transport costs a major consideration.

3.1.4.3 Habitat reinstatement

Habitat reinstatement for the return of fauna will include the following where possible;

- Hollow bearing trees that were removed should be replaced, or equivalent nesting structures, such as nest boxes should be erected. Hollow bearing trees should also be retained and used as ground habitat;
- Woody debris should be reinstated randomly over the site. This can be sourced from material stockpiled from clearing or imported from other sources or sites if not available;
- Woody material not used for habitat reinstatement should if possible be chipped, and placed on the ground after seeding to decompose and add to the organic content as well as aid in erosion control; and
- Rocks that are removed prior to drilling should be replaced in approximate size and location. These are an important habitat feature for many of reptiles that inhabit these sites. Large rocky material that was brought onto site may be used for this purpose, given that it does not interfere with revegetation/rehabilitation outcomes, i.e. dumped rather than removed.

3.2 Seasonality

The two main factors affecting seed germination and seedling survival are rainfall and temperature. Rainfall may trigger germination of seeds but if no follow up rainfall is received, the seedlings may not survive. The timing, duration and intensity of rainfall can vary considerably between years and the requirements for each plant species also varies. Temperature can affect both the germination and the growth rate of plants, especially the grasses found in tropical and sub-tropical regions. The germination success of many of the tree and shrub species is equally reduced by low temperatures with the greatest success achieved at temperatures of above approximately 20^{o}C.

4.0 Indicators of Successful Revegetation

Completion criteria will be dependent upon monitoring demonstrating that rehabilitation trajectories are trending towards baseline values. This will be established by increasing vegetation coverage, ongoing survival of planted species and sustainability by successful completion of life cycles by plant species that can be expected to produce seedlings within the monitoring timescale.

4.1 Monitoring

Initially monthly visual inspections of the corridor and the Bore 8 well development site will need to be undertaken immediately following rehabilitation. Visual monitoring can be conducted by Centennial Coal Environmental staff or a suitable representative of Centennial Coal to establish if the revegetation is occurring successfully. Visual inspections will allow for any problems with the rehabilitation that may occur to be rectified as quickly as possible.

Once the rehabilitation can confidently be considered to be progressing and stable then an annual monitoring program can be commenced. This will be undertaken to determine whether or not vegetation is approaching the form and composition of what previously occurred on site and will be continued until the vegetation can confidently be considered to be approaching the composition and structure of the reference site.

- Initial visual monitoring will include ensuring that erosion and sediment controls are functioning effectively as per the Erosion and Sediment Control Plan – Bore 8 Dewatering Facility (Appendix 5). The goals for erosion and sediment control are that no excessive erosion and sediment deposition is occurring and that any control measures are implemented as soon as required. Photo records will be sufficient and should be taken from a fixed monitoring point on every inspection or when any change or impact has occurred.
- In addition, visual inspections will monitor for the emergence of seedlings and resprouting of vegetation and that once this has occurred that vegetation cover is stable, final monitoring should demonstrate improved coverage and species composition approaching that of pre-disturbance levels.
- The regeneration of Persoonia hindii along the pipeline corridor will be monitored in accordance with the research proposal titled “Persoonia hindii: species, distribution and security on the Newnes Plateau” that is administered by Centennial Springvale.
- Evidence of sustainability should be provided by recording the production of seeds and recruitment of seedlings leading to increasing coverage, especially of fast life cycle grasses and shrubs.
- Evidence of nutrient cycling (especially of nitrogen) by leguminous species should be determined by the presence of root nodules on appropriate species. Hand excavation of roots and photographs should be included in any reports. Decomposer fungal colonization of woody material also indicates the establishment of important nutrient cycling processes, but may only be visible on older woody debris or during rainy season.
- Returning the site to the equivalent of native remnant vegetation requires the measurement of survival of planted species and increased growth. Some shrub species will have flowered and may have seed set within a 3 year monitoring period. Evidence of such indicates improving rehabilitation trajectory. Recruitment of seedlings from seed bank or from sources outside the disturbance area will also be recorded and indicates sustainable rehabilitation.
- A reference site in close proximity to the Bore 8 site within an undisturbed section of an equivalent rehabilitation target vegetation type should be included into the monitoring program. This structure, composition, condition of the vegetation, and rates of erosion within the reference site will be those that the rehabilitation will be assessed against.

If none of the above are occurring or is only occurring to a limited degree then the rehabilitation may need to be supplemented. The lack of rehab success could be simply due to a series of dry years that inhibit plant development, the leaching of soil nutrients before plants have developed natural nutrient cycles, herbivory, lack of seed viability, or there may not be any obvious cause. The more effort put into initial rehabilitation will reduce the need for supplementary rehabilitation which may significantly add to the cost.

5.0 Timetable

Table 2 Timetable for rehabilitation works.

Task	Milestone	Date
Pipeline Corridor		
Completion of pipeline emplacement	Re-spread topsoil / sub soil windrows to allow site regeneration. The removal of windrows will provide emergency access off the edge of fire trails for response vehicles. Re-spread vegetation over disturbed areas to provide fauna habitat and minimize unauthorized off road vehicle access.	Three weeks after trenching commences
Monitoring	Monthly site inspections followed by monitoring program commenced	Immediately following rehabilitation
Rehabilitation Sign-off	The final monitoring report shall be submitted to DRE	Dependent on rehabilitation success
Bore 8 Dewatering Compound		
Vegetation Cleared	Vegetation stockpiled.	Following Approval
Erosion controls	Implementation of erosion controls	On commencement of Construction
Topsoil stripped	Topsoil stockpiled	During construction
Construction infrastructure decommissioned	Surplus construction plant / materials and waste removed from bore compound.	Within three months of project commencement
Rehabilitation of the external perimeter of the Bore 8 Compound	Topsoil and vegetation re-spread erosion controls reinstated	Within three months of project commencement
Bore 8 Dewatering Compound rehabilitated	Removal of site infrastructure	Following the commissioning of Dewatering Bore 9
Monitoring	Monthly site inspections followed by monitoring program commenced	Immediately following rehabilitation of the Bore 8 Compound

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Appendix 1

Revegetation Species

Family	Scientific Name	Common Name
Trees		
Myrtaceae	*Eucalyptus blaxlandii**	Blaxland's Stringybark
	Eucalyptus dalrympleana	Mountain Gum
	Eucalyptus dives	Broad-leaved Peppermint
	*Eucalyptus oreades**	Blue Mountains Ash
	*Eucalyptus piperita**	Sydney Peppermint
	*Eucalyptus radiata**	Narrow-leaved Peppermint
	*Eucalyptus sclerophylla**	Scribbly Gum
	*Eucalyptus sieberi**	Silvertop Ash
Shrubs		
Apiaceae	*Platysace linearifolia*	Narrow-leafed Platysace
Araliaceae	*Polyscias sambucifolia*	Elderberry Panax
	Cassinia cunninghamii	Cunningham's Everlasting
Epacridaceae	*Brachyloma daphnoides*	Daphne Heath
	Epacris microphylla	Coral Heath
	Epacris pulchella	Wallum Heath
	Leucopogon lanceolatus	Lance-leaf Beard-heath
	Monotoca scoparia	Prickly Broom-heath
Euphorbiaceae	*Amperea xiphoclada* var. *xiphoclada*	Broom Spurge
Fabaceae	*Daviesia latifolia*	-
	Daviesia squarrosa	-
	Gompholobium huegelii	Pale Wedge Pea
	Phyllota squarrosa	Dense Phyllota
	Acacia buxifolia	Box-leaf Wattle
	*Acacia terminalis**	Sunshine Wattle
Myrtaceae	*Baeckea linifolia*	Weeping Baeckea
	*Leptospermum arachnoides**	-
	*Leptospermum grandifolium**	Woolly Tea-tree
	Leptospermum obovatum	-
	Leptospermum polygalifolium subsp. *polygalifolium**	Tantoon
	*Leptospermum trinervium**	Slender Tea-tree
Proteaceae	*Banksia spinulosa**	Hairpin Banksia
	*Banksia marginata**	Silver Banksia
	*Grevillea laurifolia**	Laurel-leaf Grevillea
	*Hakea dactyloides**	Broad-leaved Hakea
	*Hakea sericea**	Needlebush
	*Isopogon anemonifolius**	Flat-leaved Drumsticks
	*Lomatia silaifolia**	Crinkle Bush
	Persoonia chamaepitys	Mountain Geebung
	***Persoonia hindii* (E)**	**-**
	Persoonia oblongata	-

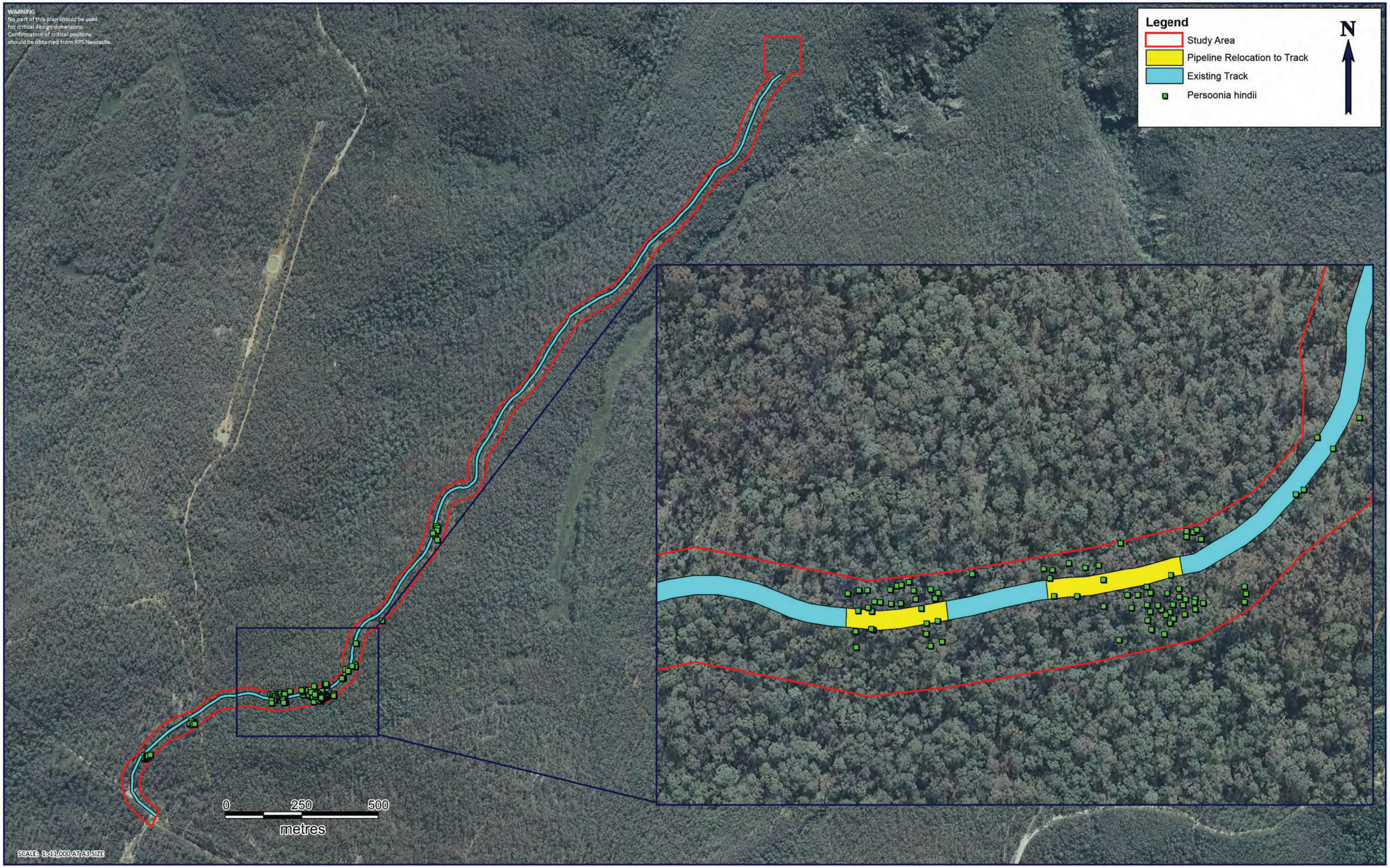
Family	Scientific Name	Common Name
	*Petrophile pulchella**	Conesticks
	Petrophile sessilis	Conesticks
Rhamnaceae	*Pomaderris andromedifolia*	-
Rutaceae	*Boronia microphylla*	Small-leaved Boronia
Santalaceae	*Leptomeria acida*	Native Currant
Santalaceae	*Omphacomeria acerba*	-
Groundcovers		
Cyperaceae	*Gahnia aspera*	Saw Sedge
	*Gahnia sieberiana**	Red-fruited Saw-sedge
	Lepidosperma laterale	Variable Sword-sedge
	Lepidosperma limicola	-
Dennstaedtiaceae	*Pteridium esculentum*	Bracken
Dilleniaceae	*Hibbertia obtusifolia**	Grey Guinea Flower
Droseraceae	*Drosera peltata*	Sundew
Droseraceae	*Drosera spathulata*	Common Sundew
Euphorbiaceae	*Poranthera microphylla*	-
Gentianaceae	*Centaurium erythraea**	Common Centaury
Gleicheniaceae	*Gleichenia dicarpa*	Pouched Coral Fern
Goodeniaceae	*Dampiera stricta**	Blue Dampiera
	*Goodenia bellidifolia**	Daisy-leaved Goodenia
Goodeniaceae	*Goodenia hederacea* subsp. *hederacea*	Ivy-leaved Goodenia
Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort
	Gonocarpus teucroides	Raspwort
Iridaceae	*Patersonia glabrata*	Leafy Purple-flag
	Patersonia sericea	Wild Iris
Lomandraceae	*Lomandra filiformis* subsp. *coriacea*	Wattle Mat-rush
	Lomandra filiformis subsp. *filiformis*	Wattle Mat-rush
	*Lomandra glauca**	Pale Mat-rush
	*Lomandra longifolia**	Spiky-headed Mat-rush
	Lomandra multiflora	Many-flowered Mat-rush
Orchidaceae	*Dipodium punctatum*	Hyacinth Orchid
Oxalidaceae	*Oxalis perrenans*	Yellow-flowered Wood Sorrel
Phormiaceae	*Dianella revoluta* var. *revoluta*	Spreading Flax Lily
Poaceae	*Austrodanthonia racemosa var. racemosa*	Wallaby Grass
	Austrostipa pubescens	Tall Speargrass
	*Joycea pallida**	Silvertop Wallaby Grass
	Microlaena stipoides var. *stipoides**	Weeping Rice Grass
	Poa seiberiana var. *cyanophylla**	-
Proteaceae	*Grevillea laurifolia**	Laurel-leaf Grevillea
Restionaceae	*Baloskion australe*	-
	Empodisma minus	-
Stylidiaceae	*Stylidium graminifolium**	Grass Trigger Plant

Family	Scientific Name	Common Name
	Stylidium lineare	Narrow-leaved Trigger Plant
Thymelaeaceae	*Pimelea linifolia* subsp. *linifolia*	Slender Rice Flower
	Tetratheca rupicola	Black-eyed Susan
	*Viola betonicifolia**	Native Violet
	*Viola hederacea**	Ivy-leaved Violet
Xanthorrhoaceae	*Xanthorrhoea resinosa*	-
Climbers		
Pittosporaceae	*Billardiera scandens**	Hairy Appleberry

**species available from local not-for-profit nurseries*

Appendix 2

Bore 8 Pipeline and Access Track Corridor



TITLE: FIGURE 1: PIPELINE AND ACCESS TRACK CORRIDOR	LOCATION: SPRINGVALE DEWATERING BORE 8 REHABILITATION PLAN	DATUM: GDA 94 PROJECTION: MGA ZONE 56	DATE: 15/03/2013 PURPOSE: REPORT FIGURE	LAYOUT REF: J:\JOBS\Centennial\All Jobs\116816 Bore 8 rehabilitation plan\10- Drafting\Workspaces VERSION (PLAN BY): A A4 (ZA)

CLIENT: CENTENNIAL COAL
JOB REF: 116816

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
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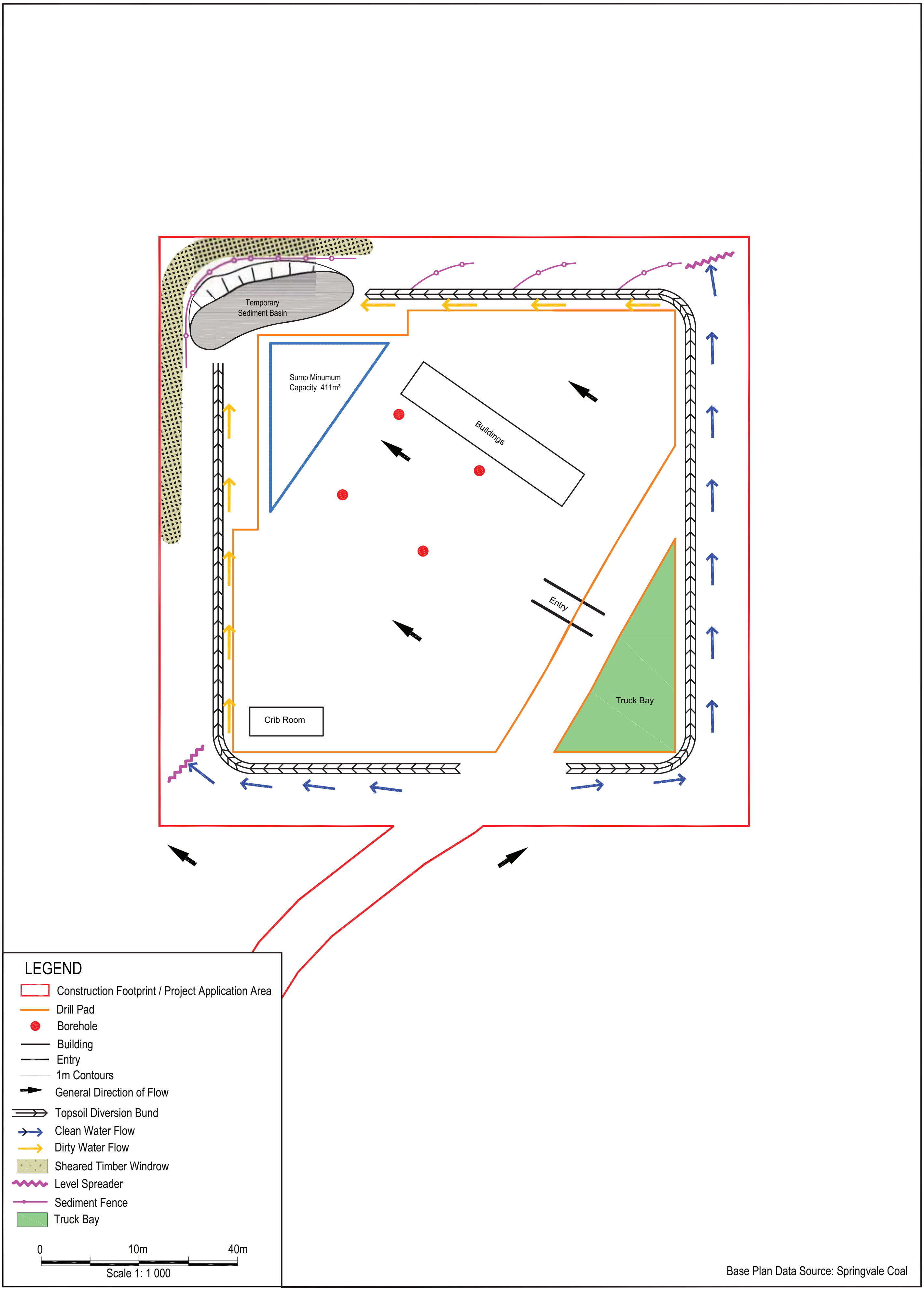
Appendix 3

Bore 8 Indicative Construction Phase Layout



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Bore 8 Indicative Construction Phase Layout

FIGURE 3

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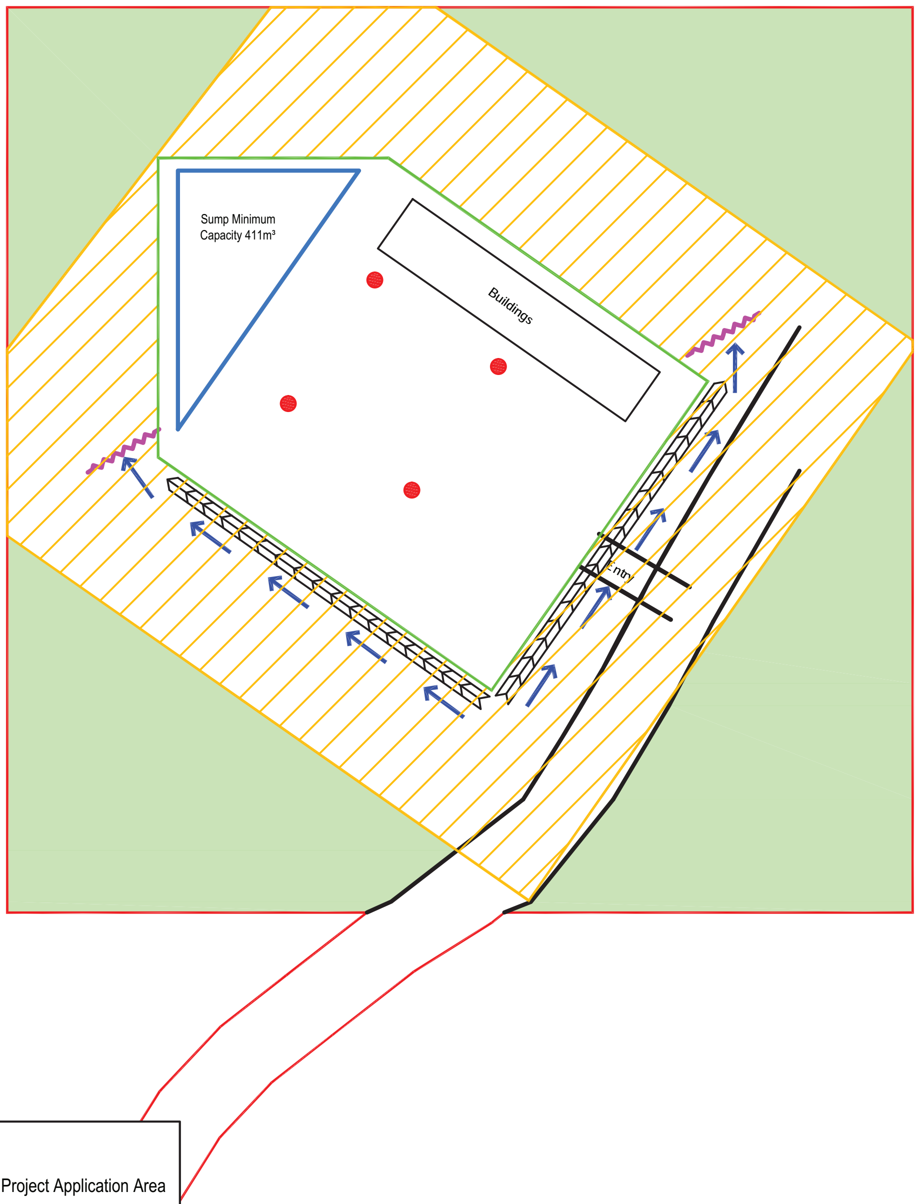
Appendix 4

Bore 8 Indicative Operational Phase Layout



LEGEND

- Construction Footprint / Project Application Area
- Final Footprint
- Borehole
- Building
- Acess Track and Entry
- 1m Contours
- Asset Protection Zone
- Topsoil Diversion Bund
- Clean Water Flow
- Level Spreader
- Partially Rehabilitated Area

0 10m 40m
Scale 1: 1 000

Base Plan Data Source: Springvale Coal

To be printed A4

Bore 8 Indicative Operational Phase Layout

FIGURE 4

V:\CCC15-005\Figures\Final\CAD\Cad files for site 130211\CCC15-005_Bore 8 Indicative Layout_130211.dwg

Appendix 5

Erosion and Sediment Control Plan – Bore 8 Dewatering Facility, Springvale Mine. March 2013

Centennial Coal

EROSION AND SEDIMENT CONTROL PLAN

Bore 8 Dewatering Facility

Springvale Mine

March 2013

Table of Contents

Figures

1. Introduction

1.1. Relationship to Approvals and Industry Standards

This Erosion and Sediment Control Plan (ESCP) has been prepared to address the specific requirement detailed in the Department of Planning and Infrastructure's Project Modification Approval for Springvale's Bore 8 Dewatering Project.

This ESCP has been prepared in recognition of industry best practice principles for the region and the specific requirements of the following documents:

- Managing Urban Stormwater; Soils and Construction (The Blue Book) Volume 1; Landcom, Sydney, 2006
- Managing Urban Stormwater; Soils and Construction Volume 2A, Installation of Services; Department of Environment and Climate Change NSW, Sydney 2008
- Managing Urban Stormwater; Soils and Construction Volume 2C, Unsealed Roads; Department of Environment and Climate Change NSW, Sydney 2008
- Managing Urban Stormwater; Soils and Construction Volume 2E, Mines and Quarries; Department of Environment and Climate Change NSW, Sydney 2008
- Environmental Assessment, Bore 8 Dewatering Facility, Springvale Colliery; GSS Environmental, September 2012
- Surface Water Assessment, Bore 8 Dewatering Facility, Springvale Colliery; GSS Environmental, September 2012
- Soil Landscapes of the Wallerawang 1:100,000 Sheet, King 1993; NSW Department of Land and Water Conservation, Sydney

1.2. Relationship to Project CEMP

Although this ESCP is presented as a standalone document, it is an integral part of the project's Construction Environmental Management Plan (CEMP).

2. Background

2.1. Project Overview and Description

This Project includes the construction and operation of a Mine Dewatering Facility additional to existing Springvale Mine surface infrastructure, and referred to as "Bore 8". Associated infrastructure requirements include an underground power supply cable, water pipeline and access track. The location of the new Bore 8 facility and its associated infrastructure is within the Newnes State Forest on the Newnes Plateau.

Bore 8, through its dewatering function, will facilitate the progress of coal extraction further to the east of existing workings at Springvale. Water levels can be kept at safe and manageable levels within the mine, through its successful operation. This facility will form a critical part of Springvale's existing dewatering system as longwall mining progresses through approved longwalls (LW) LW416 to LW419. Water pumped out of the underground workings at Bore 8 will be transferred via pipelines (predominantly trenched) to Wallerawang Power Station, as part of the existing Springvale–Delta Water Transfer Scheme (SDWTS).

Upon Project completion, the Bore 8 facility will be a fenced compound housing four surface to seam boreholes installed with submersible pumps, an associated switchroom with power control equipment for the operation of the pumps, and a sediment basin.

An upgraded access track and new infrastructure corridor into Bore 8 will also be constructed as part of this project. This infrastructure corridor is approximately 3.5 km in length and 10 m in width (including the existing track which is around 3.0m wide on average). It will contain a trench containing buried 11 kV power supply cables, fibre optic cable and the water transfer pipeline. Refer **Figure 1.**

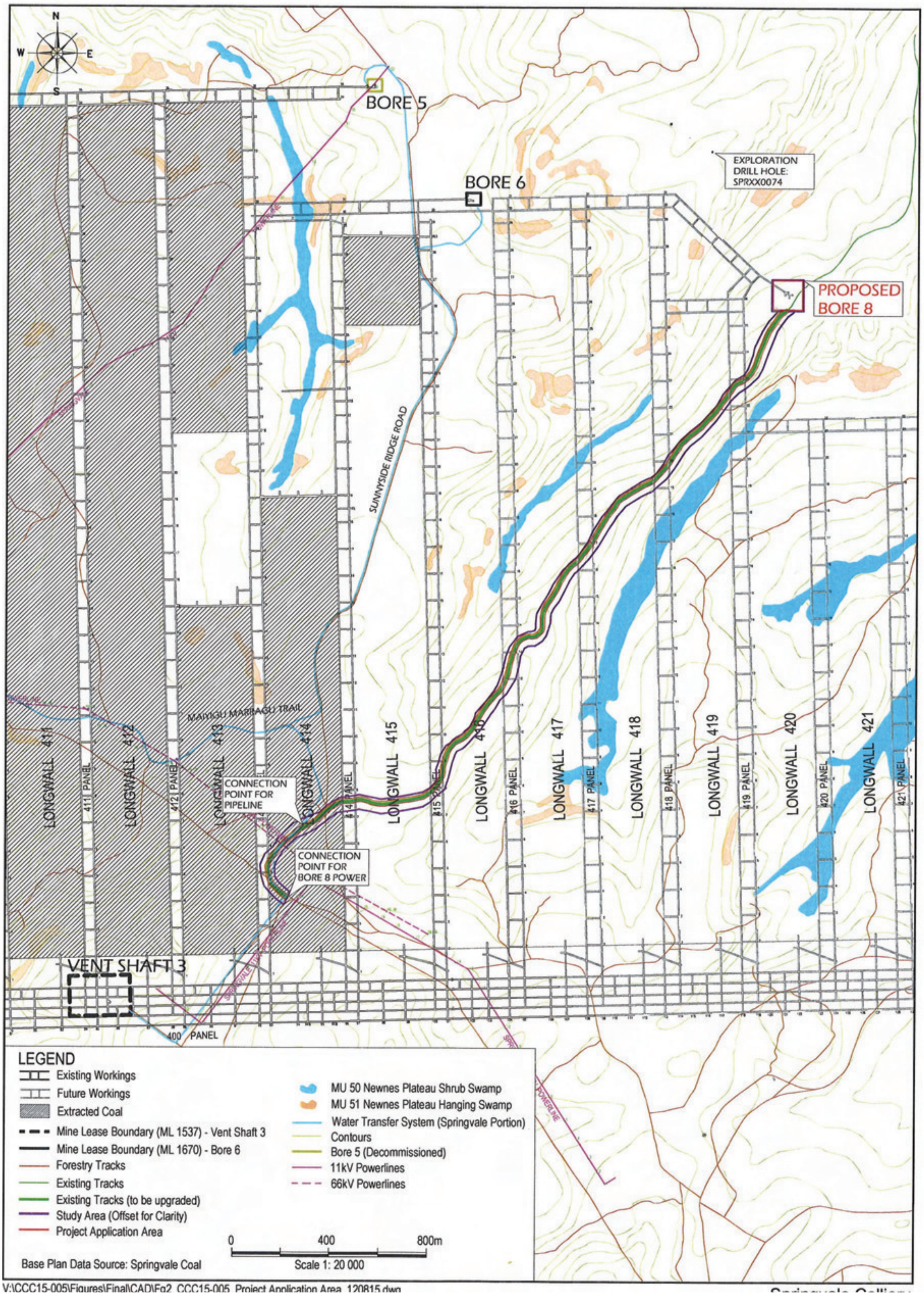


Figure 1: Location of Bore 8 infrastructure corridor and compound site (Source: Environmental Assessment, Bore 8 Dewatering Facility, GSSE 2012).

2.2. Construction Sequence

It is anticipated that the construction of the Bore 8 project will be undertaken in accordance with the following elements:

1. Installation of erosion and sediment controls along the access track and around the drill pad, including a sediment basin downslope of the drill pad;
2. Clearing of drill site;
3. Installation of surface water management structures and temporary security fencing around the drill site;
4. Drilling and casing of boreholes;
5. Progressive clearing of infrastructure corridor and upgrading of existing access track;
6. Installation of utilities (underground power cable and water pipeline) along access corridor to Bore 8.
7. Progressive rehabilitation of the access track and infrastructure corridor to a final width of approximately 5 m;
8. Installation and commissioning of submersible pumps;
9. Construction of a number of low rise buildings to house a VVVF (Variable Voltage Variable Frequency) control room, soft starter control room and an 11 kV switch room;
10. Rehabilitation of the drill site footprint will be undertaken upon completion of construction and drilling works, to reduce the area of disturbance to a final footprint of around 0.35 ha required for the operational phase of the project; and,
11. Installation of a permanent fence on the perimeter of the facility (including the basin area) with access via a lockable gate

Depending on weather conditions and construction/commissioning constraints, it is anticipated that the project will be completed within four months. Construction is expected to commence in early March 2013, with completion by late June or early July 2013.

2.3. Existing Site Conditions, Limitations and Constraints

Site Drainage

The Bore 8 project area is located in the headwaters of the Carne Creek catchment, a sub–catchment of the Wolgan River catchment. Both the infrastructure corridor and the Bore 8 compound site are located on a gently undulating ridge with no appreciable volume of runon water entering the site. No watercourse is intersected by the either the access track or the compound site.

The Surface Water Assessment (GSSE, 2012) concludes that negligible impacts are expected on the local THPSS communities (Hanging Swamps and Shrub Swamps) given the large distance from the works area to the closest THPSS communities.

Soil Erodibility

Three soil landscape units will be intersected by this project; refer **Figure 2**. The following descriptions are sourced from *Soil Landscapes of the Wallerawang 1:100,000 Sheet* (King 1993).

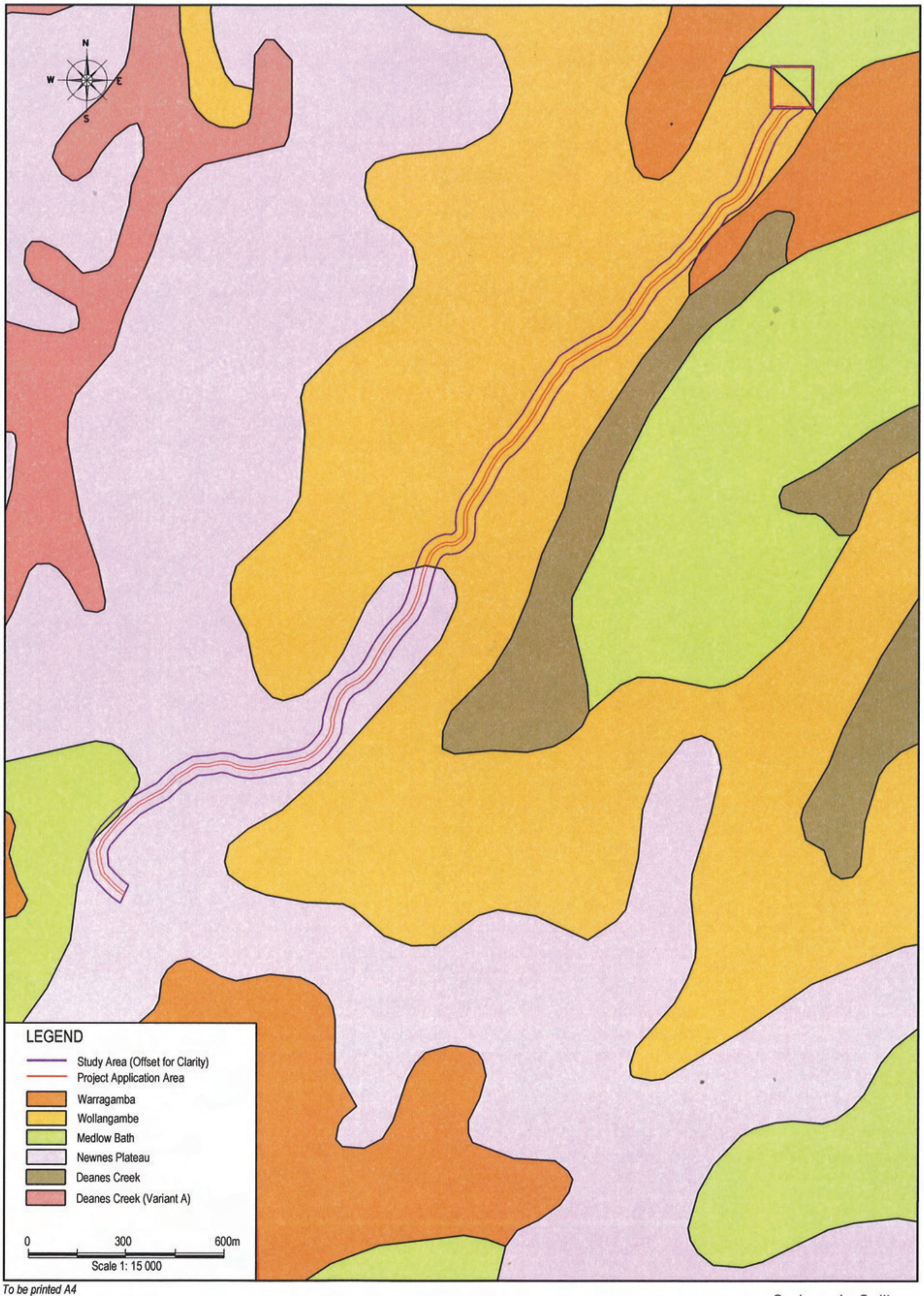


Figure 2: Soil Landscapes traversed by the project (Source: Environmental Assessment, Bore 8 Dewatering Facility, GSSE 2012).

These are:

- *Newnes Plateau (np) soil landscape unit* which occurs on the undulating crests higher in the catchment and is characterised by acidic shallow sands and clayey sands overlying sandy clay loams and friable sandstone;
- *Wollangambe (wb) soil landscape unit* which occurs further down the ridge towards the compound area and consists of sands, loamy sands, and clayey sands overlaying shallow to deep sandstone subsoils;
- *Meadlow Bath (mb) soil landscape unit* which underlies a portion of the compound site and consist of moderately deep stony and acidic earthy sands and yellow earths.

With regards to erosion and sediment control planning, all of these soils exhibit a sandy to sandy loam texture. Both erodibility and dispersibility is low (K factor values range from 0.013 – 0.017) (King 1993). While these soils are relatively easy to detach in a concentrated flow situation, subsequent transportation and sedimentation is easily controlled due to the inherent predominance of large particle sizes. Low levels of clay indicate that the site runoff should also exhibit low levels of suspended solids and resultant turbidity.

Rainfall Intensity

In this region there is higher long term average rainfall during summer months, and a marginally lower rainfall average in winter and early spring. Long term rainfall data indicates that January is in most years the wettest month, and September the driest.

The average number of mean rain days is reasonably consistent throughout the year. This then clearly indicates that higher summer rainfall averages are due to higher intensity storm events, rather than *more frequent* but *lower intensity* rainfall events. Rainfall erosivity is therefore usually at its highest during December, January and February, and at its lowest during June, July and August.

Construction is expected to commence in early March 2013, with completion by late June or early July 2013, and therefore should avoid the higher intensity summer rainfall events and the associated increased risk of erosive forces on disturbed ground.

Slope Gradient

Slope gradients both along the access track and across the compound site are very low. This will generally result in runoff velocities below the maximum permissible velocity for the abovementioned soil landscape units.

Average slope gradient along the access track is 2.5%, however, there is a limited 222m section between chainage (ch) 2055 and 2277 where the slope increases to 5.8%. Slope grade across the compound area will be confirmed following clearing, but has been estimated to be less than 3%.

3. Control Measures and Management Practices

The following suite of control measures aim to manage erosion and sedimentation by initially minimising soil detachment and transportation, controlling runoff volume and velocity, and maximising sediment deposition and retention on site.

From this point forward and for the purposes of this document, the access track and services trenching aspect of the project will be referred to as the “infrastructure corridor”, and the Bore 8 site facility as the “compound area”.

3.1. Site Management Practices – all areas

Best practice site management aims to schedule and conduct site activities so as to minimise both the extent and the duration of disturbance. Accordingly, the following site management practices will be adopted on this project:

- The maximum limits of clearing will be clearly marked out prior to clearing activities commencing. Identified communities of *Persoonia hindii* will be clearly demarcated or “flagged out”, with yellow flagging tape, and will constitute a “No-Go zone”.
- Ground disturbance will be avoided outside of the areas identified above, vehicle movements will be restricted to designated tracks, and existing clearings will be utilised as turnaround areas and laydown sites.
- Where site access permits, erosion and sediment control structures will be installed/constructed prior to commencement of site clearing/ground disturbing activities.
- In situations where some preliminary clearing is required to gain access to the site (i.e. the compound area), the required erosion and sediment control structures will be installed/constructed as a matter of priority.
- Disturbance along the infrastructure corridor will be confined to those areas involved in current construction activities. Where possible, forward clearing and trenching activities will be limited to a maximum of 200m ahead of active pipe laying activities.
- The Bureau of Meteorology five day weather forecast will be used as a trigger to minimise forward clearing activities, expedite rehabilitation activities, and schedule additional erosion control measures along the corridor when inclement weather is predicted.
- Works will also be scheduled so that an absolute minimum quantity of trench (e.g. less than 50m) is left open over any weekend.
- Timber and other vegetative material will be removed and stockpiled immediately adjacent to the works. Where practicable, this material will be windrowed on the downstream side of the works to act as a sediment barrier.
- Where possible, unless located *directly* over the trench alignment, tree stumps and roots will not generally be grubbed, in an effort to promote coppicing.
- There will be an excess of vegetative material cleared from the compound site. This material may be tub ground, stockpiled and allowed to compost in preparation for final site rehabilitation following decommissioning of the site in 2017.
- Topsoil and forest litter will be removed (to a nominal depth of 50-100mm) and stockpiled in a windrow adjacent to the timber windrow; refer to **Figure 3**. In order to maintain topsoil viability, stockpiles will not exceed 1.5m in height and will not be compacted.
- Where site contours permit, the topsoil windrow may also be used as an upslope perimeter bank, to divert clean runon water around or away from disturbed areas.
- Rehabilitation of the infrastructure corridor will commence immediately following trench backfilling. Where practicable, there will not be more than 75m of backfilled trench left un-rehabilitated as work progresses

- All site earthworks activities (including refuelling and servicing of plant and equipment) will cease during periods of heavy and/or prolonged rainfall (i.e. >25mm in 24 hours).

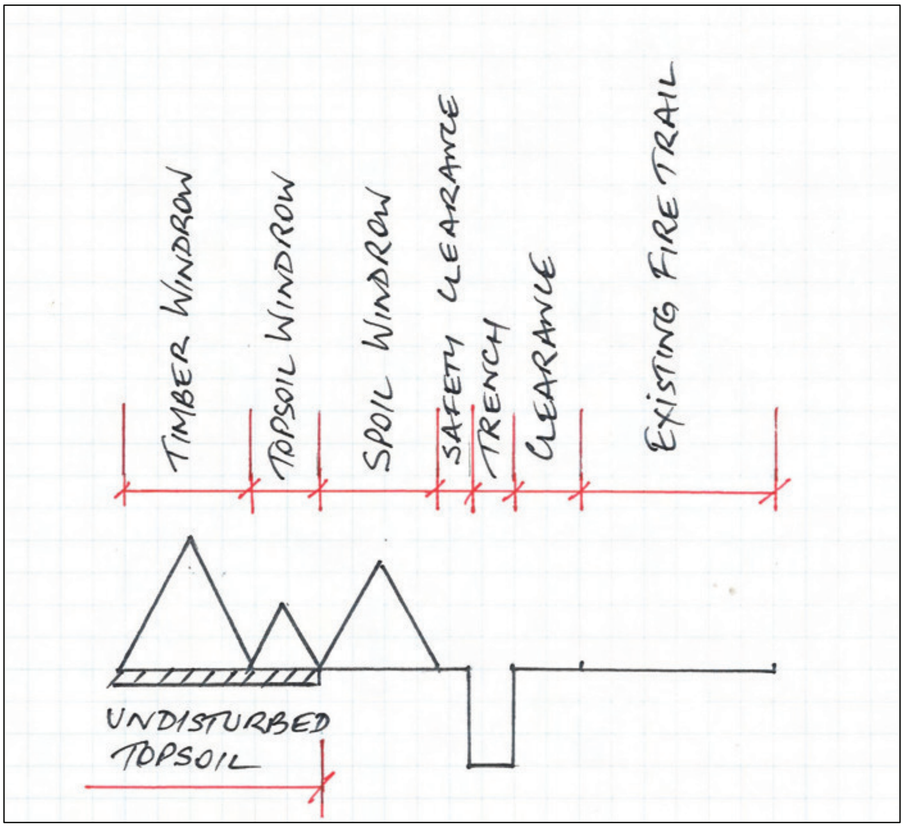


Figure 3: Diagrammatic representation of trenching, clearing and topsoil removal. Not to scale.

3.2. Erosion Control Measures – infrastructure corridor

In addition to the site management strategies listed above in 3.1, the following site specific erosion control measures will be implemented on the infrastructure corridor works:

- The backfilled trench will be thoroughly compacted to avoid settlement/subsidence of the fill material and inadvertent channelisation of water. The top 150mm of fill may subsequently be scarified or roughened (if required) to assist topsoil adhesion and vegetation establishment.
- Topsoil and forest litter material will be respread over the trench area. Logs and windrowed timber will be "randomly" scattered over the topsoiled areas. However, care will be taken to ensure that any large logs etc are always placed parallel to the contour to avoid concentration of overland flows.
- As the track follows a ridge along its entire length, the running surface of the access track will be constructed with a crown so that runoff water sheds to both sides of the track; refer **Figure 4.**
- Mitre drains will be constructed periodically to direct runoff away from the track; refer **Figure 5.**

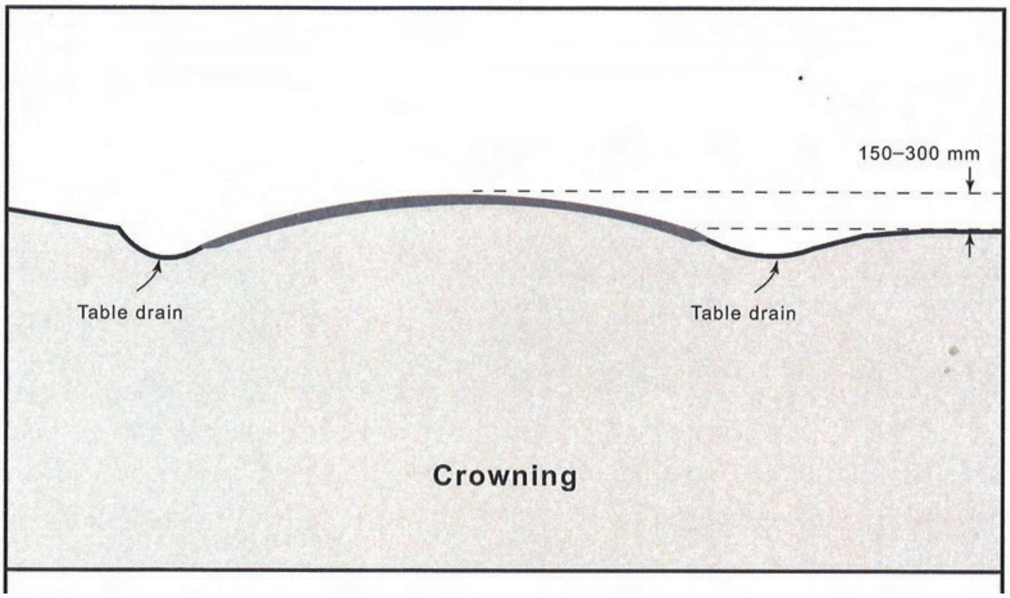


Figure 4: Typical crowning of the track surface on ridge top tracks (Source: Managing Urban Stormwater; Soils and Construction – Volume 2C Unsealed Roads).

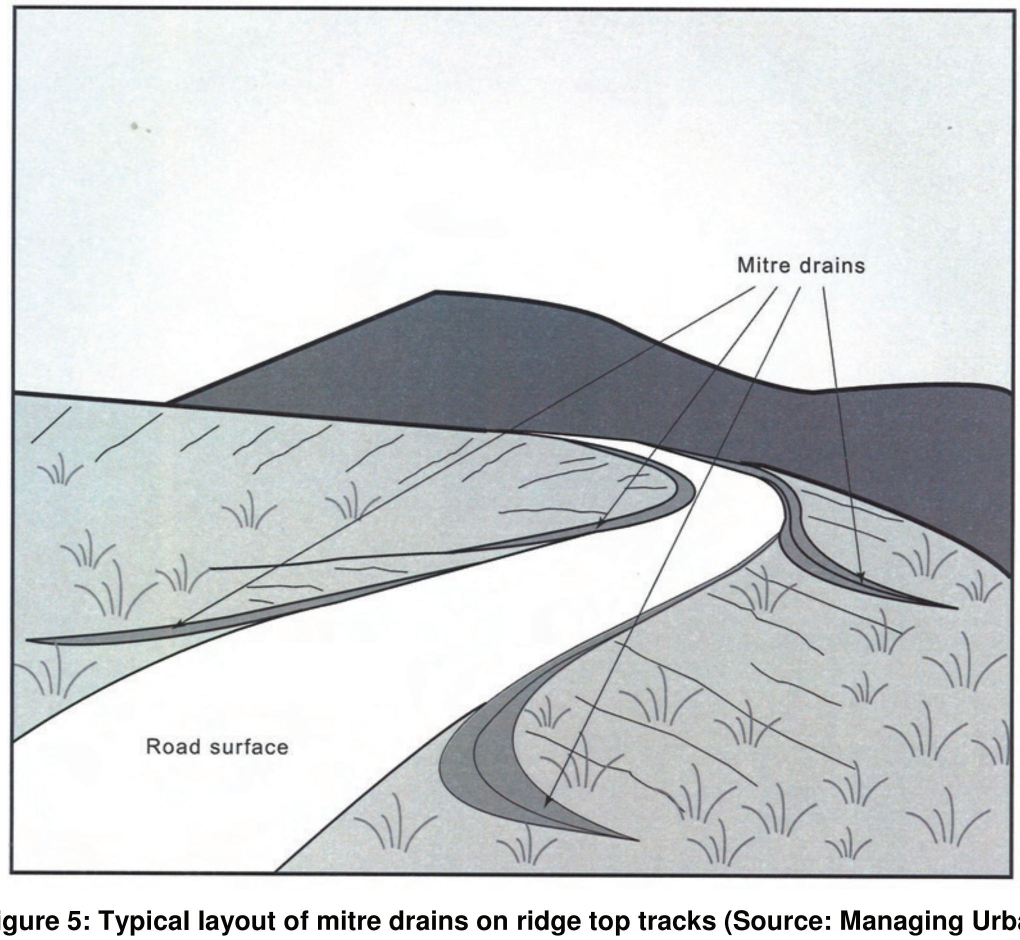


Figure 5: Typical layout of mitre drains on ridge top tracks (Source: Managing Urban Stormwater; Soils and Construction – Volume 2C Unsealed Roads).

Mitre drains will be located to utilise local surface topography. However, with an average slope gradient of only 2.5%, there will be a nominal spacing of 50m between structures.

- Mitre drains will be constructed with a trapezoidal or parabolic profile, and the channel gradient will not exceed 1:10.
- A steeper section of track exists between ch. 2055 and 2277 where the slope increases to 5.8%. Cross banks (aka. Roll over banks or Whoa-boys) will be constructed through this section to divert runoff water across and away from the track surface to a stable discharge point; refer **Figure 6**.
- Exact location of cross banks will be determined by surface topography, however, there will be a nominal spacing of 40m between structures through this area.
- Cross banks will be constructed in accordance with the specifications included in **Figure 7**.
- As all-weather access is required to this business critical facility, roadbase and/or gravel will be used (as required) to stabilise isolated areas of the track's running surface, where soft pockets of soil or boggy areas are observed.

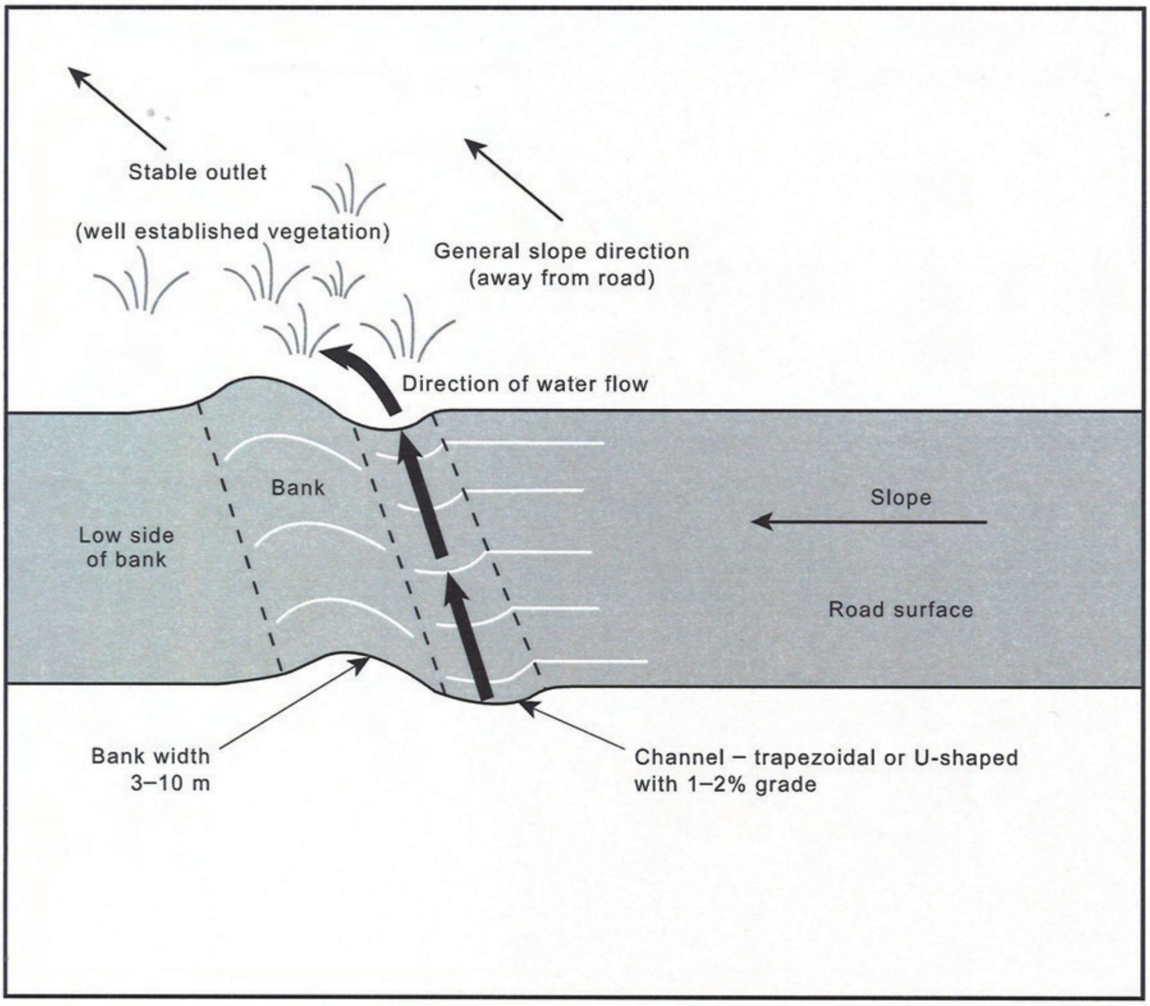


Figure 6: Typical cross bank layout and construction (Source: Managing Urban Stormwater; Soils and Construction – Volume 2C Unsealed Roads).

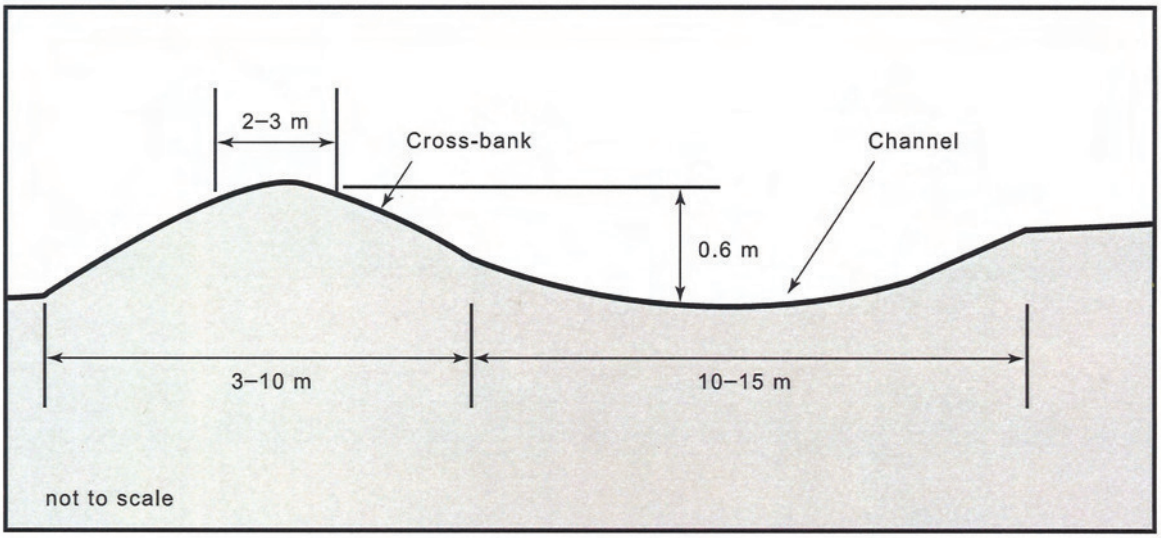


Figure 7: Cross bank dimensions (Source: Managing Urban Stormwater; Soils and Construction – Volume 2C Unsealed Roads).

3.3. Erosion Control Measures – compound area

In addition to the site management strategies listed above in 3.1, the following site specific erosion control measures will be implemented on the compound area.

- Topsoil and forest litter material will be removed from the compound area and windrowed to form an upslope perimeter (diversion) bank around the top side(s) of the site.
- This bank will act to minimise the volume of water *entering* the site by segregating clean upslope runon water, from sediment laden runoff water off the site.
- Clean water from the perimeter bank will be discharged in a location(s) such that it will not run back onto the site causing erosion.
- Following removal of the topsoil, the compound area will be covered with a protective layer (50mm) of gravel or ballast.
- Following completion of the four boreholes and construction of all ancillary buildings and structures, the compound area not required for ongoing operations will be rehabilitated. This rehabilitation will reduce the total project footprint from approx. 1.7ha in the construction phase to approx. 0.35ha in its operational phase.
- Rehabilitation will include reshaping of the surface as required to produce a free draining landform that mimics, as far as possible, the natural landform.
- The upper 150mm of the rehabilitation area may be scarified or roughened prior to re-topsoiling to assist topsoil adhesion and vegetation establishment.
- Topsoil and forest litter material will be respread over the rehabilitation area. Logs and previously windrowed timber will be “randomly” scattered back over the topsoiled areas. However, care will be taken to ensure that any large logs etc are always placed parallel to the contour to avoid concentration of overland flows.

3.4. Sediment Control Measures – infrastructure corridor

Effective erosion control will minimise the requirement for sediment control. Hence erosion control, including progressive rehabilitation, will be a priority. In addition to the site management strategies listed above in 3.1, the following site specific sediment control measures will be implemented on the infrastructure corridor works:

- In areas where the ground slope below the outlet of the mitre drain is less than 5% gradient, the coarse textured soils will generally fall out of suspension within the confines of the mitre drain, and periodically removed as required.
- In areas where the slope gradient below the outlet of the mitre drains is greater than 5%, sediments have the potential to be moved off site. In these instances, sand and/or aggregate filled sandbags may be used to construct a temporary sediment trap across the outlet of the mitre drain; refer **Figure 8**.
- As an alternative, a small excavated sediment sump (approx. 1m^3 capacity) may be excavated at the end of the above mitre drains to effectively convert them into a spoon drain.
- Timber and other vegetation cleared from the alignment may also be selectively placed and tightly stacked across the outlet of the mitre drains to act as a temporary sediment barrier.
- All these areas will be monitored on a daily basis as part of the site management protocol.

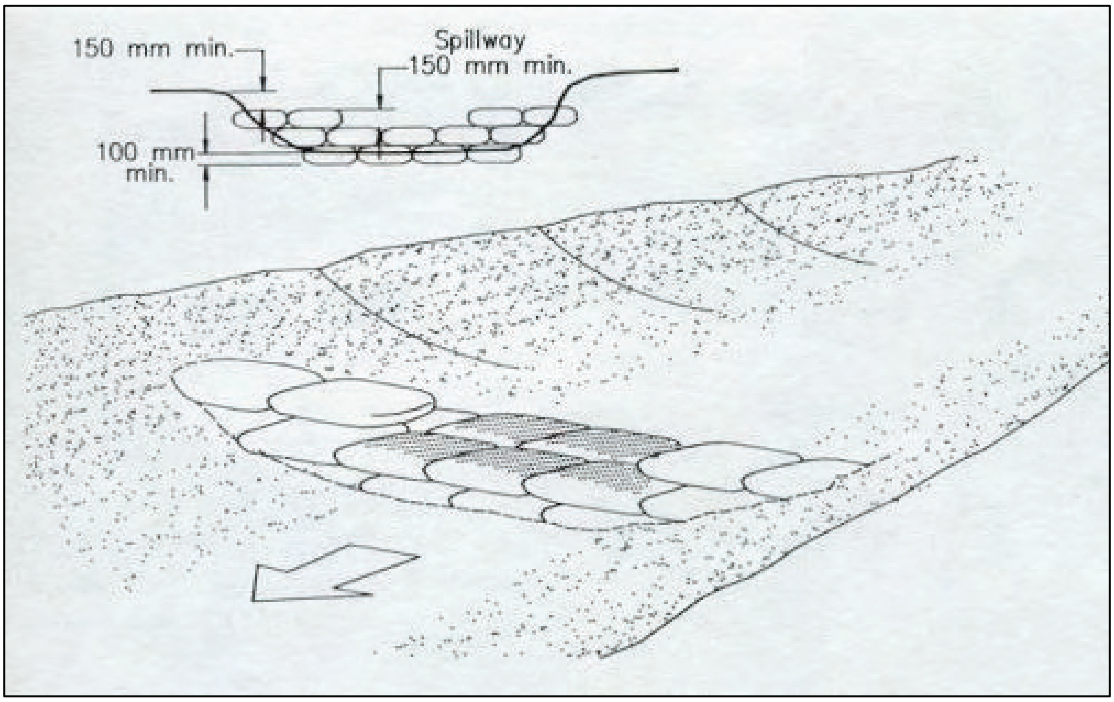


Figure 8: Diagrammatic representation of a sandbag sediment trap across the end of a mitre drain

3.5. Sediment Control Measures – compound area

Effective erosion control will minimise the requirement for sediment control. Hence again erosion control, including progressive rehabilitation, will be a priority. In addition to the site management strategies listed above in 3.1, the following site specific sediment control measures will be implemented on the compound area.

- In addition to the use of selectively placed and tightly stacked timber and vegetation as a downslope sediment barrier, the principal sediment control structure at the compound area will be the sediment basin.
- This basin will be situated to take full advantage of site topography. It will be constructed using very large concrete blocks (1200mm x 600mm x 600mm) and will be supported by an earthen embankment approximately 2.4m high.
- A Bidim A34 grade needle punched geotextile will be used as additional filter medium in front of the concrete blocks.
- Final basin capacity will be confirmed following a detailed survey. This work is scheduled for completion immediately following the initial site clearing activities. Indications at this stage suggest that the structure will have an operating capacity of between 900m^3 -1,000m^3.
- Basin sizing calculations for the site have been undertaken in accordance with the procedure detailed in the "Blue Book" for Type C basins and included as **Appendix A**. Type C basins are recommended for use with coarse grained (e.g. sandy) soils where the particles are likely to settle rapidly.
- For this project basin calculations were undertaken based on the soils of the Wollangambe (wb) soil landscape unit. These soils consist of sands, loamy sands, and clayey sands overlaying shallow to deep sandstone subsoils.
- The basin calculations in Appendix A indicate that the minimum basin size required for the compound area on this project is 88m^3. As noted above, the proposed basin/sump at the Bore 8 compound site will have an operating capacity of between 900m^3 -1,000m^3.
- Operation of the sediment basin will be monitored on a daily basis as part of the site management protocol.

4. Inspection, Maintenance, Audit & Review

4.1. Daily Reviews

The Project Manager will undertake daily reviews of the work site and will schedule any routine maintenance and/or augmentation of management practices or control measures.

4.2. Weekly Inspections and Site Meetings

Springvale's Environment Co-ordinator will undertake formal weekly inspections of the project and will also attend weekly project meetings where specific environmental issues are to be raised and/or discussed. If required, actions will then be assigned to the most appropriate responsible person.

The Environment Co-ordinator will also schedule additional site inspections following periods of heavy and/or prolonged rainfall (i.e. >25mm in 24 hours), or as requested by the Project Manager.

4.3. Specialist Advice and Audit

The Soil Conservation Service (SCS) has been engaged to provide specialist erosion and sediment control advice should the need arise at any time during the project.

The SCS has also been retained to undertake formal audits against the requirements of this plan, the project's Statement of Commitments, and the Environmental Assessment documentation should the need arise.

4.4. Monthly Review of this Plan

The Environment Co-ordinator and/or the SCS will review the adequacy of this plan on a monthly basis. If required, the proposed management strategies and control measure will be modified to address evolving site conditions, latent conditions and/or changes to the proposed construction sequence.

Any changes to the Plan will then be communicated to the relevant site personnel via daily "toolbox talk" training and weekly project meetings.

APPENDIX A

<u>TYPE C</u> SEDIMENT BASIN DESIGN SHEET

<u>Structure</u>: **<u>Bore 8 Compound Sediment Basin</u>**

Design data:

•	total catchment area - hectares	(A_t)	= 1.7
•	disturbed catchment area – hectares	(A_d)	= 1.7
•	slope gradient on steepest disturbed area - %		= 3
•	slope length on steepest disturbed area – m		= 150
•	rainfall erosivity factor	(R)	= 1705
•	soil erodibility factor	(K)	= 0.026
•	disturbed catchment area slope length factor	(LS)	= 1.09
•	soil cover factor	(C)	= 1.0
•	soil conservation factor	(P)	= 1.3
•	sediment bulk density - t/m³	(b.d.)	= 1.3

PART A - Design Peak Discharge of Catchment

Step 1 *Critical duration of design rainfall:* $t_c = 0.76\ (A/100)^{0.38}$

$= 0.76\ (1.7/100)^{0.38}$

$= 0.16$ hours (10 minutes)

Step 2 *Design rainfall intensity for an ARI of 1 year and duration of 10 minutes is:*

$I_{1,\ 0.16} = 46.5$ mm/hr

Step 3 *Design runoff co-efficient:* $C_{10} = 0.89$

Step 4 *Newnes Plateau is in Zone B with elevation above 500m*

$FF_1 = 0.57$

$C_1 = C_{10} \times FF_1$

$= 0.89 \times 0.57$

$= 0.51$

Step 5 *Design flood magnitude:* $Q_{1yr,\ tc} = 0.00278 \times C_1 \times I_{1,\ 0.16} \times A_t$

$= 0.00278 \times 0.51 \times 46.5 \times 1.78$

$= 0.12$ m³/sec

PART B – Volumetric Design of Basin

Step 1 *Sediment settling zone design inflow rate*

$Q_{(d)} = 0.25 \times Q_{1yr, tc}$

$= 0.25 \times 0.12$

$= 0.03\ m^3/sec$

Step 2 *Basin surface area*

$A_s = 4100 \times Q_d$

$= 4100 \times 0.03$

$= 123\ m^2$

Step 3 *Length and width*

$W = \sqrt{(A_s / 3)}$

$= \sqrt{(123 / 3)}$

$= 6.4\ m$

$L = W \times 3$

$= 6.4 \times 3$

$= 19.2\ m$

Step 4 *Depth of sediment settling zone* = Type C basins adopt 0.6 m

Step 5 *Sediment settling zone volume*

$V_{set} = W \times L \times d$

$= 6.4 \times 19.2 \times 0.6$

$= 73.7\ m^3$

Step 6 *Two month sediment storage zone volume*

$$V_{store} = \frac{0.17 \times A_d\ (R \times K \times LS \times C \times P)}{b.d}$$

$$= \frac{0.17 \times 1.78\ (1705 \times 0.026 \times 1.09 \times 1.0 \times 1.3)}{1.3}$$

$= 14.6\ m^3$

Step 7 *Depth of two month sediment storage zone*

$$d_{store} = \frac{V_{store}}{A_s}$$

$$= \frac{14.6}{123}$$

= 0.12 m

Step 8 *Type C Sediment Basin Volume* = volume of settling + volume of storage
= $73.7 \text{ m}^3 + 14.6 \text{ m}^3$
= 88.3 m^3

Type C Basin Summary – Bore 8 Compound Sediment Basin

Basin width (min)	= 6.4 m	
Basin length (min)	= 19.2 m	
Total depth (min)	= 0.72 m	(0.6 m settling zone + 0.12 m storage zone)
Total volume (min)	= 88 m^3	(approx. 49.4 m^3/ha)

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