5 BIOPHYSICAL STRATEGIC AGRICULTURAL LAND ASSESSMENT

The Interim Protocol (NSW Government 2013) was used to assess BSAL status of all sampling sites. A flow chart with the steps used to assess BSAL is provided in Figure 11. The limiting factors in the BSAL determination process for survey sites are highlighted via a colour-coded matrix in Appendix 8.

The following description outlines how particular factors in the BSAL flow chart were interpreted for this study:

- "Physical barrier" (Step 8) - defined as 'hard rock' or a layer with >90% coarse fragments.
- "Soil drainage better than poor" (Step 9) - poor drainage for the purpose of this report is determined by visual assessment of waterlogging indicators, i.e. the presence of mottling and/or black manganiferous nodules or concretions (>20% if present on its own) within the depth interval 0-750 mm.
- "Chemical barrier" (Step 12) - defined as ESP>6.

Figure 12 shows the two types of Protocol Verified BSAL sites that were observed, i.e. scattered individual sites that met Steps 1 to 12 of the BSAL criteria (Figure 11) but failed to exceed the >20 ha threshold, as well as clusters of BSAL sites that were verified as BSAL (Protocol Verified BSAL[1]) because they represented areas of land >20 ha.

BSAL dominant status is determined on the dominant soil type (or a combination of the main soil types) within a soil landscape unit. Three soil landscape units, 'VO-LS', 'VO-MUS/V' and 'VO-MUS/CDF' in the southern part of Doona Ridge (Figure 12; Table 6) are considered to be BSAL dominant as >70% of the soil landscape units are comprised of a dominant soil type/s which met the BSAL criteria (Figure 11). The total area of these BSAL dominant soil landscape units is approximately 2,040 ha.

Beyond the BSAL dominant soil landscape units, four other clusters of BSAL sites (i.e. >20 ha) were identified (Figure 12). The total area of the four BSAL clusters is approximately 175 ha. Accordingly, 2,215 ha of Protocol Verified BSAL is considered to be located within the Project Assessment Area. Of this, approximately 2,103 ha Protocol Verified of BSAL is predicted to experience subsidence impacts as a results of the Project (MSEC, 2014).

It is also noted that approximately 459 ha of potential BSAL, as mapped by the NSW Government, is located on properties where no access was available for ground survey as part of this assessment. Most of this potential BSAL is within the Alluvial soil landscape unit (Figure 8) which has been found to have subsoil limitations that generally exceed the relevant BSAL criteria.

Figure 13 illustrates the areas of Protocol Verified BSAL within the Project Assessment Area.

Some other individual sites met Steps 1 to 12 of the BSAL criteria (Figures 11 and 12), however the contiguous area at each site was less than 20 ha and are therefore not considered to be BSAL in accordance with the Interim Protocol.

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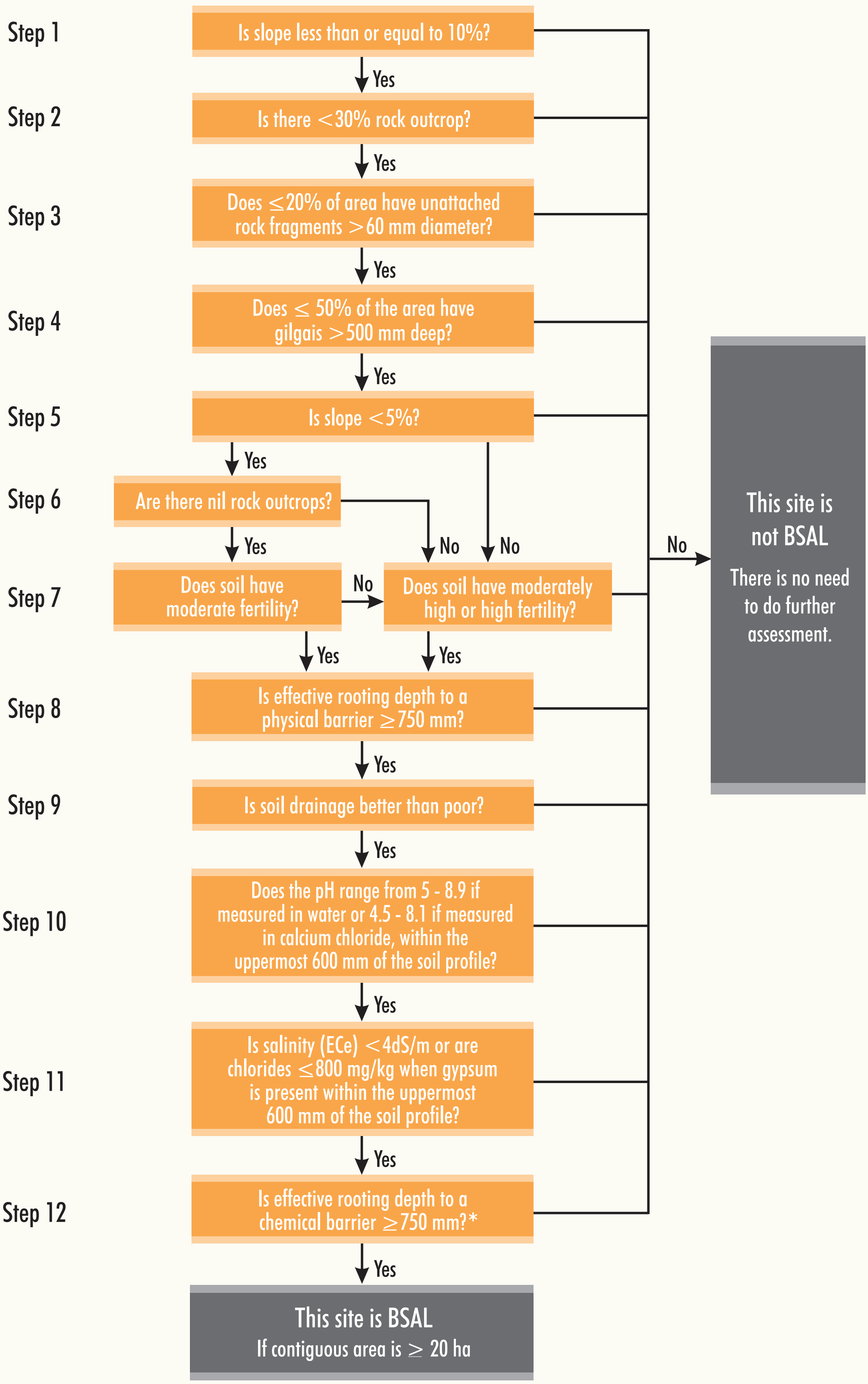
[1] BSAL that has been identified through ground survey in accordance with the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (NSW Government, 2013) and, where no access was available for ground survey, has been interpreted as BSAL based off continuity with adjacent BSAL dominant soil landscape units.



* In accordance with Section 6.10 of the Interim Protocol

Source: After NSW Government (2013)

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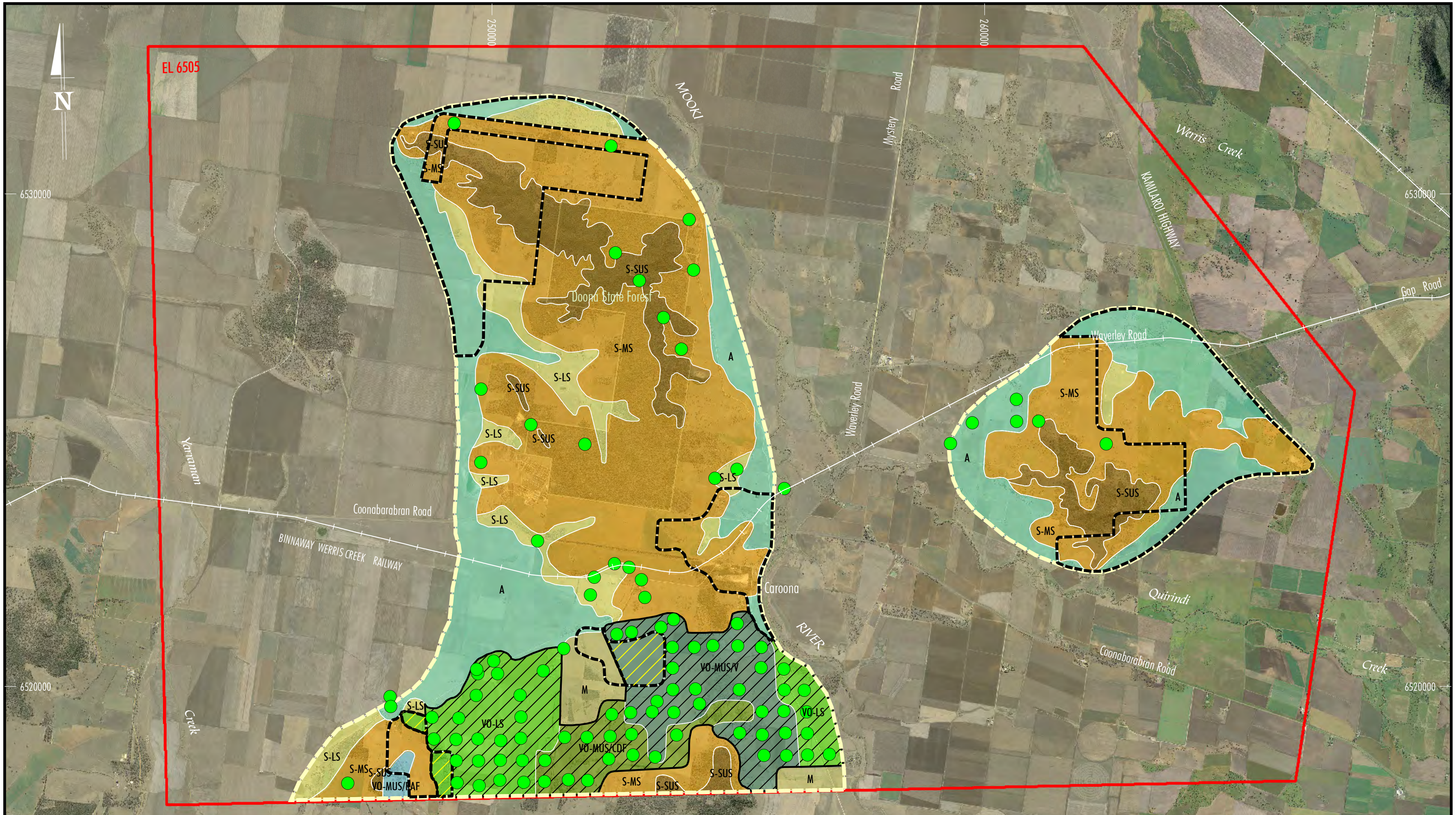
FIGURE 11
Flow Chart for Site Vertication of BSAL



LEGEND

- Exploration Licence (EL 6505)
- Project Assessment Area
- Soil Landscape Units Interpreted Using Desktop Methods

0 1 2 3 4
Kilometres
GDA 94 MGA Zone 56

Soil Landscape Unit BSAL Status

- Verified as BSAL Dominant
- Interpreted as BSAL Dominant Using Desktop Methods
- Not BSAL Dominant
- Soil Test Pit Meets BSAL Steps 1 to 12 (Refer Figure 11)

Alluvial (A)

Volcanic Parent Material

- Transferral Zone/Lower Slope (VO-LS)
- Mid/Upper Slope (Vertosols) (VO-MUS/V)
- Mid/Upper Slope (Chromosols, Dermosols, Ferrosols) (VO-MUS/CDF)
- Ridge Acidic Ferrosol (VO-MUS/RAF)

Sedimentary Parent Material

- Steep Upper Slope (S-SUS)
- Mid Slope (S-MS)
- Lower Slope (S-LS)

Sedimentary/ Volcanic Parent Material

- Mixed Origin Transferral Zone (M)

Source: Land and Property Management Authority - Topograpraphic Base 2010, Orthophoto (Curlewis 2011 & Tamworth 2010) and Office of Environment and Heritage (OEH), 2013

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FIGURE 12

Project Soil Landscape Units - with Location of BSAL Sites

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HVE-13-02_Gateway_ARA_215F

0 1 2 3 4
Kilometres
GDA 94 MGA Zone 56

Source: Land and Property Management Authority - Topograpraphic Base 2010, Orthophoto (Curlewis 2011 & Tamworth 2010) and Office of Environment and Heritage, 2013

LEGEND
- Exploration Licence (EL 6505)
- Project Assessment Area
- Protocol Verified BSAL
- Interpreted as Protocol Verified BSAL using Desktop Methods
- Areas Verified not BSAL
- New England North West SRLUP Potential BSAL

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FIGURE 13
Location of BSAL

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HVE-13-02_Gateway_ARA_216D

Table 6. BSAL Status of Soil Landscape Units in the Project Assessment Area

Soil Landscape Unit (refer to Figure 8)	Map code	Dominant soil types	Sub-dominant soil types	BSAL status
Alluvial	**A**	Black Vertosol, other Vertosols	Chromosol	Scattered (<70%) (7/90 = 8%)
Volcanic: PM: Transferral Zone/Lower Slope	**VO-LS**	Black Vertosol	Vertosol, Chromosol	Dominant (>70%) (30/37 = 81%)
Volcanic PM: Mid/Upper Slope (Vertosols)	**VO-MUS/V**	Black Vertosol, other Vertosols	Dermosol	Dominant (>70%) (28/39 = 72%)
Volcanic PM: Mid/Upper Slope (Chromosols, Dermosols, Ferrosols)	**VO-MUS/CDF**	Chromosol	Dermosol, Ferrosol	Dominant (>70%) (12/17 = 71%)
Volcanic PM: Ridge (Acidic Ferrosol)	**VO-MUS/RAF**	Ferrosol	-	No BSAL (0/1 = 0%)
Sedimentary PM: Steep Upper Slope	**S-SUS**	Dermosol	Chromosol, Tenosol, Vertosol, Kandosol, Kurosol	Present, but no >20 ha patches (1/16 = 6%)
Sedimentary PM: Mid Slope	**S-MS**	Chromosol, Dermosol	Rudosol, Tenosol, Kandosol, Sodosol, Vertosol, Kurosol	Scattered (<70%) (17/165 = 10%)
Sedimentary PM: Lower Slope	**S-LS**	Chromosol	Vertosol, Dermosol, Rudosol, Black Vertosol, Sodosol, Kandosol, Kurosol	Scattered (<70%) (6/29 = 21%)
Mixed Origin Transferral Zone	**M**	Rudosol, Chromosol, Dermosol	Vertosol, Ferrosol, Calcarosol	Present, but no >20 ha patches (1/10 = 10%)

The Protocol Verified BSAL identified in this study generally does not coincide with the NSW Government's regional BSAL mapping (Figure 6). The main departure is in relation to Vertosols on the Alluvial plains surrounding Doona Ridge and Nicholas Ridge. These areas were mapped by the NSW Government as BSAL, but this assessment has shown that these Alluvial areas are in fact non-BSAL because of strongly saline and alkaline subsoil.

As shown on Figure 13, Protocol Verified BSAL has been mapped along parts of the southern and south-eastern extents of Doona Ridge. It is reasonable to assume that these areas are contiguous with BSAL beyond the Project Assessment Area, generally in accordance with the NSW Government's potential BSAL mapping (Figure 13).

It is also noted that according to the NSW Government's potential BSAL mapping, areas to the west and east of Doona Ridge are potential BSAL. Given this assessment has verified that parts of the western and eastern margins of the Doona Ridge part of the Project Assessment Area are non-BSAL, it is likely that the land adjacent to the verified non-BSAL areas are subject to the same limitations that were observed in this survey (and hence are likely to be non-BSAL).

It is noted that eight of the 404 soil pits examined (23, 72, 146, 156, 157, 252, 253, 360) were located slightly outside the Project Assessment Area for the Soil Landscape mapping described in Table 6, however have been incorporated into this assessment for completeness; two of them were Protocol Verified BSAL.

Remote aeromagnetic survey information has been obtained by BHP Billiton across EL 6505 as part of the Project exploration program. This information has the potential to assist with the mapping of key soil factors and soil landscape units. The remote sensing data has not been used in the verification of BSAL, but is likely to be considered as part of the EIS. Electromagnetic induction data are likely to be useful for the mapping of variations in subsoil salinity across the Alluvial areas.

6 LAND AND SOIL CAPABILITY CLASSES

Land and Soil Capability (LSC) mapping was prepared for the Project Assessment Area based on the results of the soil survey conducted by McKenzie Soil Management in accordance with *The Land and Soil Capability Assessment Scheme – Second Approximation* (OEH 2012b) (LSC Assessment Scheme).

The LSC Assessment Scheme uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards (OEH 2012b). The LSC class gives an indication of the land management practices that can be applied to a parcel of land.

LSC Class >5 on the alluvial plains has severe hazards associated with salinity. Severe limitations on the ridge country include soil acidification hazard and waterlogging.

LSC Class 4 is 'moderate capability land' that has moderate to high limitations for high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialized management practices with a high level of knowledge, expertise, inputs, investment and technology (OEH 2012b).

Zones with LSC Classes 2 and 3 are considered to be capable of a wide variety of land uses including cropping, grazing, horticulture, forestry and nature conservation. Areas categorised as these classes generally coincide with the Protocol Verified BSAL shown in Figure 13.

Essential adaptations to the LSC Assessment Scheme methodology are described in Appendix 9. It is noted on page 28 of the LSC Assessment Scheme that when an initial LSC determination does not match known or indicative conditions of the landscape or soils, expert knowledge is used to record a modified LSC class that overrides the original assessment. The reasons for the change are documented in Appendix 9. This provides a mechanism to refine the logic/decision tables based on applied usage and feedback in a process of continual improvement.

Two versions of a LSC map have been prepared to illustrate the variability in LSC classification depending on farming practices. A LSC map was initially prepared assuming salt sensitive farming practices were employed, however it was evident that parts of the Project Assessment Area, particularly to the southwest of Doona Ridge, were classified with relatively poor LSC classes under this approach (e.g. Class 4 or greater), although farmers in this area regularly produce good crop yields (i.e. the LSC classes do not reflect the known conditions of the landscape). Accordingly, a second version of the LSC map has been prepared which is considered to better represent salt tolerant farming practices. Assessment matrices for the two versions of LSC classification are presented in Appendix 10.

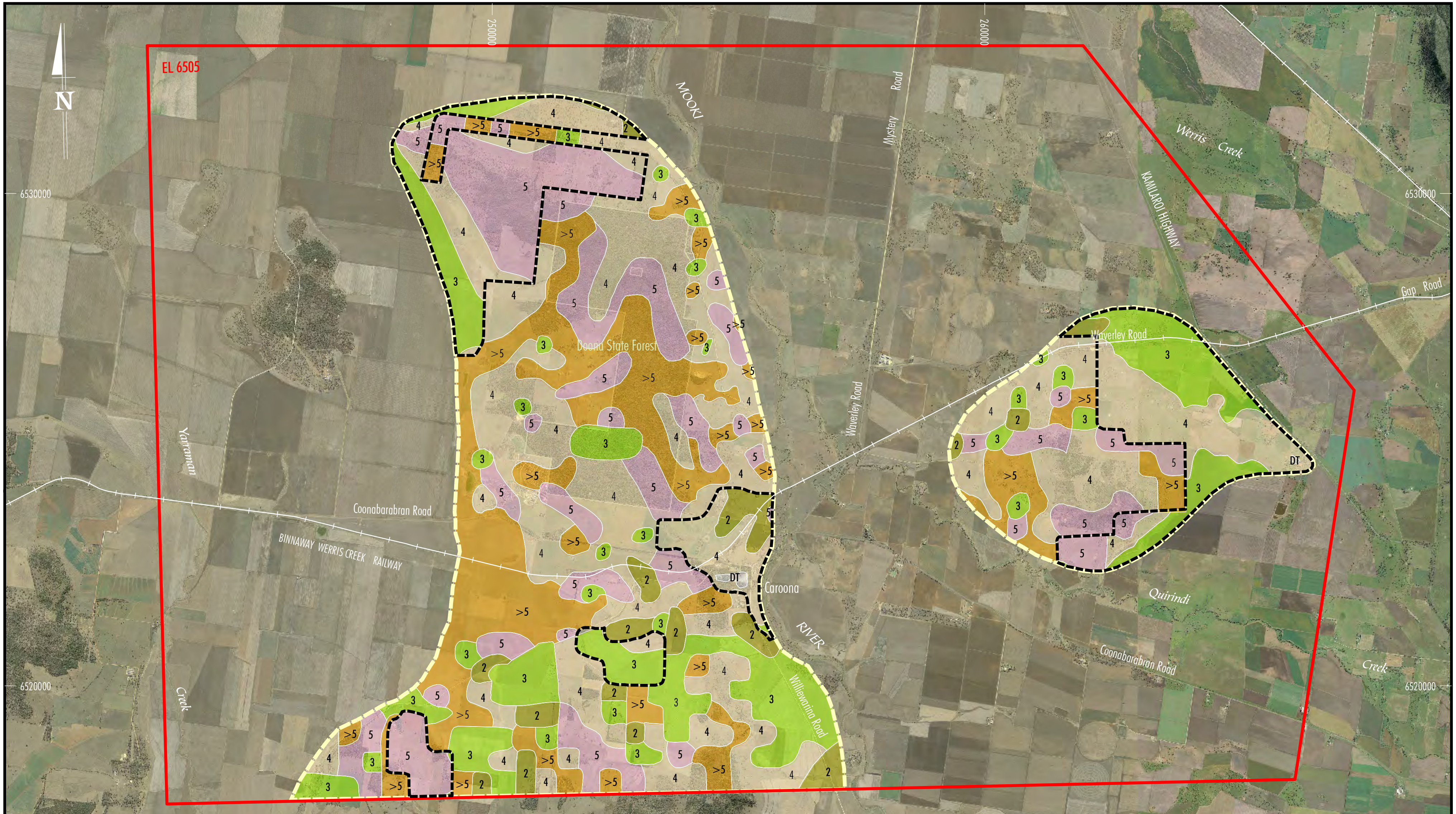
The two versions of the LSC maps are:

a) Figure 14a - Project Land and Soil Capability Salt Sensitive Scenario; use of soil salinity thresholds relevant to salt-sensitive plants (Appendix 9) and salinity measurements taken at a depth of 60-100 cm in the soil profile; and

b) Figure 14b - Project Land and Soil Capability Salt Tolerant Scenario; use of soil salinity thresholds relevant to salt-tolerant plants (Appendix 9) and salinity measurements taken at a depth of 30-60 cm in the soil profile. This simulates production of salt-tolerant crops (e.g. cotton) with spray irrigation to keep root activity closer to the soil surface. This appears to be how local irrigation farmers manage to achieve surprisingly good crop yields on the salinised flood plains in the Caroona – Lake Goran area. Dryland farmers in that area can achieve unexpectedly good yields in years when regular showers of rain keep the upper half-metre of soil topped up with low-EC water that is not given the chance to mix with high-EC shallow watertables. Hot dry finishes for dryland crops in this situation, however, can create disappointment because plant roots are forced into toxic saline zones in their search for moisture and severe plant stress tends to follow rapidly.

Regional LSC mapping prepared by the NSW Government is shown on areas not subject to ground survey.

It is noted that several Protocol Verified BSAL sites had unexpectedly poor LSC scores. Site 142 had ECe (30-60 cm) = 1.9 dS/m and ECe (60-100cm) = 13.1 dS/m. Sites 276, 284, 285, 299, 320, 337 and 342 had very poor surface soil structure (SOILpak score <0.6), caused mainly by cattle pugging or machinery compaction. The following Protocol Verified BSAL sites had poor LSC scores because of acidification hazard: 4, 31, 66, 118, 187, 301, 302, 323, 343 and 378.



0 1 2 3 4
Kilometres
GDA 94 MGA Zone 56

Source: Land and Property Management Authority - Topograpraphic Base 2010, Orthophoto (Curlewis 2011 & Tamworth 2010) and Office of Environment and Heritage (OEH), 2013

LEGEND

- Exploration Licence (EL 6505)
- Project Assessment Area
- NSW Government Regional LSC Mapping
- DT Disturbed Terrian

LSC Class

- 2 Class 2
- 3 Class 3
- 4 Class 4
- 5 Class 5
- >5 Class >5

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FIGURE 14a

Project Land and Soil Capability
Salt Sensitive Scenario

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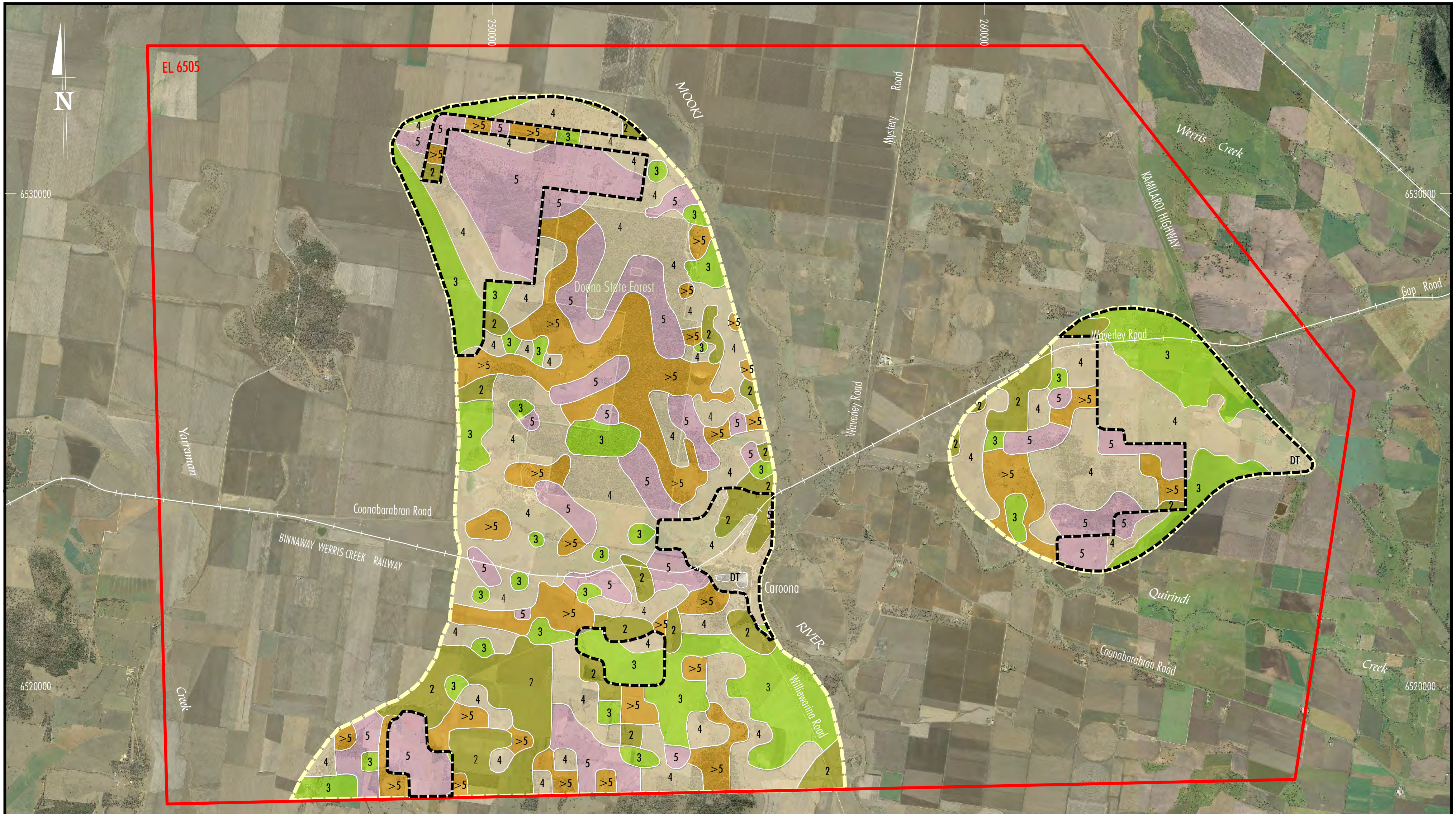

0 1 2 3 4
Kilometres
GDA 94 MGA Zone 56

Source: Land and Property Management Authority - Topograpraphic Base 2010, Orthophoto (Curlewis 2011 & Tamworth 2010) and Office of Environment and Heritage (OEH), 2013

SOILmgt

LEGEND
- Exploration Licence (EL 6505)
- Project Assessment Area
- NSW Government Regional LSC Mapping
- DT Disturbed Terrian

LSC Class
- 2 Class 2
- 3 Class 3
- 4 Class 4
- 5 Class 5
- >5 Class >5

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FIGURE 14b
Project Land and Soil Capability
Salt Tolerant Scenario

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HVE-13-02_Gateway_ARA_217C

7 POTENTIAL IMPACTS ON SOIL RESOURCES

Possible impacts to agricultural productivity as a result of the Project would be associated with temporary loss of land due to construction of mine infrastructure (e.g. surface facilities) and potential subsidence impacts. Potential impacts on agricultural activities associated with subsidence could include:

- Low points with possible waterlogging and/or salt concentration problems, and adjacent increases in slope and erosion risk, along the outside boundaries of subsided longwall panels.
- Injury to livestock caused by ground cracking.
- Loss of integrity of stock fences and water pipelines.
- Possible injury to persons undertaking agricultural activities.

Potential impacts to agricultural enterprises associated with the Project are discussed in detail in the Preliminary Agricultural Impact Statement (Short and Thomson 2014).

7.1 Post-mining Land and Soil Capability Assessment

Surface infrastructure within the Conceptual Surface Infrastructure Area (Figure 5) would temporarily remove land from agricultural land uses for the duration of the Project (approximately 30 years). Following completion of mining activities, infrastructure would be removed and the land rehabilitated to a condition consistent with the pre-mining land use.

A 251 ha rejects emplacement would be located in the north of EL 6505 (Figure 5) on land with predominately LSC Class equal to or greater than 5 (according to the salt tolerant LSC mapping, Figure 14b) and non-BSAL. Topsoil would be stripped from the coal rejects emplacement footprint and stockpiled in accordance with the measures described in Section 7.2. It is anticipated that the emplacement could be remediated to LSC Class 4 land through sealing with a suitable material, placement of stripped subsoil and topsoil onto the final landform and seeding with an appropriate grass and woodland vegetation mix. It is anticipated that the remediated coal rejects emplacement could sustain livestock grazing at least as well as the existing land use.

Infrastructure such as the CPP, offices and workshops is anticipated to be predominately located on LSC Class 4, 5 and >5 land (according to the salt tolerant LSC mapping, Figure 14b), however some infrastructure may be located on LSC Class 2 or 3 land. Topsoil – also the subsoil where appropriate – would be stripped and managed in accordance with the measures described in Section 7.2 so that it could be replaced across the land following removal of surface infrastructure and remediation of soil compaction where necessary (e.g. through shallow ripping and re-grading). It is anticipated that the existing LSC classes within the proposed infrastructure areas could be re-established following remediation.

Table 7 presents the estimated pre-mining and post-mining LSC class areas (for both salt sensitive and salt tolerant scenarios) within the Project Assessment Area.

Table 7. Estimated Pre-mining and Post-mining LSC Class

Land and Soil Capability Class	Area pre-mining[1] (ha)	Area post-mining[1] (ha)	Change
Salt-sensitive cropping (refer Figure 14a)			
1	0	0	0%
2	535	535	0%
3	2,174	2,171	-0.2%
4	4,287	4,518	5.4%
5	2,385	2,283	-4.3%
>5	2,464	2,339	-5.1%
TOTAL	11,845	11,845	0%
Salt-tolerant cropping (refer Figure 14b)			
1	0	0	0%
2	1,239	1,239	0%
3	2,098	2,088	-0.5%
4	4,379	4,619	5.5%
5	2,244	2,140	-4.6%
>5	1,885	1,759	-6.7%
TOTAL	11,845	11,845	0%

[1] Includes regional LSC mapping prepared by the NSW Government for areas not subject to ground survey (Figures 14a and 14b).

7.2 Soil Resource Management Measures

General soil resource management practices, where surface development is proposed within the Project area, should involve the stripping and stockpiling of soil resources prior to any mine-related disturbance, other than clearing vegetation. The general strategy should be for those disturbance areas to be rehabilitated progressively.

The objectives of soil resource management for the Project are to:

- Identify and quantify potential soil resources for rehabilitation.
- Optimise the recovery of useable topsoil and subsoil during stripping operations.
- Manage topsoil and subsoil reserves so as not to degrade the resource when stockpiled.
- Establish effective soil amelioration procedures to maximise the availability of soil reserves for future rehabilitation works.
- Take into account the need to provide soil conditions that minimise the risk of soil loss via wind and water erosion during and after rehabilitation.

Stripping

A detailed 0-50 cm depth mapping survey is recommended prior to the commencement of construction activities to accurately inform the stripping depths and soil amelioration requirements across the surface disturbance areas. The following management measures should be implemented during the stripping of soils at the Project:

- Areas of disturbance requiring soil stripping are to be clearly defined following vegetation clearing.

- CPP reject emplacement areas are to be stripped progressively, as required, to reduce potential erosion and sediment generation, and to minimise the extent of topsoil stockpiles and the period of soil storage.
- Topsoil and subsoil stripping during periods of high soil moisture content (i.e. following heavy rain) is to be avoided to reduce the likelihood of damage to soil structure.

The degree of success of a stripping and stockpiling program is strongly influenced by soil water content. Attempts to strip soil under moist conditions with inappropriate machinery settings can aggravate structural degradation problems. Excessive compaction and/or remoulding of the soil by heavy machinery under wet conditions also can be a major problem.

Stockpile Management

The following management measures should be considered for implementation during the stockpiling/storage of soils at the Project:

- Topsoil and subsoil stockpiles should be retained at a height of no more than 2 m, with slopes no greater than 1:2 (vertical to horizontal [V:H]) and a slightly roughened surface to minimise erosion.
- Construct the stockpiles in a way that minimises erosion, encourages drainage, and promotes revegetation.
- Where amendments such as lime, gypsum and fertiliser are needed to improve the condition of cut soil, they should either be applied to the stockpiles in-between the application of separate layers from the scrapers, or be spread on the soil prior to scraping.
- Wherever practicable, soil should not be trafficked, deep ripped or removed in wet conditions to avoid breakdown in soil structure.
- All topsoil and subsoil stockpiles should be seeded with a non-persistent cover crop to reduce erosion potential as soon as practicable after completion of stockpiling. Where seasonal conditions preclude adequate development of a cover crop, stockpiles should be treated with a straw/vegetative mulch to improve stability.
- Grow deep-rooting vegetation to encourage organic matter accumulation and maintain microbial activity. Stockpile height can be excessive because of limited space at mine sites, but try to keep it as low as possible. This maximises the chances of plenty of plant roots reaching the base of the stockpile as it awaits redistribution. This also provides mitigation for wind erosion.
- There should be no vehicle access on soil stockpiles, except when soil quality monitoring is required.
- Soil stockpiles should be located in positions to avoid surface water flows. Silt stop fencing would be placed immediately down-slope of stockpiles until stable vegetation cover is established.
- In the event that unacceptable weed generation is observed on soil stockpiles, a weed eradication program should be implemented.
- An inventory of topsoil and subsoil resources (available and stripped) on the Project site should be maintained and regularly reconciled with rehabilitation requirements.
- In preference to stockpiling, wherever practicable, stripped topsoil and subsoil should be directly replaced on completed sections of the final landform of the CPP reject emplacement area.

Application of Soil on Rehabilitated Landforms

The following management measures should be implemented during the application of soils on rehabilitated CPP reject emplacement landforms at the Project:

- Topsoil and subsoil placement shall only proceed once the final landform and major drainage works (i.e. graded banks, drainage channels and rock waterways if required) have been completed.
- Topsoil and subsoil placement is to be undertaken from the top of slopes or top of sub drainage catchment to minimise erosion damage created by storm run-off from bare upslope areas.
- Topsoil and subsoil placement is to be conducted along the general run of the contour to minimise the incidence of erosion.
- Topsoil and subsoil is not to be placed in the invert of drainage lines or drainage works.
- Spread topsoil/subsoil profile thickness and quality is to be evaluated prior to sowing.

Remediation of Soil Compaction Beneath Infrastructure Areas

Following removal of infrastructure during mine closure, soil profile inspections are recommended to quantify the depth and severity of soil compaction damage. Deep ripping will then be carried out under dry conditions to de-compact the identified hard layers and provide a favourable root zone.

Rehabilitation Management Plan

It is recommended that a Rehabilitation Management Plan for the Project be prepared to detail the soil resource management measures outlined in the sections above. The Rehabilitation Management Plan should be progressively updated to cater for the site-specific management requirements of soils as the Project progresses.

7.3 Remediation Strategies for Subsidence Impacts

Remediation of surface cracks and/or low point development/slope steepening would be undertaken using conventional earthmoving equipment (such as backhoe or grader). Minor cracks (i.e. less than 50 mm) that develop are not expected to require remediation as geomorphological processes would result in these cracks filling naturally (MSEC, 2014).

Where subsidence occurs under cracking clays, the fissures within the root zone are likely to have similar characteristics to shrinkage cracks that are observed currently under dry conditions. Fissuring on the non-shrink-swell soils is likely to be beneficial within the root zone where compaction is a problem and mechanical loosening has been recommended. No major changes to soil chemical properties are anticipated as a result of subsidence.

It is noted that Frazier *et al.* (2010) found no significant effect of longwall mining subsidence on agricultural production, including cattle grazing, in the Hunter Valley region.

Monitoring of any new topographical depressions in the existing saline alluvial areas should be conducted to identify changes in soil salinity. The vertical and lateral hydraulic conductivity of sodic clay subsoil can be surprisingly large where highly saline groundwater is present (Hillel 1980). Should salinity levels increase, it may be necessary to modify farming practices to ensure ongoing agricultural productivity. It is noted that no Protocol Verified BSAL is located within these existing saline alluvial areas.

8 CONCLUSION

This assessment has identified that approximately 2,215 ha of Protocol Verified BSAL is located within the 11,850 ha Project Assessment Area. The remainder of the Project Assessment Area has a broad range of constraints which preclude the land from being classified as BSAL, including subsoil with salinity, alkalinity and sodicity problems, excessive slope (>10%) and rock close to the soil surface.

The Project would result in subsidence of approximately 2,103 ha of the Protocol Verified BSAL identified within the Project Assessment Area.

Possible impacts to agricultural productivity as a result of the Project would be associated with temporary loss of land due to construction of mine infrastructure (e.g. surface facilities) and potential subsidence impacts.

With the implementation of subsidence management measures for surface cracking, topographical depressions and localised slope changes, and the remediation of land disturbed by surface infrastructure, it is considered that there would be no significant change to the long term agricultural productivity of the Project area as a result of subsidence impacts on agricultural land.

Monitoring of any new topographical depressions in the existing saline alluvial areas should be conducted to identify changes in soil salinity. If salinity levels increase, it may be necessary to modify farming practices to ensure ongoing agricultural productivity. It is noted that no Protocol Verified BSAL is located within these existing saline alluvial areas.

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