Supplemental Data, Appendix A. Risk source component BN model tables

Table 1.
Natural risk source component model nodes, states and their values with input site specific data for Kleinkopje and Caval Ridge shown.

Nodes	**States and #values**	**Input data, Kleinkopje**	**Input data, Caval Ridge**	**Description and supporting references**
SOILS	% risk			Child node
Physical Properties	L risk H risk			Parent node.
PAW Note: PAW could replace the: Soil Water Content, Soil Texture and Topsoil Depth nodes. PAW has not been used in the soil compaction BN model.	L (< 20 - 40 mm, SA) M (40 – 60 mm, SA) H (60 to > 100 mm, SA) Regional values. L (< 100 mm/m, AU) M (100 – 200 mm/m, AU) H (> 200 mm/m, AU) Regional values.	PAW: 44.6 mm (Quinary 449, data). = M	PAW: +Hypothetical = L AWC: 5 - 15% in top 0 - 5 cm (Australian Collaborative Land Evaluation Program 2018).	Plant Available Water (PAW) of a soil profile or soil horizon is that store of soil water readily available to a plant for purposes of transpiration and consequently growth (Schulze 1997). This may also be an indicator for soil compaction, as soil compaction is closely dependent on soil moisture. PAW is calculated by taking into consideration soil depth, soil water content and texture. The depth and extent of compaction increases when soil is disturbed when wet (Voorhees and others 1986). The Australian Collaborative Land Evaluation Program (2018) describe Available Water Content (AWC) as computed for each of the specified depth increments, measured as a %.

				State values for South Africa adapted from Schulze (1997). State values for Australia adapted from Hazelton and Murphy (2007).
Soil Water Content	L (wilting point, –1500 kPa, SA, AU) M (field capacity, -5 to -55 kPa, SA, AU) H (saturated, SA, AU) Universal values.	Wilting point: topsoil: 0.156 m/m and subsoil 0.189 m/m (Quinary 449) Field capacity: topsoil: 0.233 m/m and subsoil 0.263 m/m (Quinary 449). Saturated: topsoil 0.435 and subsoil 0.413 m/m (Quinary 449) Hypothetical = M	[+]Hypothetical = L	The onset of stress is expressed as the critical soil water content at which the plant’s total evaporation is reduced to below its maximum evaporation (Schulze 1997). Ideally, soils should be stripped and replaced at a moisture content of between 10% and 15% to avoid the adverse effects of compaction and structural breakdown (Australian Government and others 2016). Stripping of soils should be done when moisture content is < 10% to minimize soil compaction risk (Anglo Coal Environmental Rehabilitation Improvement Group 2009). Wilting point is taken as the dry limit for water available to plants. At wilting point water cannot move over even short distances to the roots fast enough to satisfy the transpirational demand (Schulze and others 1985). Field capacity is the soil water condition reached when water has been allowed to drain naturally from the soil until drainage ceases and the water remaining is held by capillary forces that are great enough to resist gravity, i.e. the wet limit of the

				moisture available to plants (Schulze and others 1985). State values for South Africa and Australia provided by experts.
Soil Texture	L (light– sands and loamy sands, SA, AU) M (medium – loamy sands, clayey sands and sandy loams, SA, AU) H (heavy – loams, clay loams and clay soils, SA, AU) Universal values.	Bainsvlei, Avalon, Mispah and Clovelly/Hutton, most abundant soil forms (Anglo Operations (Pty) Ltd 2018). Range between fine, sandy loam, sandy loam and loamy sand (Anglo Operations (Pty) Ltd 2018) = M	Yellow Duplex soils, Red Brown Duplex Soils, Deep Sandy Loams, Uniform Clays, Brigalow Clays, Shallow Heavy Clays, Skeletal Clays, Shallow Sandy Soils and Dark Heavy Clays. Textures include clay loam to light clay, with a weak to moderate platy to sub-angular blocky structure. Clay content varies between 17% and 39%. (BHP Billiton Mitsubishi Alliance	The relative proportion of sand to silt to clay-sized particles determines the soil property known as texture. Sandy textured soils have percent sand content > 45 to 50% and rapid infiltration of rain occurs as well as rapid draining. Clay soils have > 40% clay and are susceptible to compaction. Loamy soils have approximately equal proportions of sand and silt, with smaller amounts of clay (Newton and Claassen 2003). Fine materials (0.2 to 0.02 mm diameter) are most susceptible to compaction and the formation of high bulk densities (Chamber of Mines of South Africa 1981; 2007). Problem soils in South Africa include: Sandy kaolinthic soils, gleyed, melanic and vertic (Chamber of Mines of South Africa 2007). Red and yellow apedal soils (which predominate on many surface mines) are very susceptible to compaction (Rethman 2006). State values for South Africa and Australia adapted from Davies and Lacey (2011).

			Coal Operations Pty Ltd 2018). = M	
Topsoil Depth	L (0.25 m – 0.6 m, arable land, SA, AU) H (0.15 - 0.25 m, wilderness and grazing land, SA, AU) Regional values. or L (Class I – IV, suitable for cultivation, AU) H (Class V - VIII, not suitable for cultivation and grazing AU) Regional values.	Thickness of topsoil: 0.24 m (Quinary 449). 0 – 1.0 m predominantly (Anglo Operations (Pty) Ltd 2018) = H	< 0.25 – 1.25 m (Australian Collaborative Land Evaluation Program 2018). Class V-VIII – not suitable for cultivation or grazing (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018) 0.15 m (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018) = H	This is given as a depth (mm) for the entire soil profile for both the dominant and subdominant soil groups per zone (Schulze 1997). Australian Collaborative Land Evaluation Program (2018) describe Depth of Soil as Depth of soil profile (A & B horizons), measured in m. State values for South Africa adapted from land capability classes (Chamber of Mines of South Africa 1981; 2007). State values for Australia adapted from (Rosser and others 1974).
Chemical Properties	L risk H risk			Parent node.
Saline	L (chloride levels > 0.5%/ EC > 8 - 16 dS/cm, SA, AU)	EC < 200 mS/m (Anglo Operations (Pty) Ltd 2018)	The topsoil is non-saline (EC 0.04 to 0.32 dS/m)	Excessive salt in soil water decreases the effective moisture content (Newton and Claassen 2003).

	M (chloride levels > 0.2%/ EC > 4 - 8 dS/cm, SA, AU) H (not saline < 4 dS/cm, SA, AU) Universal values.	= M	(BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018). = H	This can occur via capillary rise into the topsoil and via saline seepage where saline materials are placed in and above ground landforms (Australian Government and Department of Industry Tourism and Resources 2006). Surface horizons of most soil types in coal mining areas in Australia are generally low in salt, but subsoils may contain levels high enough to adversely affect plant growth (Department of Minerals and Energy 1995). Overburden in the Bowen Basin is frequently high in soluble salts (Department of Minerals and Energy 1995). State values for South Africa and Australia adapted from Department of Minerals and Energy (1995) and provided by experts. EC method to include saturated paste extract method.
Sodic	L (not sodic, SA, AU) M (sodic ESP > 6, SA, AU) H (strongly sodic ESP > 15, SA, AU) Universal values.	[+]Hypothetical = M	An ESP value of between 6% and 14% indicates that these materials are regarded as marginally sodic to sodic (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018).	Sodium causes soil aggregates to disintegrate, making soils susceptible to compaction and water infiltration difficult (Newton and Claassen 2003). Soils affected by salinity and sodicity commonly occur in arid and semi-arid areas (Minerals Council of Australia 1998). Sodicity is a measure of ESP (Department of Minerals and Energy 1995).

			=M	State values for South Africa and Australia adapted from Department of Minerals and Energy (1995) and provided by experts.
Biological Properties	L risk H risk			Parent node.
Organic Matter Content	L (1.6 to > 7%, SA, AU) H (< 1 - 1.6%, SA, AU) Universal values.	1.11% (Anglo Operations (Pty) Ltd 2018) = H	0.2 – 2.0% in 0-5 cm) (Australian Collaborative Land Evaluation Program 2018) = H	Organic matter reduces the potential for compaction to occur and can also mitigate compaction once it has occurred. Soils with high organic matter hold the soil particles apart so that they don’t pack and adhere tightly together (Newton and Claassen 2003). Soane (1990) describes organic matter as comprising of either: living or directly related to living organisms or as roots, fungal hyphae or faecal pellets. For arable and pasture land carbon % > 2% is recommended (Anglo Coal Environmental Rehabilitation Improvement Group 2009). Australian Collaborative Land Evaluation Program (2018), describes Organic Carbon as the mass fraction of carbon by weight in the < 2 mm soil material as determined by dry combustion at 90 degrees celsius, measured as a %. State values for South Africa and Australia provided by experts and adapted from Hazelton and Murphy (2007).

Cryptogram Cover	L (10 to > 50% contribution, SA, AU) H (1 to 10% contribution, SA, AU) Universal values.	+Hypothetical = H	+Hypothetical = L	'Cryptogam' is a generic term that includes algae, fungi, lichens, mosses, liverworts and fruiting bodies of mycorrhizas (Tongway and Hindley 2004).Their presence would reduce soil compaction. South African and Australian state values adapted from Tongway and Hindley (2004).
TOPOGRAPHY	% risk			Child node
Aspect	L (north hot and dry, SA, AU) M (east, west or flat, SA, AU) H (south cold and wet, SA, AU) Universal values.	Flat = M	Flat to undulating (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018) = M	In the southern hemisphere north facing slopes are hot and dry, whilst south facing slopes are cold and wet and therefore retain more moisture and may be more susceptible to soil compaction. Australian Collaborative Land Evaluation Program (2018), describe Aspect as measuring the direction in which a land surface slope-faces. The direction is expressed in degrees from north. State values for South Africa and Australia provided by experts.
Elevation/ Altitude	L (0 – 600 m, SA) M (600 – 1250 m, SA) H (1250 – 2500 m, SA) Regional values.	1500 – 1750 m (Schulze 1997). 1498-1590 m (Anglo Operations (Pty) Ltd 2018) = H	260 m (Moranbah Water Treatment Works) (Bureau of Meteorology 2018c).	Altitude influences climate and hence hydrological responses. Altitude can act as a barrier to rain-bearing masses or can force moist air to rise by orographic lifting, with windward facing slopes experiencing more total rainfall and more raindays. Increased thunderstorm activity and higher

	L (0 - 300 m, AU) M (300 – 600 m, AU) H (> 600 m, AU) Regional values.		220 m to 274 m across the site (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018) = L	stormflow producing events may result (Schulze and others 2011). Higher altitudes have reduced temperatures and reduced evaporative losses, therefore are more at risk to soil compaction. State values for South Africa adapted from Schulze (1997). State values for Australia adapted from Australian Government Geoscience Australia (2018).
Drainage	L risk H risk			Parent node.
Slope Gradient	L (< 33% or < 1:3, SA, AU) M (20% or 1:5, SA, AU) H (> 1% or 1:100, SA AU) Universal values.	Gently undulating terrain = H	Low (Australian Collaborative Land Evaluation Program 2018). < 1% (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018) = H	The flatter the slope, the more likely it is to retain water and the more susceptible it is to soil compaction. Australian Collaborative Land Evaluation Program (2018), describe Slope as measuring the inclination of the land surface from the horizontal and is measured as a %. State values for South Africa and Australia provided by experts.
Slope Shape	L (convex, SA, AU) M (rectilinear, SA, AU) H (concave, SA, AU)	Rectilinear = M	Rectilinear = M	Concave slopes hold water, whilst convex slopes do not. State values for South Africa and Australia provided by experts.

	Universal values.			
VEGETATION	% risk			Child node
Ground Cover	L risk H risk			Parent node
Perennial Vegetation	L (> 20%, high below ground contribution, SA, AU) M (1 – 20% low to moderate below ground contribution, SA, AU) H (1% or less, no below ground contribution, SA, AU) Universal values.	+Hypothetical = M	+Hypothetical = L	South African and Australian state values adapted from Tongway and Hindley (2004).
Litter	L (50 - 100% cover of plant litter, SA, AU) H (< 10 – 50% cover of plant litter, SA AU) Universal values.	+Hypothetical = H	+Hypothetical = L	Undecomposed organic matter can accumulate on the soil surface. Frequently this is fibrous or, in the case of forests, woody material which may form a continuous layer several centimetres thick. Such a layer might be expected to have the effect of increasing the effective contact area of wheels or tracks, thus reducing contact stress and reducing compaction within the surface layers of the soil (Soane 1990).

				South African and Australian state values adapted from Tongway and Hindley (2004).
Disturbance	L risk H risk			Parent node
Size	L (small site, SA, AU) M (intermediate site, SA, AU) H (large site, SA AU) Universal values.	The mine boundary area of the Kleinkopje Colliery is approximately 4000 ha in size (Anglo Operations (Pty) Ltd 2018). = H	+Hypothetical = M	State values for South Africa and Australia provided by experts.
Landuse Transformation	L (wilderness vegetation, SA, AU) M (agricultural pastures, SA, AU) H (agricultural cropping, SA, AU) Universal values.	Before transformation was grassland. Agricultural cropping – predominant, some grazing (Anglo Operations (Pty) Ltd 2018) = H	Brigalow. (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018). = L	States for South Africa and Australia provided by experts
Access				Parent node
Access	L (people, SA, AU) M (animals, SA, AU) H (vehicles, SA AU) Universal values.	Vehicles from past cultivation = H	The project site and adjoining areas have historically been and are	State values for South Africa and Australia provided by experts.

			currently used for cattle grazing (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018). = M	
HYDROLOGY	% risk			Child node
Surface water	L risk H risk			Parent node
Wetlands and Rivers/Creeks	L (not present, SA, AU) H (present, SA, AU) Universal values.	Present (River and wetlands) = H	Present (Creeks). Alluvial plains (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018) = H	Wetland soils, which are wet and high in clay, will remain compacted for decades after compaction and cannot be loosened because they never adequately dry out (Newton and Claassen 2003). State values for South Africa and Australia provided by experts.
Inundation	L (infrequent, shallow or short duration, SA, AU) H (frequent, deep or long duration, SA, AU) Universal values.	Frequent, deep or long duration = H	Infrequent, shallow or short duration. All watercourses and tributaries within the project site are ephemeral watercourses. Periods of flow are	State values for South Africa and Australia provided by experts.

			generally short and limited to periods during and immediately after rainfall (BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd 2018). = L	
Flow and Quantity	L (high velocity or low volume, SA, AU) H (low velocity or high volume, SA, AU) Universal values.	Low velocity or high volume = H	High velocity or low volume = L	State values for South Africa and Australia provided by experts.
Groundwater	L risk H risk			Parent node
Groundwater Levels	L (deep, > 15 mbs, SA, AU) H (shallow, 1-15 mbs, SA, AU) Universal values.	1-15 mbs (Anglo Operations (Pty) Ltd 2018) = H	+Hypothetical = L	In Australia's arid and semi-arid regions, the groundwater is deep, with a low permeability, unsaturated zone above (Australian Government and Department of Industry Tourism and Resources 2006). State values for South Africa and Australia provided by experts.
Groundwater Depth	L (thin layer, SA, AU)	+Hypothetical = L	+Hypothetical = L	State values for South Africa and Australia provided by experts.

	H (thick layer, SA, AU) Universal values.			
CLIMATE	% risk			Child node
Precipitation	L risk H risk			Parent node
Mean Annual Precipitation	L (< 100 - 600 mm, SA) M (600 – 800 mm, SA) H (800 to > 1200 mm, SA) Regional values. L (50 – 200 mm, AU) M (200 – 400 mm, AU) H (400 – 3000 mm, AU) Regional values.	648 mm (Quinary 449). 696 mm (Anglo Operations (Pty) Ltd 2018) = M	614 mm (Moranbah Water Treatment Works) (Bureau of Meteorology 2018c). = H	The long-term quantity of water available to a region for hydrological purposes (Schulze and others 2011). South African state values adapted from Schulze (1997). Australian state value adapted from Bureau of Meteorology (2018b). Note: The Wentworth, Queensland weather station states MAP as 495 mm. Rainfall statistics are calculated for this station since 1963. No climate statistics are however available; hence the Moranbah weather station was used for data input for Caval Ridge.
Variability	L (35 to > 40%, CV, SA) M (30 – 35%, CV, SA)	CV of Annual Rainfall: 20.4% (Quinary 449). = H	0.75 – 1.0 (Bureau of Meteorology 2018b) = M	CV is the natural year to year variability of rainfall that occurs, it is expressed as a percentage (Schulze 1997). The higher the CV the more variable the year-to-year rainfall of a locality is. It indicates climate risk.

	H (< 20 – 30%, CV, SA) Regional values. L (L to M, 0 – 0.75 percentile, AU) M (M to H, 0.75 – 1.25 percentile, AU) H (H to extreme, 1.25 - > 2 percentile, AU) Regional values.			The Mpumalanga Highveld in South Africa is characterized by rainfall distribution (over the year) and variability (from year to year) which can result in either drought stress and/or waterlogging both within and between seasons (Rethman 2006). South African state values adapted from Schulze (1997). Australian state values adapted from Bureau of Meteorology (2018b).
Rainsplash impact	L (High to very high rainsplash protection, 30 to > 50% projected cover, SA, AU) M (Moderate rainsplash protection, 15 – 30% projected cover, SA, AU) H (No to low rainsplash protection, < 1% to 15% projected cover, SA, AU) Universal values.	[+]Hypothetical = H	[+]Hypothetical = L	Raindrop impact is noted by Limpitlaw and others (1997) as of importance and its link with slope steepness, slope length and plant cover. South African and Australian state values adapted from Tongway and Hindley (2004).
Drying-out Potential	L risk H risk			Parent node

Mean Annual Temperature	L (18 to >22 ^{0}C, SA) M (14 – 18 ^{0}C, SA) H (< 8 – 14 ^{0}C, SA) Regional values. L (39 – 24 ^{0}C, AU) M (24 – 18 ^{0}C, AU) H (18 to -3 ^{0}C, AU) Regional values	15.3 ^{0}C (Quinary 449). = M	27 – 30 ^{0}C (Bowen Basin) (Bureau of Meteorology 2018b). = L	The colder temperature regions are more susceptible to soil compaction as the cool temperatures prevent the soils from drying out. South African state values adapted from Schulze (1997). Australian state values adapted from Bureau of Meteorology (2018b)
Mean Annual Potential Evaporation	L (2400 mm > 3000 mm, SA) M (2000 – 2400 mm, SA) H (< 1400 – 2000 mm, SA) Regional values. L (4000 – 2800 mm, AU) M (2800 – 2000 mm, AU) H (2000 – 1000 mm, AU) Regional values.	Mean Annual Potential Evap (Penman-Monteith method): 1644 mm (For A-pan equivalent 1644x1.23) (Quinary 449). = H	2000 – 2400 mm (Bowen Basin) (Bureau of Meteorology 2018b). = M	Regions with low mean annual potential evaporation tend to hold soil moisture more and therefore are more susceptible to soil compaction. South African state values adapted from Schulze (1997). Australian state values adapted from Bureau of Meteorology (2018b).
Solar Radiation (Dry/wet season)	L (18 to >19 $MJ.m^{-2}.day^{-1}$, July, SA) M (16 – 18 $MJ.m^{-2}.day^{-1}$, July, SA) H (< 12 - 16 $MJ.m^{-2}.day^{-1}$, July, SA) Regional values.	17 - 19 $MJ.m^{-2}$.day^{-1} (Schulze 1997). = M/L	20 – 22 $MJ.m^{-2}$ (Bowen Basin) (Bureau of Meteorology 2018a) = M	High altitudes have reduced atmospheric pressure, which enhances the transmissivity of solar radiation and increases the rate at which water can vaporise under clear sky conditions (Schulze 1997). Based on Clemence’s equation.

	L (32 to 22 $MJ.m^{-2}$, July, AU) M (22 – 18 $MJ.m^{-2}$, July, AU) H (18 – 6 $MJ.m^{-2}$, July, AU) Regional values.			South African state values adapted from Schulze (1997). Australian state values adapted from Bureau of Meteorology (2018a).
Other				
Frost	L (frost free area, SA) M (1 – 30 days < 0 ^{0}C, SA) H (31 to >120 days < 0 ^{0}C, SA) Regional values. L (frost free areas, AU) M (0 - 20 days, AU) H (20 – 150 days, AU) Regional values.	1 – 30 days (Schulze 1997). = M	0 – 10 days (Bowen Basin) (Bureau of Meteorology 2018b). = M/L	Frost and snow prevent the soil from drying out and therefore increase susceptibility to soil compaction. Refers to number of days with frost. Although Caval Ridge is noted as having 0 -10 days of frost (M), frost generally disappears with sunrise, therefore L is also applicable. For interest we have chosen to apply M for Caval Ridge. South African state values adapted from Schulze (1997). Australian state values adapted from Bureau of Meteorology (2018b).
Relative Humidity, Daily Mean (Winter, July)	L (< 52 – 58%, July, SA) M (58 – 64%, July, SA) H (64 to > 68%, July, SA)	56 – 60% (Schulze 1997). = M	67%, 9 am (Moranbah Water Treatment Works) (Bureau of Meteorology 2018c).	Winter states have been used as mean annual temperatures are coldest and soil will therefore be moister at this extreme time of year. Humid area will have moister soil and it is expected that the soil will not dry out easily.

	Regional values. L (0 – 50%, July, AU) M (50 – 70%, July, AU) H (70 – 100%, July, AU) Regional values.	= M	South African state values adapted from Schulze (1997). Australian state values adapted from Bureau of Meteorology (2018b).

Note:
[+]'Hypothetical' data scenarios were entered when site data was unobtainable.
[#]Values were defined based on universal values (i.e. can be applied to any region and include well known specialist terminology) or regional South African and Australian values.
Abbreviations: L-low, M-medium, H-high, SA-South Africa, AU-Australia, CV-Coefficient of variation, PAW-Plant Available Water, AWC-Available Water Capacity, EC-Electrical conductivity and ESP-Exchangeable Sodium Percentage.

Table 2.
Anthropogenic risk source component model nodes, states and their values with input data for poor and improved management scenarios shown.

Nodes	States and #values	Input data, Poor and improved management	Description and supporting references
SOIL MANAGEMENT	% risk		Child node
Soil Condition at Handling	L risk H risk		Parent node.
Soil Water Content	L (wilting point, –1500 kPa, SA, AU) M (field capacity, -5 to -55 kPa, SA, AU) H (saturated, SA, AU) Universal values.	+Hypothetical = L and H	Handling soils when wet increases soil compaction risk. Compaction is usually greatest when soils are moist, soils should therefore be stripped when moisture content is as low as possible. Stripping and replacement of soil should be done during the dry winter months (summer months in Mediterranean climate areas) when rainfall is at its lowest and soils are driest (Anglo Coal Environmental Rehabilitation Improvement Group 2009). State values provided by experts.
Rain Season	L (dry season) H (rain season) Universal values.	+Hypothetical = L and H	Rehabilitation should preferably be undertaken in the dry season. State values provided by experts.

Existing Compaction	L (Soil strength 0.5 - 3 MPa or Bulk density 1.0 – 1.50 g/cm^3). H (Soil strength 3 – 5.5 MPa or Bulk density 1.5 – 2.0 g/cm^3). Universal values.	+Hypothetical = L and H For Kleinkopje, 1.56 g/cm^3 (Anglo Operations (Pty) Ltd 2018) = L For Caval Ridge 1.0 – 1.6 g/cm^3 (Australian Collaborative Land Evaluation Program 2018) = L	Soils that are already compacted should be handled with care or ameliorated. Bulk density is expressed as the dry weight of soil per unit area e.g. g/ cm^3 (Newton and Claassen 2003). Low/ hard bulking factors can expand by 25% and high/ soft bulking factors can compact by 15% (Chamber of Mines of South Africa 2007). Soil strength values: low (< 2 MPa), medium (2.5 – 3 MPa) or high (> 3 MPa) (Rethman 2006). Australian Collaborative Land Evaluation Program (2018), describes Bulk Density of the whole soil (including coarse fragments) in mass per unit volume by a method equivalent to the core method, measured as in g/cm^3. State values provided by experts and as adapted from Rethman (2006) and the Australian Collaborative Land Evaluation Program (2018).
Soil Characterisation	L risk H risk		Parent node.
Soil Separation	L (yes) H (no) Universal values.	+Hypothetical = L and H	When care has not been taken to separate soil types, there is an increased risk of compaction occurring, i.e. clay soils which are more susceptible to compaction may become mixed with other soils. State values provided by experts.
Impermeable Material	L (below) H (above) Universal values.	+Hypothetical = L and H	If impermeable materials are placed as a top layer, the risks of compaction increase, as drainage is impeded. State values provided by experts.

Soil Stockpiles	L risk H risk		Parent node.
Height and Footprint	L (no stockpiles) M (1.5 m – 3 m, medium surface area) H (> 3 m, small surface area) Universal values.	[+]Hypothetical = L and H	Stockpiling may have certain negative impacts on soils. These may include among other the increase in bulk density (Rethman 2006). The higher the stockpile and the smaller its surface area the greater the risks of compaction (Anglo Coal Environmental Rehabilitation Improvement Group 2009; Rethman 2006). Fairly large areas (footprints) and low heights are recommended. While heights of 2 – 3 m would be acceptable, a maximum height of 1.5 m would be preferred (Rethman 2006). The maximum height of topsoil stockpiles must be 3 m to minimize soil compaction (Anglo Coal Environmental Rehabilitation Improvement Group 2009). State values provided by experts and as recommended by ARC-Institute for Soil Climate and Water (2016).
Double Handling	L (No) H (Yes) Universal values.	[+]Hypothetical = L and H	Double handling increases the risks of compaction. Wherever possible, stripping and replacing of soils should be done in a single action (live placement) (Anglo Coal Environmental Rehabilitation Improvement Group 2009) State values provided by experts.
Age	L (< 9 months old) M (9-24 months old) H (> 24 months old)	[+]Hypothetical = L and H	Soils that have been stockpiled for long periods of time become compacted.

	Universal values.		State values provided by experts.
MACHINERY MANAGEMENT	% risk value		Child node
Loading	L risk H risk		Parent node.
Tyres	L (low pressure and/or wide) H (high pressure and/or narrow) Universal values.	+Hypothetical = L and H	State values provided by experts.
Tracks	L (wide) H (narrow) Universal values.	+Hypothetical = L and H	State values provided by experts.
Axle load	L (range) M (range) H (>5 tons per axle) Universal values.	+Hypothetical = L and H	State values provided by experts.
Actions	L risk H risk		Parent node.
Machinery choice	L (draglines) L to M (truck and shovel) M (dozers with tracks)	+Hypothetical = L and H	Draglines (Removal of topsoil (partial), overburden (major) and replacement of topsoil (partial). Scrapers/ bowlscrapers (topsoil replacement). Shovel (backhoe) and truck (topsoil replacement). Graders (smoothing of replaced soil).

	M to H (graders with wheels) H (scrapers/ bowlscrapers) Universal values.		Dozer (smoothing of replaced soils). State values provided by experts.
No of passes	L (<3) M (3 - 8) H (>8) Universal values.	[+]Hypothetical = L and H	Soil compaction increases with number of passes. State values adapted from Troldborg and others (2013).
Speed	L (fast) H (slow) Universal values.	[+]Hypothetical = L and H	State values provided by experts.

Note:
[+]'Hypothetical' data scenarios were entered as examples.
#Values were defined based on universal values (i.e. can be applied to any region and include well known specialist terminology).
Abbreviations: L-low, M-medium, H-high, SA-South Africa and AU-Australia.

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