The BOS comprises the following approach designed to maintain or enhance the ecological values of EECs and threatened species and their habitats in the region. These measures include:

- establishment and long-term protection of a 350ha off-site offset area, the Kokoda Offset Site, to allow for the conservation of large areas of existing vegetation and the protection of threatened woodland birds, micro-bats and EECs;
- the development, and implementation, of an active ecological restoration and regeneration program within the proposed offset site to enhance existing EECs and threatened species habitat; and
- the development of an appropriate ecological monitoring program to assess the success of the BOS in counterbalancing the residual impacts of DGR's the Project on ecological values.

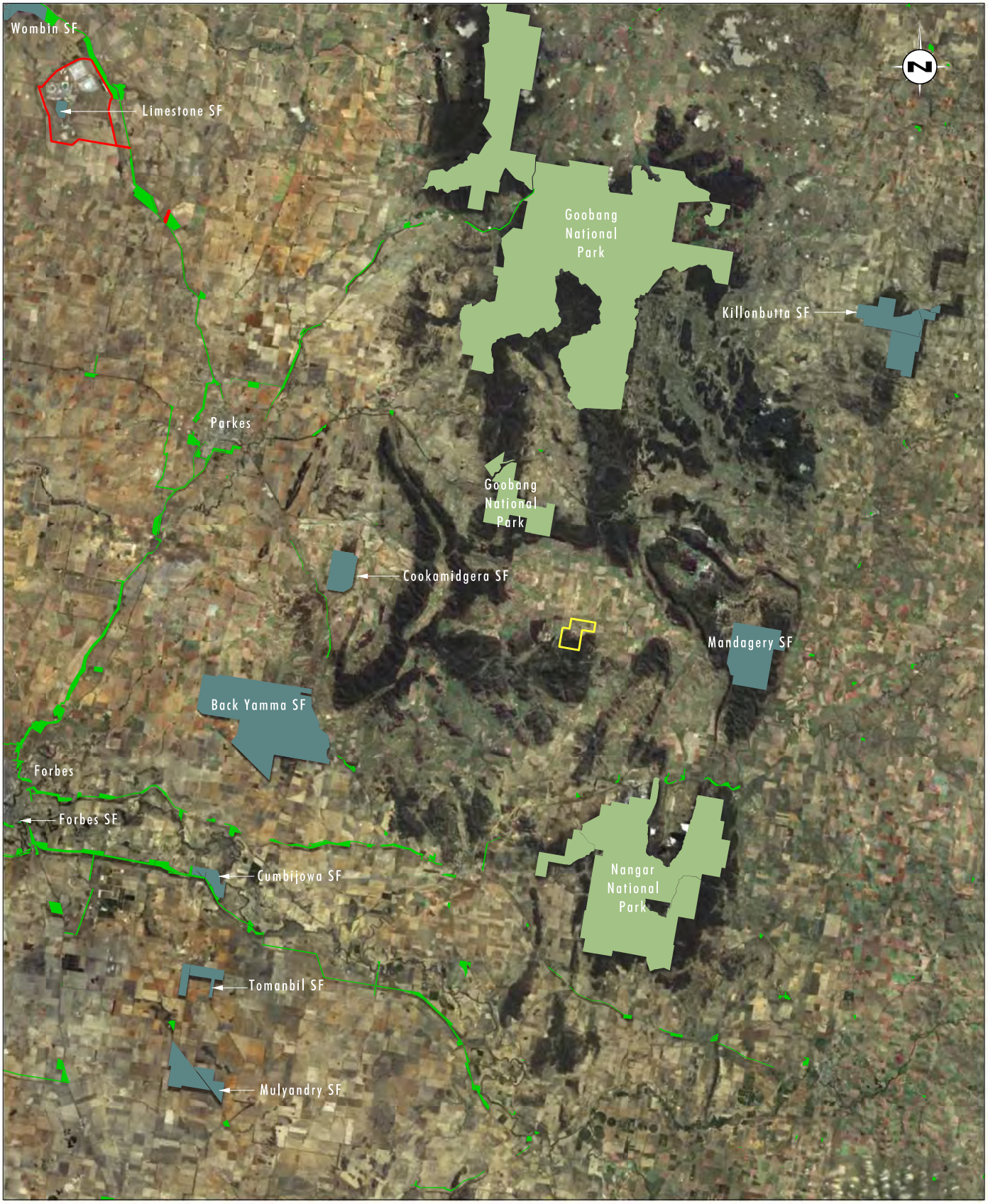
Throughout the Project design phase, NPM have actively investigated a range of land based and other non land based strategies that would effectively contribute to the BOS for the Project. This process has included targeted searches and inspections of a range of properties that had the potential to contain target vegetation communities and habitat values required for the Project. In addition, NPM have consulted with the Lachlan CMA and Department of Lands to identify potential offset properties and other regional biodiversity conservation programs being implemented in regard to the target vegetation communities and species.

On the basis of these reviews, areas within the local area and region (within approximately 50 kilometres of the Project Area) were identified, that could provide suitable offset properties through containing target vegetation communities, including derived native grassland components, and habitat features necessary to offset the residual impacts of the Project. This sizeable search area was necessary given that in proximity to the Project area, the majority of native vegetation occurs as highly fragmented remnants located along road reserves and property margins, or located within State Forests and TSRs.

The proposed Kokoda Offset Site is a 350 hectare site located in the Mandagery locality of the Central West Slopes of NSW (refer to **Figure 5.14**). The Kokoda Offset Site is strategically located along a north-south potential corridor of remnant woodland and forest vegetation that runs along ridges and hills from north of Eugowra in the south to east of Narromine in the north (refer to **Figure 5.14**). The north-south potential corridor includes Goobang National Park, the largest conserved remnant of woodland and forest vegetation in the Central West region of NSW.

A detailed survey methodology was undertaken across the Kokoda Offset Site to determine the ecological attributes of the site. Field surveys were undertaken from 27 to 31 May 2013. Flora survey comprised systematic plots, rapid assessments, general reconnaissance and targeted eucalypt sampling. Fauna survey comprised area search methods including targeted winter migratory bird surveys, walking and driving spotlight surveys, micro-bat echolocation recording, remote cameras, nocturnal call playback and targeted survey and call playback for Sloanes froglet. Further detail on the survey completed to date within the proposed Kokoda Offset Site is provided in **Appendix 9**. NPM will undertake further surveys of the Kokoda Offset Site in spring 2013 to provide further targeted threatened species searches and to further refine mapped areas of DNG to inform active management.

Two TECs were recorded within the Kokoda Offset Site that correspond with the two TECs (at the NSW and Commonwealth levels) located within the proposed disturbance area. **Table 5.14** lists the two TECs and area of each TEC recorded within the Kokoda Offset Site. **Figure 5.15** shows the location of the vegetation communities present on the Kokoda Offset Site.



Source: Google Earth (2012), NPM (2011), Department of Lands (2011)

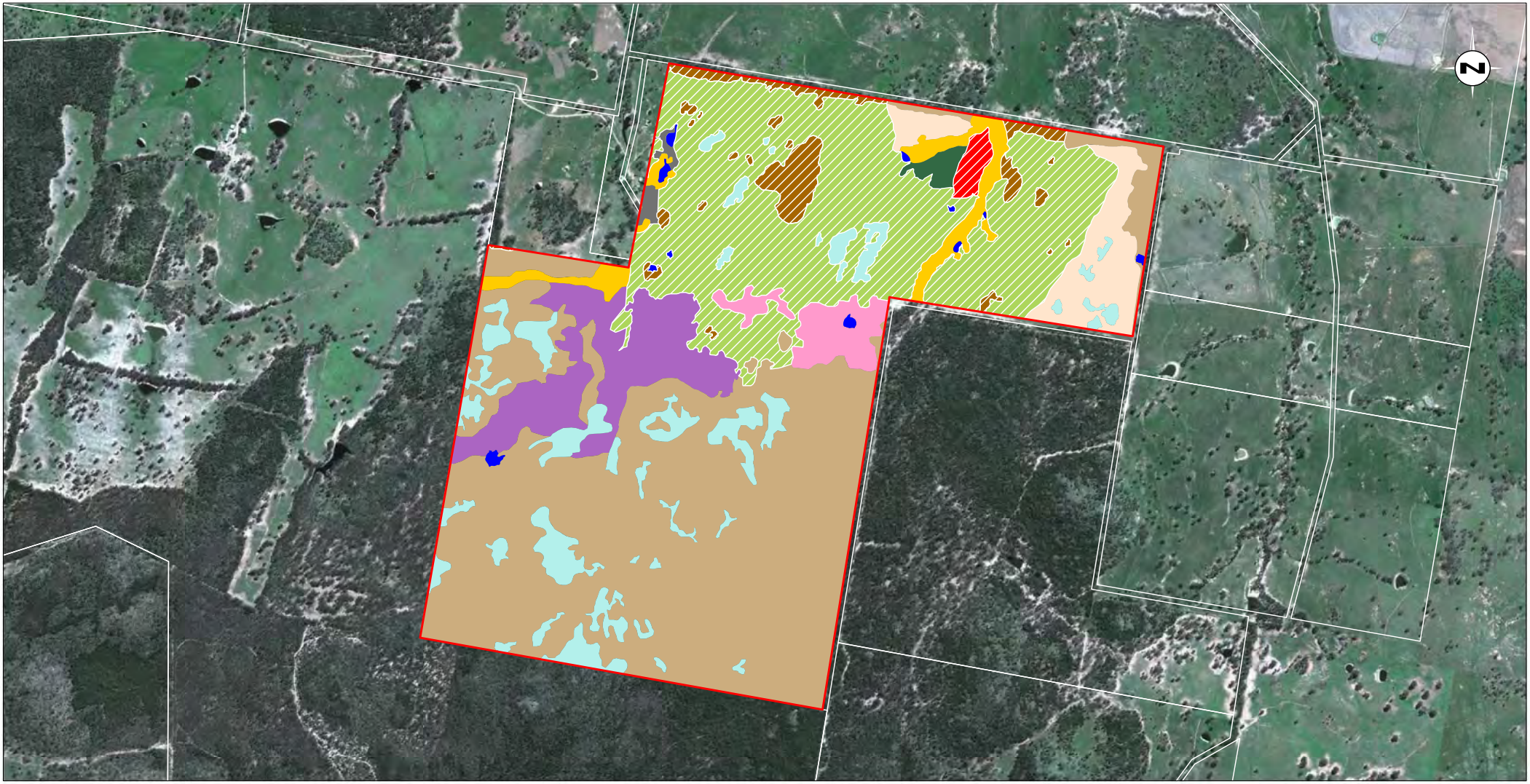
0 5 10 20 km
1: 400 000

Legend

- Project Area
- Proposed Kokoda Offset Site
- National Parks and Nature Reserves
- State Forest
- Travelling Stock Reserves

FIGURE 5.14

Kokoda Offset Site Regional Location



Source: Google Earth (2010), Department of Planning (2009) and Umwelt (2013)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed Kokoda Offset Site Boundary
- Grey Box Grassy Woodland (EEC - TSC Act/CEEC - EPBC Act)
- Grey Box Grassy Woodland - DNG (EEC - TSC Act/CEEC - EPBC Act)
- White Box Grassy Woodland (EEC - TSC Act/CEEC - EPBC Act)
- Dwyer's Red Gum Creekline Woodland
- Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Pine Forest
- Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Pine Forest DNG
- Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Woodland Low Quality
- Farm Dam
- Farm Track - Disturbed Land
- Grey Box - Ironbark Woodland
- Mugga Ironbark Woodland
- Rocky Rise Shrubby Woodland

FIGURE 5.15

Vegetation Community Mapping - Proposed Kokoda Offset Site

File Name (A4): R10/2949_336.dgn
20130703 15.24

Table 5.14 – TECs recorded across the Kokoda Offset Site

TEC	Status		Area (ha)
	TSC Act	EPBC Act	
Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions AND Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	EEC	EEC	106
White Box – Yellow Box – Blakely's Red Gum Woodland[1] AND White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland	EEC	EEC	2.2
		Total[1]	**108**

1 = Rounding of totals applied (numbers greater than 10 - zero decimal places)
CEEC = Critically Endangered Ecological Community
EEC = Endangered Ecological Community
EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*
TSC Act = *Threatened Species Conservation Act 1995*

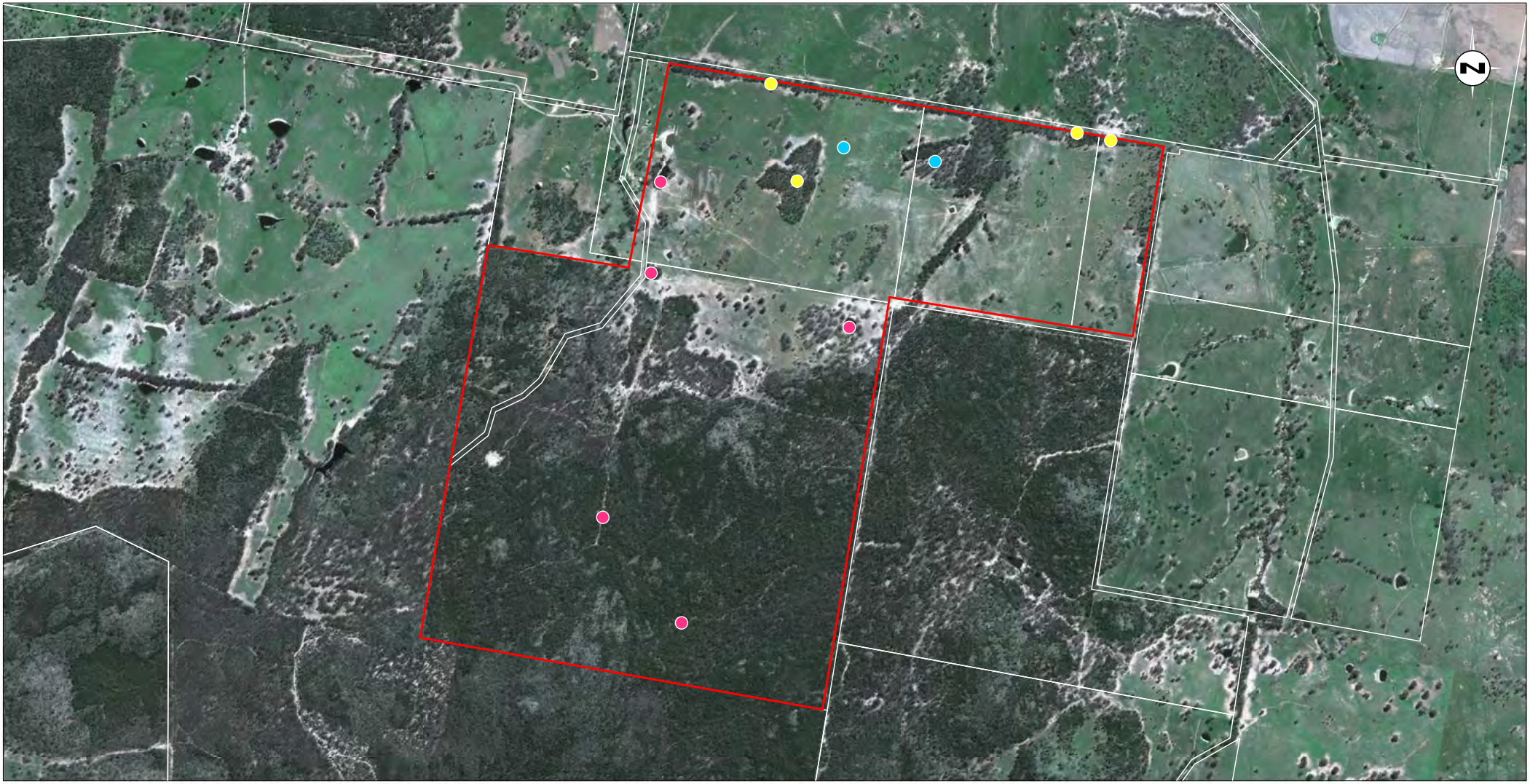
A total of three threatened fauna species were identified across the Kokoda Offset Site during field surveys in May 2013 (refer to **Figure 5.16**). **Table 5.15** lists the three threatened species and the likely frequency of occurrence of each species.

Table 5.15 – Threatened Fauna Species Recorded Across the Kokoda Offset Site

Common Name	Scientific Name	TSC Act	EPBC Act	Likely Frequency of Occurrence
Little lorikeet	*Glossopsitta pusilla*	V		Occasional visitor
Grey-crowned babbler	***Pomatostomus temporalis temporalis***	V		Likely resident species
Eastern bentwing-bat	*Miniopterus schreibersii oceanensis*	V		Likely resident species although no roosting habitat is present

V = Vulnerable
TSC Act = *Threatened Species Conservation Act 1995*
EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

In addition to providing habitat for threatened fauna species recorded on the Kokoda Offset Site, the site also provides potential habitat for a further 25 threatened fauna species that were identified as occurring or potentially occurring within a 20 kilometre radius of the Kokoda Offset Site (refer to **Table 5.16** and **Appendix 9**).



Source: Google Earth (2010), Department of Planning (2009) and Umwelt (2013)

0 0.25 0.5 1.0km
1:20 000

Legend

- Proposed Kokoda Offset Site Boundary
- Grey-crowned babbler
- Little lorikeet
- Eastern bentwing-bat

FIGURE 5.16

Threatened Fauna Locations - Proposed Kokoda Offset Site

File Name (A4): R10/2949_335.dgn
20130703 15.19

Table 5.16 – Threatened Fauna Species with Potential to Occur on the Kokoda Offset Site

Common Name	Scientific Name	Status	
		TSC Act	EPBC Act
Pink-tailed worm-lizard	*Aprasia parapulchella*	V	V
Little eagle	*Heiraaetus morphnoides*	V	
Grey falcon	*Falco hypoleucos*	E	
Black falcon	*Falco subniger*	V	
Glossy black-cockatoo	*Calyptorhynchus lathami*	V	
Turquoise parrot	*Neophema pulchella*	V	
Superb parrot	*Polytelis swainsonii*	V	V
Swift parrot	*Lathamus discolor*	E	E
Barking owl	*Ninox connivens*	V	
Brown treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	V	
Speckled warbler	*Chthonicola saggitatus*	V	
Regent honeyeater	*Anthochaera phrygia*	CE	E, MIG
Black-chinned honeyeater (eastern subspecies)	*Melithreptus gularis gularis*	V	
Hooded robin (south-eastern form)	*Melanodryas cucullata cucullata*	V	
Scarlet robin	*Petroica boodang*	V	
Flame robin	*Petroica phoenicea*	V	
Varied sittella	*Daphoenositta chrysoptera*	V	
Gilbert's whistler	*Pachycephala inornata*	V	
Diamond firetail	*Stagonopleura guttata*	V	
Spotted-tailed quoll	*Dasyurus maculatus*	V	E
Koala	*Phascolarctos cinereus*	V	V
Eastern pygmy-possum	*Cercartetus nanus*	V	
New Holland mouse	*Pseudomys novaehollandiae*		V
Corben's long-eared bat	*Nyctophilus corbeni*	V	V
Little pied bat	*Chalinolobus picatus*	V	

CE = Critically Endangered
E = Endangered Species
MIG = Migratory species
V = Vulnerable Species
TSC Act = *Threatened Species Conservation Act 1995*
EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

Habitat areas within the Kokoda Offset Site are of a similar condition to the vegetation within the proposed disturbance area. The condition of vegetation on the Kokoda Offset site was also in low to moderate condition and varied from being dominated by regenerating trees to being dominated by middle aged and mature trees. The condition of the woodland areas, along with large areas (approximately 96 hectares) of the Inland Grey Box DNG EEC, provide opportunity for active regeneration and enhancement of this community across broad areas of the Kokoda Offset Site, providing for enhancement of these features within the region.

NPM commit to implementing a range of improvements and management actions across the Kokoda Offset Site. A Biodiversity Offset Management Plan for the Kokoda Offset Site will be prepared to detail the planned improvements to the Kokoda Offset Site and its ongoing management for biodiversity conservation and enhancement purposes.
The Kokoda Offset Site will be managed to conserve and enhance ecological values with a focus on weed and pest control, and regeneration of DNG areas. A monitoring program will be established to assess the progress and determine the success of ongoing management actions.

Preliminary on-ground works are proposed to involve (further details provided in **Appendix 9**):

- weed and pest control programs;
- exclusion of stock from the Kokoda Offset Site;
- planting of DNG areas with poor recovery potential; and
- undertaking ecological monitoring across the Kokoda Offset Site to monitor the success of plantings and to monitor the recovery of DNG areas that have a high natural recovery potential.

Following the completion of the Biodiversity Offset Management Plan it will be submitted to DP&I for approval. The Biodiversity Offset Management Plan will include a concise and auditable strategy for the implementation of the offset, which will provide for the measurement of success of the proposed management initiatives and an adaptive approach to management in response to monitoring outcomes.

The Kokoda Offset Site will be secured for in perpetuity conservation. The mechanism for securing this conservation will be placing a covenant over the land reflecting this conservation status along with appropriate management mechanisms. This will be developed with the landholder and in consultation with DP&I, OEH, and DSEWPC (as relevant). The property will be secured by NPM within 3 months of the granting of Project Approval.

The BOS provides an adequate and appropriate means to counterbalance the residual impacts of the Project on ecological values and provides for the enhancement of ecological values in the medium to long term. **Table 5.17** shows the threatened species, EECs and other significant ecological features impacted by the Project and indicates how the BOS addresses these residual impacts.

Table 5.17 – Project Impacts and Offset Actions for Key Matters to be Impacted

Values to be Offset	Project Area Habitat to be Impacted and Likely Size/Area of Impact	Kokoda Offset Site	20 Year Offset Outcome
Grey Box Grassy Woodland	23 ha woodland 15 ha DNG	10 ha woodland 96 ha DNG (with active regeneration to woodland)	106 ha woodland
White Box – Yellow Box – Blakely's Red Gum Woodland	0.28 ha	2.2 ha	2.2 ha
Habitat for the regent honeyeater and swift parrot[1]	37 ha	95 ha of equivalent habitat[2]	191 ha of equivalent habitat[2]
Habitat for the superb parrot[1]	52 ha	206 ha of potential habitat	206 ha of potential habitat
Habitat for threatened woodland birds and bats[1]	52 ha	236 ha of potential habitat	348 ha of potential habitat

Note:1= The assessment of significance concluded that there was no potential for a significant impact on the regent honeyeater, swift parrot, grey-headed flying-fox, and threatened woodland birds and microbats in the Project area, however they are included here to show that they are adequately covered by the BOS.

Note: 2 = Areas containing non-eucalypt species were devalued according to the percentage of non-eucalypt species (e.g. a 10 ha patch containing approximately 30 per cent non-eucalypts was given the equivalent habitat value of 7 ha).
**Potential habitat for Sloanes froglet and Diuris tricolor within the proposed disturbance area will be informed through further survey during suitable conditions to determine presence and/or refine extent of potential habitat. The outcomes of this assessment will be further considered as part of the implementation of the BOS.

In addition, the proposed BOS has been assessed against relevant offsetting policies and guidelines including the NSW OEH Principles for Biodiversity Offsetting (DECC 2008a) and Commonwealth EPBC Act Environmental Offsets Policy and Offset Assessment Guide (October 2012) (refer to **Appendix 9**). This assessment concluded that the proposed BOS is consistent with the intent and objectives of these relevant policy and guidelines.

Together, the Kokoda Offset Site and the proposed mitigation measures (refer to **Section 5.6.8**) ensure that the residual ecological impacts of the Project are adequately mitigated, offset and counterbalanced.

5.7 Groundwater

A comprehensive assessment of potential groundwater impacts has been undertaken for the Project by Golder Associates (Golder) and is provided in **Appendix 10**. The assessment was prepared in accordance with the DGR's and relevant water planning policies and guidelines. This section provides a summary of the key findings of the groundwater assessment.

5.7.1 Existing Groundwater Resources

The geological strata known to occur within and surrounding the Project Area form part of a geological structure known as the Lachlan Fold Belt (LFB). NPM is located in the Upper Bogan Valley, within the LFB sequence, a consolidated bedrock sequence overlain by unconsolidated alluvium. The bedrock mass is a very low permeability, fractured rock, and is host to volcanic intrusions that form the ore bodies at NPM.

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The LFB and associated alluvium are generally considered to be a poor aquifer in terms of potential water resource. NPM is located outside the recognized groundwater intake area of the Great Artesian Basin to the north, and there is no evidence for connection with the Lachlan alluvial groundwater system to the south.

The regional groundwater resource is contained within the fractured rock aquifers of the LFB complex. Groundwater resources in the region are generally limited due to the low potential for rainfall infiltration through surficial silts and clays, and the poor storage and transmission characteristics of the deeper strata. The regional water table prevails at a depth of about 40 metres below ground level and groundwater quality is variable but mostly brackish to saline.

The regional groundwater is assumed to flow in a north-westerly to northerly direction, based on trends interpolated by previous studies of groundwater resources within the Project Area. This trend is consistent with surface drainage away from the regional catchment divide, which is located south of the Project Area.

Overlying the LFB are inactive quaternary alluvial-colluvial plains and residually weathered bedrock, some of which host minor unconsolidated aquifers. In the vicinity of the Project Area the Bogan River and its tributaries are ephemeral and only flow after sustained periods of intense rainfall, in response to overland runoff (refer to **Section 5.8**). Losses due to evaporation are significant and there is no permanent baseflow because the groundwater table lies well below the base of the channel. Isolated lenses of shallow perched groundwater have been found beneath some channel sections where alluvial deposition has accumulated sufficient sediment. Owing to the high evaporation rate, recharge to these perched aquifers is likely to be very low and they do not have substantial resource potential.

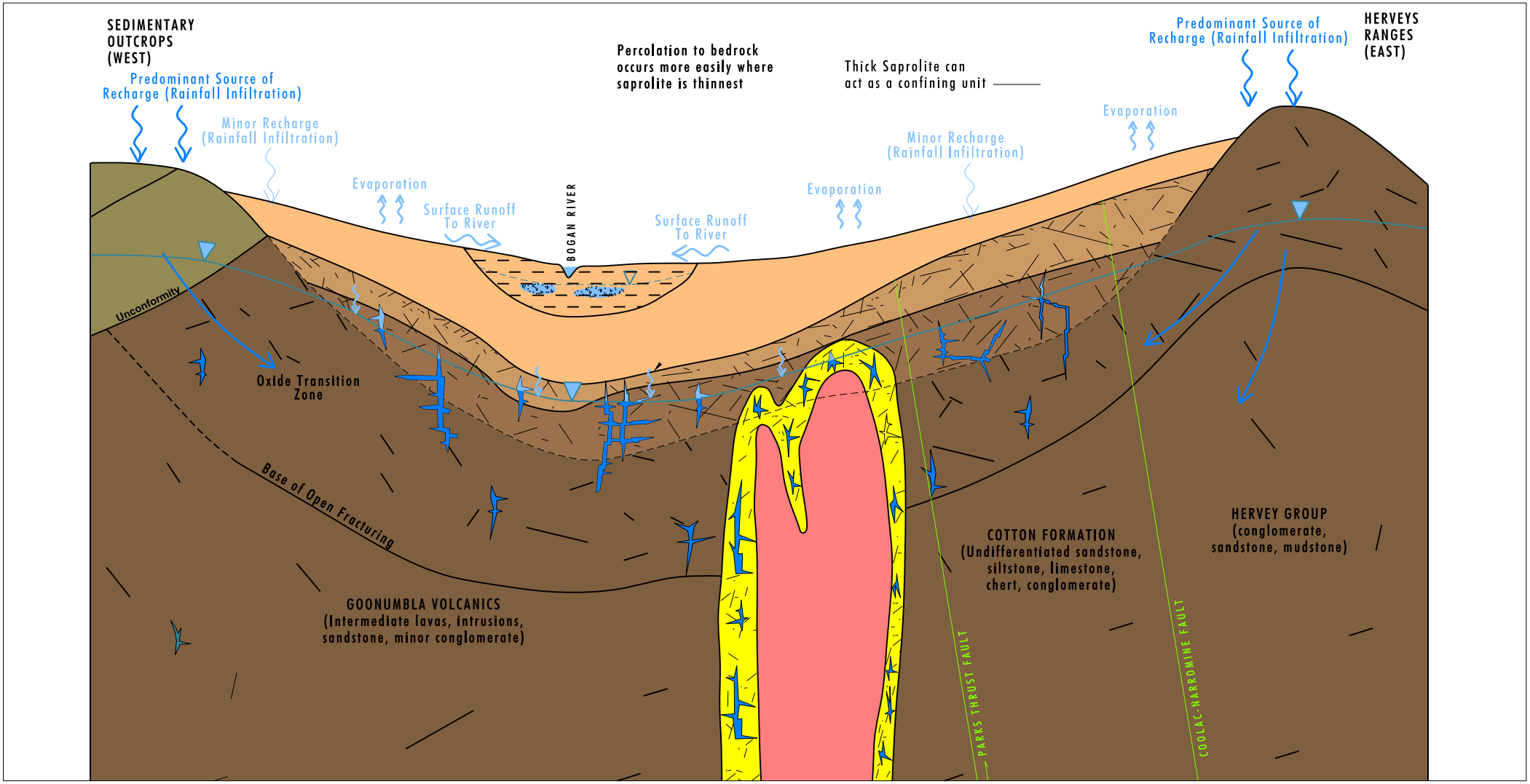
Available information suggests the water table lies well below the base of the surface water features and does not intersect the surface drainage lines, including the Bogan River in the vicinity of the Project Area. This suggests the groundwater does not provide baseflow to the surface water resources within the vicinity of the Project Area.

A conceptual model of the groundwater resources within and surrounding the Project Area is shown on **Figure 5.17**.

5.7.2 Existing Groundwater Interactions

The LFB is considered a poor groundwater resource. The fold belt rocks generally have low yielding bores due to their low permeability and low fracture density and therefore low in porosity and storage capacity (fractures predominantly clay filled). Bores are typically low yielding (domestic water supplies) and do not tap into consistent and extensive aquifer systems. The average reported bore yield for the LFB within the vicinity of the Project Area is <1 L/s. A search of the NOW registered water bores showed that the majority of the registered bores are registered as stock and irrigation supply bores, with a smaller proportion as domestic.

The existing and approved operations at NPM have interacted with existing groundwater resources within and surrounding the Project Area since the commencement of mining operations in the mid-1990s. Dewatering programmes were developed to extensively dewater the site aquifers prior to mining, which began in 1995. Dewatering occurred by means of bores to lower the water table and to allow extraction of the ore. Due to the very low permeability of the bedrock, groundwater is encountered only as seepage into the mine via fracture zones (MER 2006). Historically, mine dewatering has been maintained by pumping groundwater seepage from sumps located at the base levels of the mine.



Source: Golder (2013)

0 20 40 80 m
1:1 500

Legend

Regolith
- Palaeochannel Sediments (Quaternery to Tertiary) - undersaturated, low permeability clays
- Alluvium/Colluvium (Quaternery to Tertiary) - undersaturated, low permeability clays
- Saprolite - Highly Weathered Bedrock (Middle to Late Ordovician) - undersaturated, low permeability clays, clay infilled fractures
- Saprock - Oxidised Bedrock (Middle to Late Ordovician) - upper fractured aquifer
- Folded, Fractured Bedrock (Middle to Late Ordovician) - lower fractured aquifer

Bedrock
- Volcanics - Monzonite Porphyry (Middle to Late Ordovician) - ore body
- Volcanics - Mineralised Halo (Middle to Late Ordovician) - mineralised fractured halo aquifer
- Sedimentary Formations (Late Silurian to Early Devonian) - permeable formations; source of recharge

- Closed (infilled) Fractures
- Open Fractures
- Potentiometric Table
- Regional Potentiometric Table
- Sediment Lense (Perched Groundwater Zone

FIGURE 5.17

Conceptual Groundwater Model of the Northparkes Region

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Groundwater supplies within the NPM site are generally of poor quality. The existing NPM operations utilise insignificant volumes of groundwater which has seeped into the underground or open cut mines. The groundwater flow within the NPM site reflects the site topography and is drawn towards the existing open cut pits and underground mining areas.

NPM has a number of existing licences relating to groundwater monitoring as well as extraction bore licences for four bores. NPM currently monitor groundwater at 48 locations across the Project Area. In addition, NPM hold all relevant licences for groundwater interception associated with existing mining areas.

5.7.3 Methodology

5.7.3.1 General Assessment Approach

The groundwater assessment seeks to build upon the previous detailed groundwater impact assessment, including modelling to predict potential impacts on existing groundwater resources from previous detailed studies completed for existing and approved operations (MER 2006). The detailed groundwater impact assessment specifically considers the potential impacts associated with the proposed increased depth of mining (E22), and the additional mining areas. The groundwater related impacts arising from the Project have been assessed via the development of a computer based model that simulates the groundwater systems and their interactions with the mining process.

5.7.3.2 Groundwater Model

A detailed conceptual hydrogeological model of the mine site is presented in **Appendix 10**. The model provides details on the following:

- mine site hydrostratigraphy;
- structural controls on groundwater distribution and movement;
- hydraulic parameters of the strata;
- groundwater levels and flow direction;
- surface water drainage at the site;
- characterisation of groundwater quality; and
- assessment of groundwater availability and use.

Details from the conceptual hydrogeological model were used to assist in the analysis of groundwater impacts associated with the Project, by verifying the previous whole of mine site numerical groundwater model prepared for the E48 project, which included all existing and approved mining operations, by MER (2006). Details of the numerical model developed for the Project are discussed below.

5.7.3.3 Model Overview

MODFLOW was used to construct the groundwater model in Groundwater Vistas and was selected to enable the previous MER (2006) model to be replicated. MODFLOW was used in conjunction with the MODFLOW-SURFACT V4 software, which is an industry standard and widely accepted numerical code for the temporal simulation of saturated and unsaturated groundwater flow in three-dimensions.

The model was calibrated through the comparison of modelled results with the observed groundwater characteristics from groundwater monitoring undertaken at NPM. Generally the groundwater levels computed with the calibrated model tended to be higher than the observed groundwater levels.

Further details on model parameters and calibration process are provided in **Appendix 10**.

5.7.4 Groundwater Impact Assessment

5.7.4.1 Aquifer Impacts

The groundwater impact assessment assessed the potential impacts on the aquifers within the Project Area during the Project life. The assessment of impacts focussed on the prediction of total aquifer impact as this would represent the potential worst case predictions based on the maximum removal of the target ore bodies from the LFB. An additional assumption in the model was that all pits would continue to be dewatered until all mining operations had ceased. This was considered to be likely to provide a worst case scenario for inflows to the mine and extent of drawdown and was determined to be suitable for this groundwater assessment.

Pit Seepage

Predictive modelling was used to calculate groundwater seepage rates for each of the mining areas associated with the Project. The predictive modelling was completed for each of mining area based on the expected mine schedule, with results reported as average seepage levels across all mining areas. A summary of the pit seepage results include:

- modelled inflows to the individual operations are relatively stable, with no significant predicted spikes in groundwater seepage apart from that which occurs at the start of each operation;
- there is a steady increase expected in groundwater seepage into the mine as the mine progresses. The maximum modelled inflow is approximately 0.8 ML/day; and
- proposed locations for TSFs do not contribute to predicted seepage to the mine, due to the low permeability layers near the surface and the design of the TSFs.

Aquifer Drawdown

The impact of the proposed Project on groundwater levels is expected to be localised, and limited mainly to the vicinity of the mine operations. The predictive modelling results do not indicate a significant change in groundwater regional flow direction as a result of the Project activities.

There is no measureable groundwater impact on the surface water system within and in the vicinity of the Project Area as a result of the dewatering activities. Groundwater does not provide baseflow to the surface water within the Project Area.

As provided in **Appendix 10**, the assessment of aquifer impacts found that:

- continued block cave mining in the E26 and E48 ore bodies have the most substantial influence on predicted groundwater seepage;

- groundwater levels are anticipated to be drawdown by a maximum of 42 metres (at E26) after mine closure, with other block cave zones are predicted to be depressed by approximately 10 metres, with modelling indicating that aquifer impacts within open cut mining area would be relatively short duration, with groundwater levels in the vicinity of open pits recovered at the end of the Project (refer to **Appendix 10**); and

- at cessation of the proposed mining, the lateral extent of bedrock drawdown is approximately 4.5 kilometres from the mining areas, though this is likely to be an over-estimation as the predicted modelling drawdown is greater than historically observed drawdown.

5.7.4.2 Groundwater Quality

Potential impacts to groundwater quality are associated with potential for chemicals and wastes to seep into the groundwater system. The Project has been designed to effectively capture and management all areas of potential contamination which will minimise the risk of contamination of groundwater resources (refer to **Section 5.15**). Specifically the existing and proposed TSF are designed and constructed to minimise seepage to the environment.

Hydrochemical characteristics of the regional groundwater suggest that dissolution and other processes relating to seepage are not likely to change the total dissolved salts content in the regional aquifers in a significant way. It is therefore unlikely that any measurable change in regional groundwater quality would be observed as a result of the proposed mining operations (MER 2006).

5.7.4.3 Impacts to Groundwater Users

As outlined in **Section 5.7.2**, the LFB is considered a poor groundwater resource with existing bores typically low yielding (domestic water supplies) that do not tap into consistent and extensive aquifer systems. The average reported bore yield for the LFB within the vicinity of the Project Area is <1 L/s.

Based on the extent of the predicted drawdown associated with the Project, no private groundwater users have been identified as being affected or potentially by the Project. No private bores are within the category ‘currently in use’. There are no private bores located within the zone of one metre drawdown based on modelling results.

As the aquifers around the mine site are very low yielding and of low quality, there is currently little development of groundwater sources in the vicinity of the mine site and the potential for future development of these groundwater sources is minimal. The alluvial aquifer system within and in the vicinity of the Project Area is low yielding and not generally used for productive land use. The alluvial groundwater resource is not predicted to be impacted by the Project.

5.7.4.4 Impacts to Groundwater Dependent Ecosystems

There are no identified high priority GDEs (springs, karsts, wetlands) or national parks located within or surrounding the Project Area. The nearest high priority GDEs spring, identified in the WSP for the NSW Murray Darling Basin (MDB) Fractured Rock Groundwater Sources, is located outside of the Study Area and at a distance greater than 50 kilometres south-east of the mine site and is located well beyond the modelled zone of influence of the mine dewatering.

As detailed in **Section 5.6**, the flora and fauna assessment indicated that there were no known GDEs within the Project Area. Areas of the vegetation community River Red Gum Woodland may potentially constitute GDEs. A very small area of River Red Gum Woodland (approximately 2.1 hectares) occurs in the Project Area, but outside of the proposed disturbance area, and a number of other areas along Bogan River outside of the Project Area. Due to the very small area of potential GDE occurring in the Project Area, the Project is unlikely to significantly impact any potential GDEs. As outlined in **Section 5.7.4.1** above, groundwater modelling indicates that dewatering from the mining operations is not expected to impact surface water flow in the Bogan River or its tributaries, due to the perched nature of the surface water and alluvial groundwater resources associated with these water bodies.

5.7.4.5 Final Void Impacts

Subsidence is a planned long-term outcome of NPM operations. These impacts, would be localised to the mine operation areas. Given the low conductivity and low flow rates within the aquifers, it is not anticipated that subsidence will detrimentally impact the regional groundwater flow regime. The anticipated zone of subsidence will be confined to the locations of underground pits and will be contained within the NPM boundaries.

The management strategy will include careful planning and site design in relation to the proximity of the subsidence zones to current and proposed tailings storage areas and water storage facilities. This will aim to ensure that the subsidence zone does not encroach on these areas which could cause permanent changes in rock hydraulic characteristics and consequentially elevated seepage of water beneath. Appropriate monitoring systems will be in place to monitor the groundwater levels in the vicinity of the subsidence zones and final voids (refer to **Section 5.14**).

5.7.5 Groundwater Management and Monitoring Commitments

5.7.5.1 Existing Groundwater Monitoring

The existing groundwater monitoring program will be maintained as part of the overall mine environmental monitoring. There are currently 48 groundwater monitoring locations across the existing site. NPM hold all relevant licences for groundwater interception associated with existing mining areas.

Groundwater at the mine is currently monitored by NPM personnel and/or the appointed subcontractors. Monitoring includes:

- water level measurements or formation pressures in local and regional piezometers;
- water quality sampling (electrical conductivity (EC), pH and ionic speciation); and
- monitoring of inflows to the pits for water management purposes.

NPM commit to the continuation of the existing approved monitoring groundwater monitoring program as part of the Project.

5.7.5.2 Proposed Monitoring Program

In addition to the continuation of the existing groundwater monitoring program, NPM commit to the following additional groundwater monitoring and management measures:

- The extent of dewatering, impacts on current users and future resources will be monitored throughout the life of the Project in accordance with a revised groundwater monitoring program.

- Monitor dewatering volumes to verify that volumes are within licenced allocations.
- Trigger levels, regarding declines in groundwater levels and the degradation of groundwater quality, will be reviewed to manage the potential impacts as part of updated monitoring program. Where monitoring results indicate levels in excess of the trigger values, an investigation appropriate for the situation will be conducted to assess the need to implement management/mitigation/remedial measures.
- The existing water monitoring program will be updated for the Project in accordance with relevant Project Approval requirements.

5.8 Surface Water

A detailed Surface Water Assessment (SWA) (refer to **Appendix 11**) has been completed in accordance with the DGR's for the Project to assess the potential impact on surface water quality and quantity. A summary of the key findings are outlined below.

5.8.1 Existing Environment

The Project Area is located within the headwaters of the Macquarie-Bogan River catchment, which contributes surface water runoff from approximately 74,800 km² to the Murray-Darling Basin System. The Bogan River, which forms part of the Macquarie-Bogan River system, starts in the Harvey Range near Goonumbla and flows north-west towards Nyngan before joining the Darling River near Bourke. Within the upper southern reaches of the catchment, the Bogan River collects flows from Tenandra Creek, Goonumbla Creek and Cookopie Creek (refer to **Figure 5.18**).

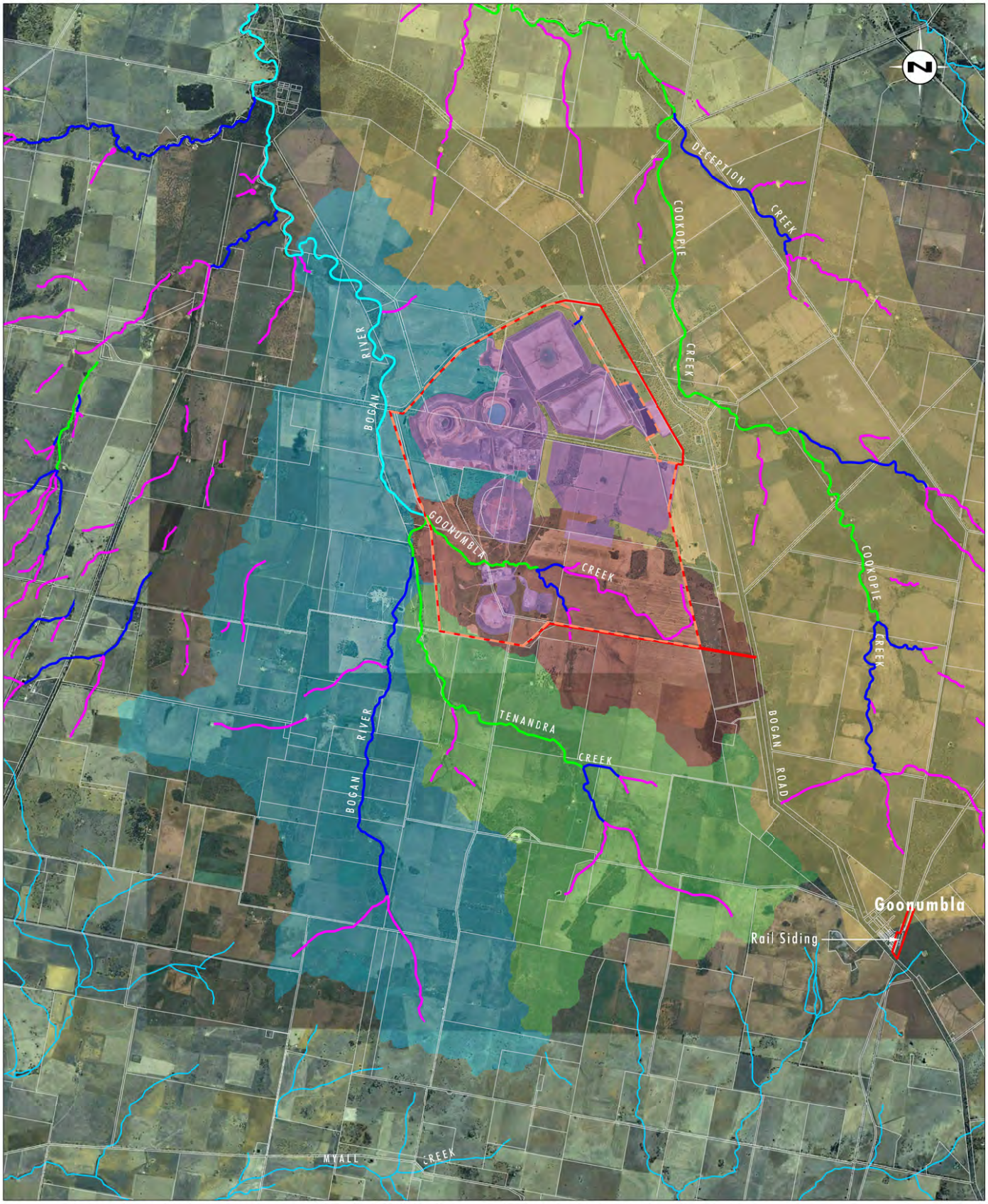
Within the vicinity of the Project Area, Bogan River and its tributaries (Tenandra Creek, Goonumbla Creek and Cookopie Creek) are generally ephemeral and surface water only flows after heavy or prolonged rainfall events. The SWA included the modelling of flood and flow within the surface water resources within and surrounding the Project Area, including the modelling of 1 in 100 Average Recurrence Interval (ARI) year flood levels as shown on **Figure 5.19**.

The extent and relative proportion of the Project Area within each of the catchment areas are listed in **Table 5.18**.

Table 5.18 – Summary of Watercourses and Catchments

Watercourse	Catchment (hectares)	Within Approved Development Consent Area (hectares)	Within Project Area[1] (hectares)
Tenandra Creek	2,866	21 (1%)	21 (1%)
Goonumbla Creek	1,849	1015 (55%)	1025 (55%)
Cookopie Creek	17,600	847 (5%)	983 (6%)
Bogan River (at Bogan Weir at Peak Hill) [1]	103,600[2]	2,495 (2.5%)	2,641 (2.5%)
Bogan River [3]	180,000,000[2]	2,495 (0%)	2641 (0%)

Note: Includes existing Project Approval area.



Source: Project Area: NPM (2013), Drainage Lines: LPMA (2011) Aerial: Google Earth (2006)

0 1 2.5 5km
1:100 000

Legend

- Project Area
- Existing Development Consent Boundary
- 1st Order Stream
- 2nd Order Stream
- 3rd Order Stream
- 4th order Stream
- Bogan River Catchment
- Tenandra Creek Catchment
- Goonumbla Creek Catchment
- Cookopie Creek Catchment
- Approved Mine Water Management System Catchment

FIGURE 5.18

Existing Surface Water Environment

Source: Project Area: NPM (2011), Drainage Lines: LPMA (2011), Aerial: Google Earth (2006)

0 0.5 1 2km
1:40 000

Legend

- Project Area
- Proposed Tailings Storage Facility Extension
- Proposed TSF3
- New Underground Block Cave Mining Area
- Proposed Open Cut Areas
- Proposed Upgrade to McClintocks Lane
- Proposed Access Control and Visitor Car Park
- Proposed Waste Dumps
- Proposed Site Access Road
- Proposed Haul Road
- 1 in 10 year ARI
- 1 in 20 year ARI
- 1 in 100 year ARI
- Drainage Line

FIGURE 5.19

Modelled Flood Extents - 10 year, 20 year and 100 year ARI Critical Duration Design Storm Events

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