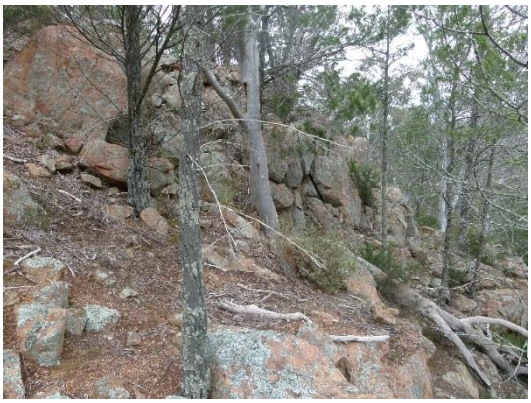
Ginninderry Project – Rosenberg's Goanna Habitat Assessment

Prepared for
The Riverview Group

2 December 2016



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1 Introduction

The proposed Ginninderry development area is situated adjacent to the suburbs of Holt and West McGregor, Canberra, and traverses both NSW and the ACT. The proposed development would support new housing, education infrastructure, and open spaces to the West Belconnen/Parkwood region.

Over approximately 10 years of consideration, the boundary between developed and conserved land has been defined to accommodate threatened species habitat in accord with an assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is understood that the current development boundary in NSW was shaped by the habitat (occupied and likely) of *Aprasia parapulchella* (Pink-tailed Worm Lizard – PTWL; listed as Vulnerable under the EPBC Act), whilst both PTWL habitat and the extent of Blakely's Red Gum – Yellow Box Woodland (listed as critically endangered ecological community under the EPBC Act) defined the boundary within the ACT.

The development area includes largely unwooded areas, which either had rocky outcroppings and/or embedded boulder fields with predominantly native grasses or areas previously cleared along the riparian zone, as well as the woodland. The conservation area additionally encapsulates the majority of the vegetated riverine gorge.

The recent detection of *Varanus rosenbergi* (Rosenberg's Goanna), a listed threatened species (vulnerable under the NSW *Threatened Species Conservation Act 1995*) in the Ginninderra Creek Catchment warrants a re-examination of the boundary to ensure that the habitat requirements of Rosenberg's Goanna are addressed in the conservation footprint. The species is not listed under relevant Commonwealth or ACT legislation.

In this report, the study area is defined as a combination of the majority of the development area and conservation area within NSW (**Figure 2**). This area was subsequently extended to the north and south to include potential habitat for Rosenberg's Goanna.

The scope of this project is to document the extent and quality of potential habitat for the Rosenberg's Goanna within the study area. In particular, work is required to determine if the area currently proposed for urban development contains a significant number/distribution of habitat elements essential to the ongoing viability of the Rosenberg's Goanna population observed to be using parts of the study area. This report will help determine evidenced-based boundaries between areas for conservation and residential area. Actions to mitigate any potential impacts and to improve habitat values in areas to be managed for conservation outcomes are proposed.

A review of current knowledge of the species ecology, particularly home range and territorial requirements, has been undertaken so as to reconcile this with the documented extent and quality of habitat identified.

Figure 1: A Rosenberg's Goanna exhibiting a form of escape behaviour near Elanora Heights, NSW (photo courtesy Tom Hackman 2106)

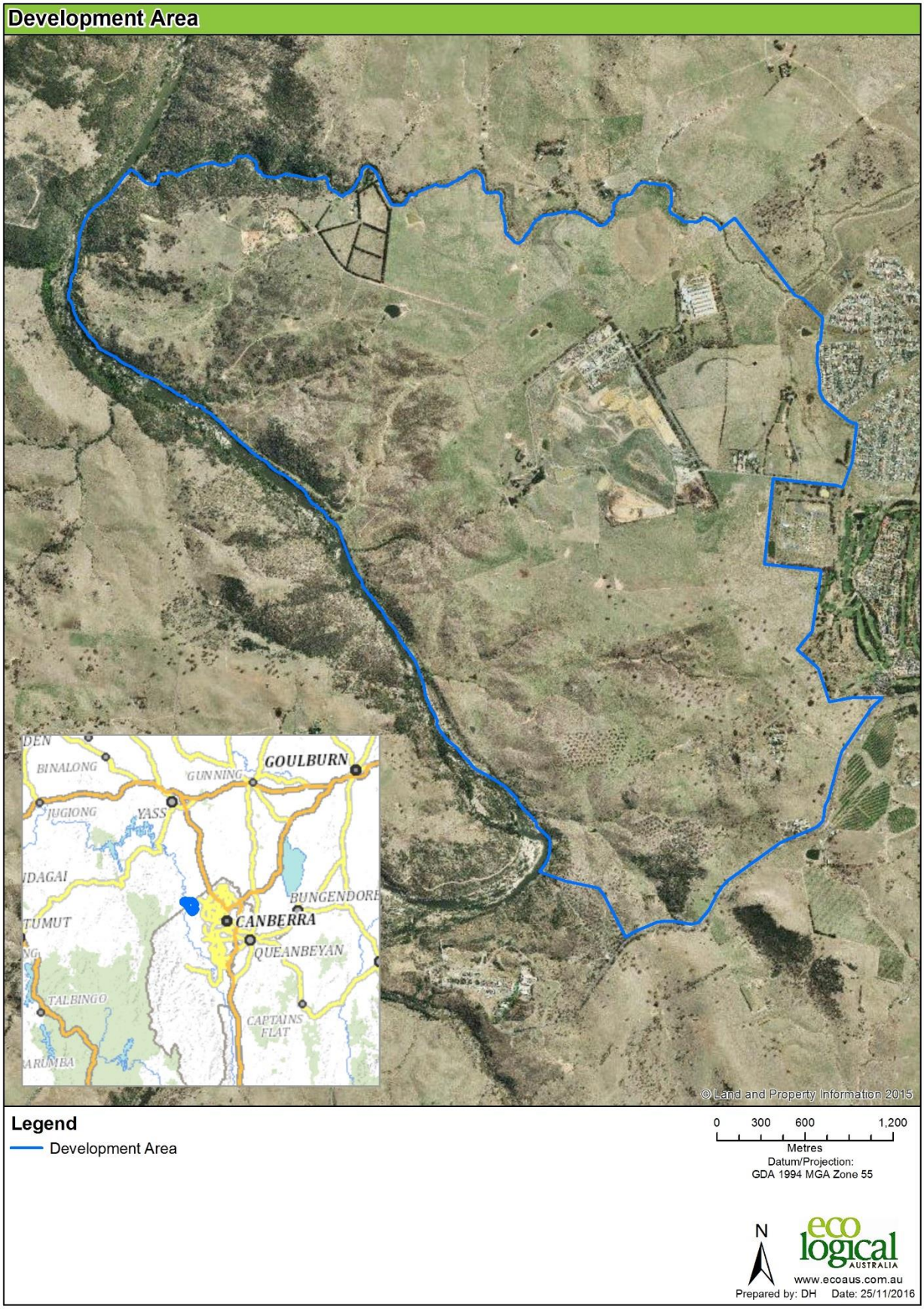

Figure 2: Location of the Ginninderry development area

1.1 Rosenberg's Goanna

The Rosenberg's Goanna (also referred to as Heath Goanna) is a medium-sized member of the lizard family Varanidae. Australia is the centre for this family's radiation with more than 32 species of the current global total of 79, and in many ecosystems where they occur they form the apex predator.

For many years Rosenberg's Goanna was considered to be a sub-species of the more widely distributed *Varanus gouldii* (Sand Goanna) complex and the alpha taxonomy of both these assemblages is still not completely resolved with both these 'species' and the larger *Varanus varius* (Lace Monitor) being sympatric in some areas of eastern Australia (Cogger 1975, 2014; Shea 1994).

Rosenberg's Goanna can reach a length of approximately 1.5 m. They are generally a dark grey with yellow and white spotting with black bands on the body and extending for the length of the tail.

The pairs of narrow, regular dark and light bands along the entire length of the tail is a distinguishing feature, which readily separates it from the more common Lace Monitor and Sand Goanna where they co-exist. Rosenberg's Goanna has distinct, finely barred "lips", whereas the Lace Monitor has far broader bands around the snout. Lace Monitor also usually lacks the dark temporal streak present in Rosenberg's Goanna and which is a pale-edged black stripe running from the eyes, across the ears and onto the neck. Juveniles are brighter in colour, having an orange wash on the sides of the face and body.

1.1.1 Habitat requirements

Rosenberg's Goanna occupies an array of habitats from broadly defined open forest, woodland and heath environments across its range in Australian and various island systems along the southern coastline from WA to Victoria (OEH 2016a). It has a disjunct distribution, however, some habitat features and ecological factors appear consistent across many of the isolated 'populations'.

The species is a high trophic order consumer and has been recorded feeding on small mammals, birds, reptiles, invertebrates as well as carrion.

When compared to the Lace Monitor the species does have a greater tendency to remain on the ground but will, when pursued, still climb trees to evade capture or predation (**Figure 1**)(R. Wells pers. comm., L. McKinnon pers. comm; pers. obs.).

The species readily and preferentially occupies rocky or stony country where there are outcrops, ledges and large ground boulders to retreat beneath/within. They also will readily evade capture within large ground logs and so likely benefit from these habitat features both directly, but also because such habitat complexity likely improves it as habitat for prey items.

Termitaria are often presented as vital and/or a critical habitat component for the species (OEH, 2016; Ehmann, 1992; Green and King 1993; King and Green, 1999). However, Rosenberg's Goanna are not obligatory termitaria users as is often thought and whilst ground termitaria are often used as breeding chambers, at least some populations will use other sites as nesting chambers. For example, in sandstone habitats of the Sydney Basin, Rosenberg's Goanna will often use termitaria when/if of large enough size are available (Ehmann et al. 1991), as will the Lace Monitor (R. Wellington pers. obs., R. Wells, pers. comm., G. Staines, pers. comm). Inspection of termitaria present in a locality can be a useful indicator of the species presence where signs of excavation and the creation of burrow openings may be visible (ELA 2009). However, the species can use other nesting sites. Other nesting sites identified include within crevices on suitable substrate and in burrows (R. Wells pers. comm.; R. Wellington pers. obs.).

Rosenberg's Goanna tend to nest in elevated areas in and around Sydney and usually have a ridge-gully system (i.e. creek line) within the home range area. Newly hatched juveniles are almost invariably detected in elevated ridge areas which further supports this observation based generalisation.

The species may be wide ranging but home range and territory requirements are highly variable and fluctuate seasonally (Green and King, 1993; King and Green, 1999). Whilst extensive studies on Rosenberg's Goanna on Kangaroo Island have been used to describe minimum home range requirements (Green and King, 1993; Rismiller *et al.* 2010), care needs to be taken when applying them to mainland situations where habitats and predator/prey complexities are different.

As for home range and territorial behaviour we need to keep in mind that they are not the same thing.

Home ranges in Varanids are generally known to be highly plastic (Guarino 2002); they are adaptive and have to be to deal with stochastic events like fire and climatic events like prolonged drought (as well as broad scale agricultural clearing). They are of different sizes in different localities and dependent on resource availability, and, hence, influence population density. Quite often home ranges of different individuals are overlapping and in part shared for paired males and females. Territories on the other hand are usually much smaller, they are defended when encroached and presumably these areas are critical to resource sufficiency and for defending mates (most Varanids pair bond). Territories can also be large and up to the size of the home range for the same individuals. But in some locations the defended territory may be much smaller than the home range and other individuals are tolerated. Again, the consequence of resource availability, population density and mating behaviour of individuals being factors influencing the size of the relative areas.

Quite clearly in areas where they interact with people, they will adjust their home range (and presumably their territory) to adapt to a concentration of resources. In some circumstances they may have a food resource like a BBQ or picnic area in a bushland reserve which results in an overlap of home ranges for several individuals or pairs of goannas. This has been observed in many areas of NSW where *V. varius* occurs, but the phenomena is not exclusive to this species. The Sydney sandstone 'form'/population of Rosenberg's Goanna has a similar observed pattern of intersecting home ranges in the Terrey Hills and Davidson areas around a rubbish tip (Ehmann et al. 1991). A similar concentration of overlapping home ranges occurs for Rosenberg's Goanna at Woy Woy tip, on the NSW Central Coast (R. Wellington pers. obs.). This species also has a strong presence and persistence pattern at the urban bushland interface around Beacon Hill, Forestville and Warringah. These northern Sydney suburbs have considerable urban development but even though the species has suffered significant habitat fragmentation and contraction, the extensive areas of retained bushland have enabled the species to persist. A similar overlapping home range 'plasticity' is also observed along sections of busy roads where road mortality creates a higher than normal concentration of resources (roadkill) for foraging by Varanids on the carrion (Ward and Carter 1988). In these locations home ranges and presumably territories adapted to the linear nature of resource occurrence and do not conform to some 'idealistic' home range shape or dimension.

Richard Wells and Ross Wellington have made a number of unpublished observations of Rosenberg's Monitor behaviour. Winter shelter site selection is often within rocky ledges with a suitable aspect. Such sites are likely a very important habitat component for the species and an essential component of a home range. Rosenberg's Goanna can often be best or most readily detected around these sites in mid to late autumn when they are preparing for their extended aestivation period. During this generally winter period they may experience breaks in torpor and take advantage of warm episodes and become active but tend to vacillate about these refugia. At other times diurnal episodes of extremely high temperatures are the best period for detection. Furthermore, they not entirely ground dwelling and will readily climb trees which

is another 'absolute' often incorrectly stated and is perhaps a result of an extrapolation from observations based on Island populations of the species (R. Wellington pers. comm.).

An understanding of the home range requirement of the species is largely based on long term studies of somewhat atypical island populations of the Rosenberg's Goanna on Kangaroo Island and other populations along the southern coastline of Australia. In these locations, Rosenberg's Goanna is also atypically the apex consumer/predator in the system under study (Rismiller et al. 2007; 2010). In these studies, extremely large home ranges (~300-1500 ha) have been estimated and which appear to grow ever larger as the studies have progressed. Whilst useful and informative studies, the findings can not necessarily be translated to the current situation where the habitat remnant is in an area of long degraded agricultural landscape and where the species is not necessarily the apex predator. Ginninderra Catchment Group (2016) rely on unpublished studies by Warwick Smith, whose preliminary findings on a more regionally comparable population (the Googong area) gives quite different but still quite large spatial indicators (~170 ha) of home range requirements.

1.1.2 Historical and regional distribution

The type locality of Rosenberg's Goanna is Stirling Range in south western, Western Australia where a substantial population still persists (Cogger et al. 1983). To the east are other isolated pockets of distribution occurring along the Great Australian Bight, on Islands of the Recherche Archipelago in WA, Port Lincoln, York and Fleurieu Peninsulas, Adelaide, Adelaide Hills and Kangaroo Island in SA (Atlas of Living Australia 2016). In Victoria the Rosenberg's Goanna occurs in the central west of the State and as other isolates around Walwa and Towong. In southern NSW, the species can be found around Khancoban in the Kosciuszko Ranges and Kosciuszko National Park (Jenkins and Bartell 1980; OEH 2016a; OEH 2016b). Further to the east is another isolated and fragmented population which extends from the vicinity of Cooma in the south, north to encapsulate parts of the ACT and adjacent areas of NSW towards Yass (OEH 2016a). Elsewhere in NSW the species persists as another series of fragmented and isolated populations within sandstone habitats of the Sydney Basin from the Shoalhaven north including Sydney, Blue Mountains, Central Coast and Wollemi (Atlas of Living Australia 2016; OEH 2016b). On the north coast of NSW sporadic sightings have also been made from around Bulahdelah north to sandstone habitat areas around Grafton (Atlas of Living Australia 2016).

The distributional records of the Rosenberg's Goanna from around the ACT and neighbouring areas of NSW have been summarised in Ginninderra Catchment Group (2016) which reports 36 records existing in the ACT and surrounding NSW. Most of these records are from upland areas of the ACT in Namadgi National Park, the Cotter Catchment and the Googong area. The nearest record to the study area is approximately 8 km away in Stony Creek Nature Reserve and within Brindabella National Park. Due to misidentification issues there may be some question about some peripheral records and whether historically the Lace Monitor may have also occurred in some of these locations. Jenkins and Bartell (1980) only record the Lace Monitor as occurring in the 'Australian High Country' and the photo of the roadkill Rosenberg's Goanna depicted in Ginninderra Catchment Group (2016 p. 29) appears to be a Sand Goanna (*Varanus gouldii* complex member), which demonstrates that at least three species of monitor lizard have been positively recorded in the ACT.

2 Methods

2.1 Literature review

A literature review was undertaken of recorded observations and information for Rosenberg's Goanna relevant to the study area. The following documentation and mapping was analysed:

- Ginninderra Catchment Group recorded observations and information
- BioNet (Atlas of NSW Wildlife) database to examine the local extent of recorded distribution of varanid records and any evident vegetation associations (OEH 2016b)
- Any anecdotal observations that may have been made in the area including records of road kill.

2.2 Field survey

Consultation was undertaken with the Riverview Group and other stakeholders, including Ginninderra Catchment Group, to determine and refine a field survey procedure for the assessment of potential habitat of Rosenberg's Goanna.

The field survey was conducted by ecologists Bruce Mullins and Mitchell Scott from 29 June to 1 July 2016. Weather conditions during the survey were clear to partly cloudy (**Table 1**).

Table 1: Weather conditions during the field survey

Date	Temperature (°C)		Max wind speed (km/h)	Rainfall (mm)
	Minimum	Maximum		
29 June	-4.3	12.8	15	0.2
30 June	-3.6	7.8	57	0
1 July	-0.4	11.6	48	1

Weather observations were taken from www.bom.gov.au Canberra Airport (070351) (temperature, wind speed and rainfall)

The field survey included contiguous woody vegetation that extended approximately 1 km north and 2 km south of the proposed development site within the Ginninderra Creek and Murrumbidgee River corridors (the study area), and was the most likely area to support a local population of Rosenberg's Goanna. Grassland within the development area was included, giving a total study area of approximately 1,100 ha (**Figure 3**).

The entire area was divided into approximately 1,100 100 x 100 m quadrats. Of these, 80 woodland sites and 15 grassland sites were randomly selected as potential survey sites. Of these, 12 grassland sites and 51 woodland sites were surveyed. This included seven quadrats that were surveyed opportunistically. Three were located in areas of known habitat for Rosenberg's Goanna (sites 101, 102 and 103), three were surveyed due to difficulty accessing randomly selected sites (site 78a, 104 and 105), and one as it contained many high quality features (site 108). Restricted access to private property on the western side of the Murrumbidgee River prevented assessment of quadrats in the north western part of the study area within the time available.

Each quadrat was located by one ecologist using GPS navigation, and the boundaries of each quadrat were identified by using georeferenced maps on iGIS and PDF Maps, with position validated using mapped aerial imagery.

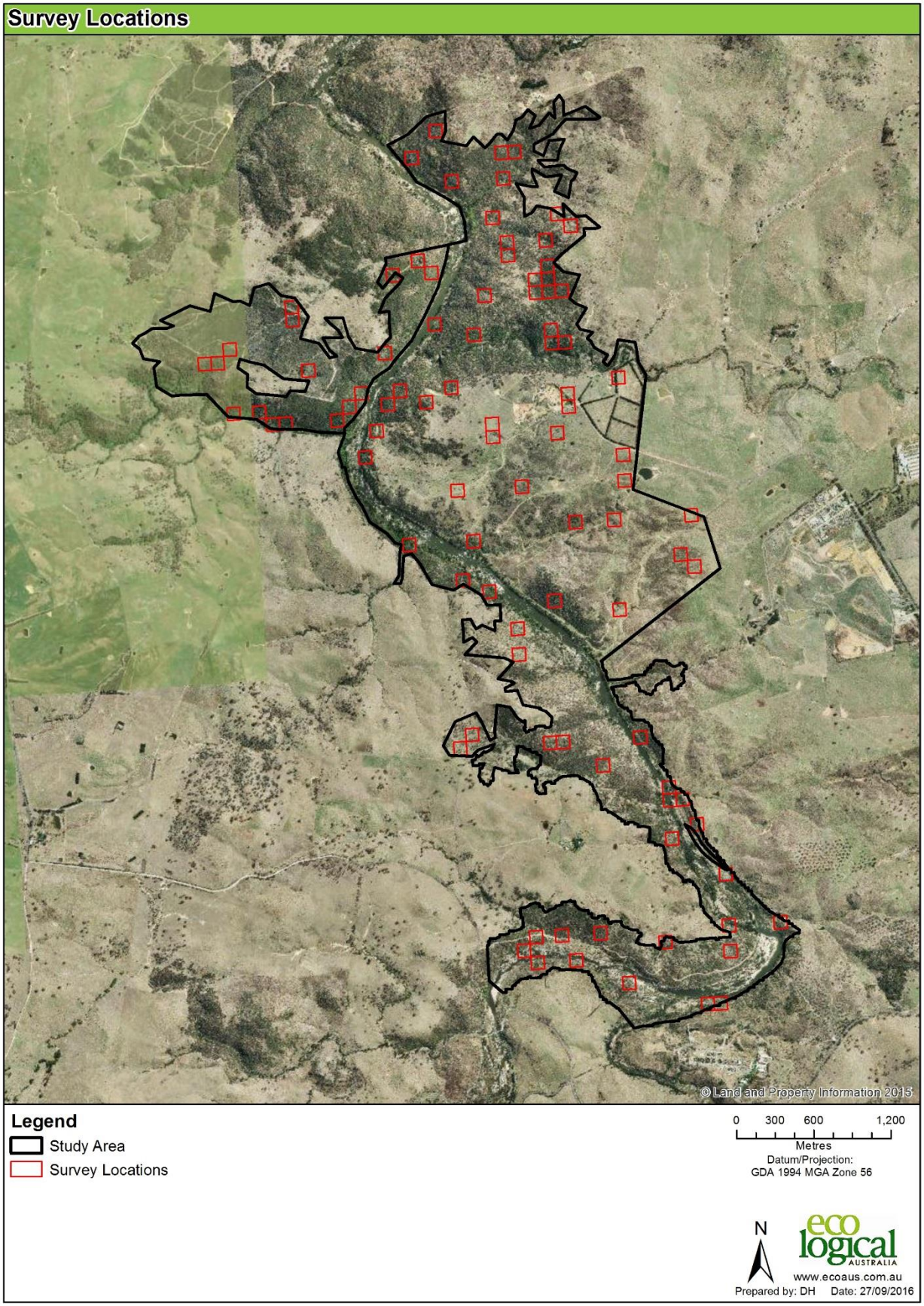

Figure 3: Location of randomly selected 100 m x 100 m quadrats

A qualitative and quantitative rapid assessment of habitat features and condition relevant to Rosenberg's Goanna was conducted within each quadrat, which included:

- Aspect
- Slope
- Observer
- Canopy cover (%) and arrangement
- Shrub cover (%) and arrangement
- Overall bush rock, rock piles, rock on rock, and rock overhangs (% cover for each attribute)
- Fallen timber
- Hollow logs
- Connectivity
- Termite mounds
- Wombat and rabbit burrows
- Photos
- General habitat description.

The field team traversed large areas of the site between quadrats and recorded incidental observations of termite mounds with a hand held GPS, noting recent disturbance or repair.

Habitat scores for each quadrat were extrapolated across the study area based on similar landscape features to create a habitat map.

2.3 Habitat mapping

Habitat feature data for each quadrat was converted to a subjective score according to its importance to Rosenberg's Goanna ecology (**Table 3**). Higher scores were given to features that positively correlated to Rosenberg's Goanna ecology (habitat that was suitable for foraging, overwintering, breeding, dispersal).

Scores from each habitat feature were summed to give a 'total habitat suitability score' for each quadrat. This score was allocated into five categories of 'Habitat Condition': very low, low, moderate, high, very high (**Table 2**).

Table 2: Habitat suitability score and habitat condition

Total Habitat Suitability Score	Habitat Condition
> 40	Very high
31 – 40	High
21 – 30	Moderate
10 – 20	Low
0 - 9	Very low

Habitat scores for assessed quadrats were used to extrapolate habitat condition across the study area based similar landscape features (contour lines, aspect, aerial vegetation mapping) to create a habitat map.

Survey limitations

Some quadrats could not be entirely traversed due to topography, such as high escarpments, steep slopes and riverine features. In these cases the habitat features were assessed from a distance, or the quadrat was re-allocated to an adjacent quadrat.

Two observers conducted the field survey, which may result in observer bias. To limit the influence of observer bias, both observers conducted the first quadrat together to calibrate their approach.

The hand held GPS units used to mark the location of termite mounds varying in accuracy depending on satellite reception. This means that the coordinates presented may have an error of up to 15 m.

Table 3: Habitat features assessed during the field survey

Habitat feature	Description	Importance for Rosenberg's Goanna	Weighting of habitat feature (score)
Aspect	The direction that the slope is facing.	Aspect is important for basking and overwintering habitat. An aspect ranging from west to north are important	Aspect 261° - 360° = 5 Aspect 90° - 260° = 1 Aspect 0° - 89° = 3
Slope	The gradient of the slope.	Increased slope often correlates with increased rock exposure. Steeper slopes with a west to north west aspect are good overwintering and basking sites	Slope > 15° = 5 Slope 15° - 4° = 3 Slope < 4° = 1
Canopy cover %	The percent cover of vegetation at the canopy level.	High canopy cover provides refuge and cover	Canopy cover > 12 % = 5 Canopy cover 5 – 12 % = 3 Canopy cover 1 – 4 % = 2 Canopy cover < 1 % = 0
Canopy arrangement	The distribution of the canopy: even, patchy, isolated clumps or nil.	A continuous canopy increases connectivity and cover	Even = 4 Patchy = 3 Isolated clumps = 2 Nil = 0
Shrub cover %	The percent cover of vegetation at the shrub level.	High shrub cover provides refuge and cover	Shrub cover > 49 % = 4 Shrub cover 19 - 49 % = 5 Shrub cover 6 – 18 % = 3 Shrub cover 1.2 – 5 % = 2 Shrub cover < 1.1 % = 0
Shrub arrangement	The distribution of shrubs: even, patchy, isolated clumps or nil.	A continuous shrub increases connectivity and cover	Even = 4 Patchy = 3 Isolated clumps = 2

Habitat feature	Description	Importance for Rosenberg's Goanna	Weighting of habitat feature (score)
			Nil = 0
Overall bush rock (m^2)	The approximate overall coverage of bush rock, calculated from both rock plates and scattered bush rock.		Not weighted
Rock piles	The number of occurrences of rocks piled together (three or more rocks). This measure only takes into account rocks large enough to contribute to a small rock crevice.	Large rock piles can create gaps for Rosenberg's Goanna	Rock piles >4 = 2 Rock piles 1 - 4 = 1 Rock piles < 1 = 0
Rock on rock (m^2)	The approximate overall coverage of bush rock in direct contact with other bush rock, calculated from both rock plates and scattered bush rock.	Rock on rock can provide gaps used as cover by a range of reptiles, and other fauna	Rock on rock > 1499 m^2 = 4 Rock on rock 501 m^2 – 1499 m^2 = 3 Rock on rock 101 m^2 – 500 m^2 = 2 Rock on rock 1 m^2 – 100 m^2 = 1 Rock on rock < 1 m^2 = 0
Rock crevices	The number of rock crevices which are large enough for a small goanna.	Rock crevices are an important refuge for Rosenberg's Goanna	Rock crevices present = 5 Rock crevices absent = 0 (added to) Rock overhangs present = 1 Rock overhangs absent = 0
Rock overhangs	The number occurrences of suspended rocks with a space between them and the ground.	Rock overhangs are an important refuge for Rosenberg's Goanna	
Fallen timber	Large woody debris in contact with the ground, with a diameter larger than 10 cm.	Fallen timber provides cover and habitat for Rosenberg's Goanna and prey items	Fallen timber > 500 m = 5 Fallen timber 200 m -500 m = 4 Fallen timber 100 m -200 m = 3 Fallen timber 50 m -100 m = 2 Fallen timber 10 m - 50 m = 1 Fallen timber 1 m -10 m = 0.5 (multiplied by) Hollow logs absent = 1
Hollow logs	The estimated total length of logs >100 mm diameter (in total length classes), and the number of logs with hollows which are large enough for a small goanna to enter.	Fallen hollow logs are used by Rosenberg's Goanna for cover	

Habitat feature	Description	Importance for Rosenberg's Goanna	Weighting of habitat feature (score)
			Hollow logs present = 1.5
Connectivity	A measure of habitat features near the boundary of the quadrat which would facilitate movement from one quadrat to the next. This measure is scored from 0 to 4 (with 0.5 increments). If the entire side of one quadrat facilitates easy movement (for example, due to high canopy and shrub cover) that side would contribute a score of 1. If one side is has features which are unlikely to facilitate movement (for example, an open plain, or a river) that side would contribute a score of 0. If one side has habitat features along half it's boundary (for example, rock piles) it may contribute a score of 0.5. If all sides facilitate movement, the quadrat would receive a maximum score of 4 (out of 4).	Contiguous habitat allows Rosenberg's Goanna to move freely about the landscape	Connectivity 4 = 5 Connectivity 3 – 3.5 = 4 Connectivity 2 – 2.5 = 2 Connectivity 0.5 – 1.5 = 1 Connectivity 0 = 0
Termite mounds	The number of termite mounds within the quadrat. Additional notes including evidence of disturbance, recent or active disturbance, evidence of repair, and photos, were recorded.	Termite mounds are used as breeding habitat	Termite mounds > 1 = 7.5 Termite mounds 1 = 5 Termite mounds 0 = 0
Wombat and rabbit burrows	The number of wombat burrows within the quadrat. Additional notes including height / diameter, evidence of disturbance, recent or active disturbance and photos, were recorded.	Anecdotal evidence suggests that Rosenberg's Goanna may use burrows as refuge	Burrows present = 2 Burrows absent = 0

3 Results

3.1 Literature review

A search of BioNET Atlas of NSW Wildlife found that there are no records of Rosenberg's Goanna within the study area (OEH 2016b). The closest record is 8 km away, within Brindabella National Park, although this species has also been recorded near Hall (11 km away), Cotter Pumping Station (13 km), and south if Tharwa along the Murrumbidgee River (over 30 km away). These records occur in similar landscapes to the study area.

Ginninderra Catchment Group recorded two camera trap observations of Rosenberg's Monitor, approximately in the centre of the study area, adjacent to the eastern bank of the Murrumbidgee River (GCG 2015).

3.2 Field survey

A total of 63 quadrats (51 woodland and 12 grassland sites) were assessed within the study area (**Figure 4**).

Thirty-six termite mounds were recorded across the study area within surveyed quadrats (19) and as incidental observations (17) (**Figure 5**). None of the termite mounds had evidence of activity from Rosenberg's Goanna or recent repair.

The dimensions of termite mounds recorded in the surveyed area are in **Table 4**.

Table 4: Termite mounds in the surveyed quadrats

Quadrat	Termite mound
28	1. No disturbance
36	1. No disturbance 2. No disturbance
103	1. Some disturbance at base, no repair 2. 1/3 of side removed, no repair
51	1. No disturbance
59	1. No disturbance
102	1. No disturbance
86	1. No disturbance 2. Yes disturbance, no repair
92	1. No disturbance
89	1. No disturbance 2. No disturbance 3. No disturbance

Quadrat	Termite mound
83	1. No disturbance
73	1. No disturbance 2. Yes disturbance, no repair 3. Yes disturbance, no repair
81	1. No disturbance

3.3 Habitat mapping

Of the 63 quadrats assessed:

- 11 quadrats were scored as very high habitat condition
- 16 quadrats were scored as high habitat condition
- 22 quadrats were scored as moderate habitat condition
- 8 quadrats were scored as low habitat condition
- 6 quadrats were scored as very low habitat condition

High and very high habitat condition was characterised by a west to north aspect, steep slope (generally > 10°), high overall percent cover of bush rock (generally > 1,500 m^2), moderate percent cover rock on rock (generally > 200 m^2), presence of multiple rock crevices, termite mounds, and hollow logs, and a high connectivity score (3 – 4). This habitat condition was generally mapped along north and west facing slopes in the northern portion of the study area, and small patches throughout the southern slopes of the study area. The southern side of Ginninderra Creek contained a large area of very high condition habitat, along with habitat further north (**Figure 6**).

Low and very low habitat condition was characterized by a low gradient slope (generally <5°), nil to isolated patches of shrub and canopy cover, low rock on rock (most often none), an absence of rock crevices, hollow logs, and termite mounds, and a low connectivity score (0). Most instances of very low and low condition habitat were located in open grassland/pasture, and in riparian vegetation along the Murrumbidgee River.

Habitat condition scores for quadrats were extrapolated across the study area to create a habitat condition map. However, some licence was taken to adjust scores for some sites that either were just short of or just over a particular condition threshold when creating the map. This was the case for quadrats 50 and 51, which scored "low" but were considered to be in "very low" condition and, conversely, quadrat 101 that was elevated from "high" to "very high" condition (**Figure 6**), based on our understanding of the surrounding landscape.

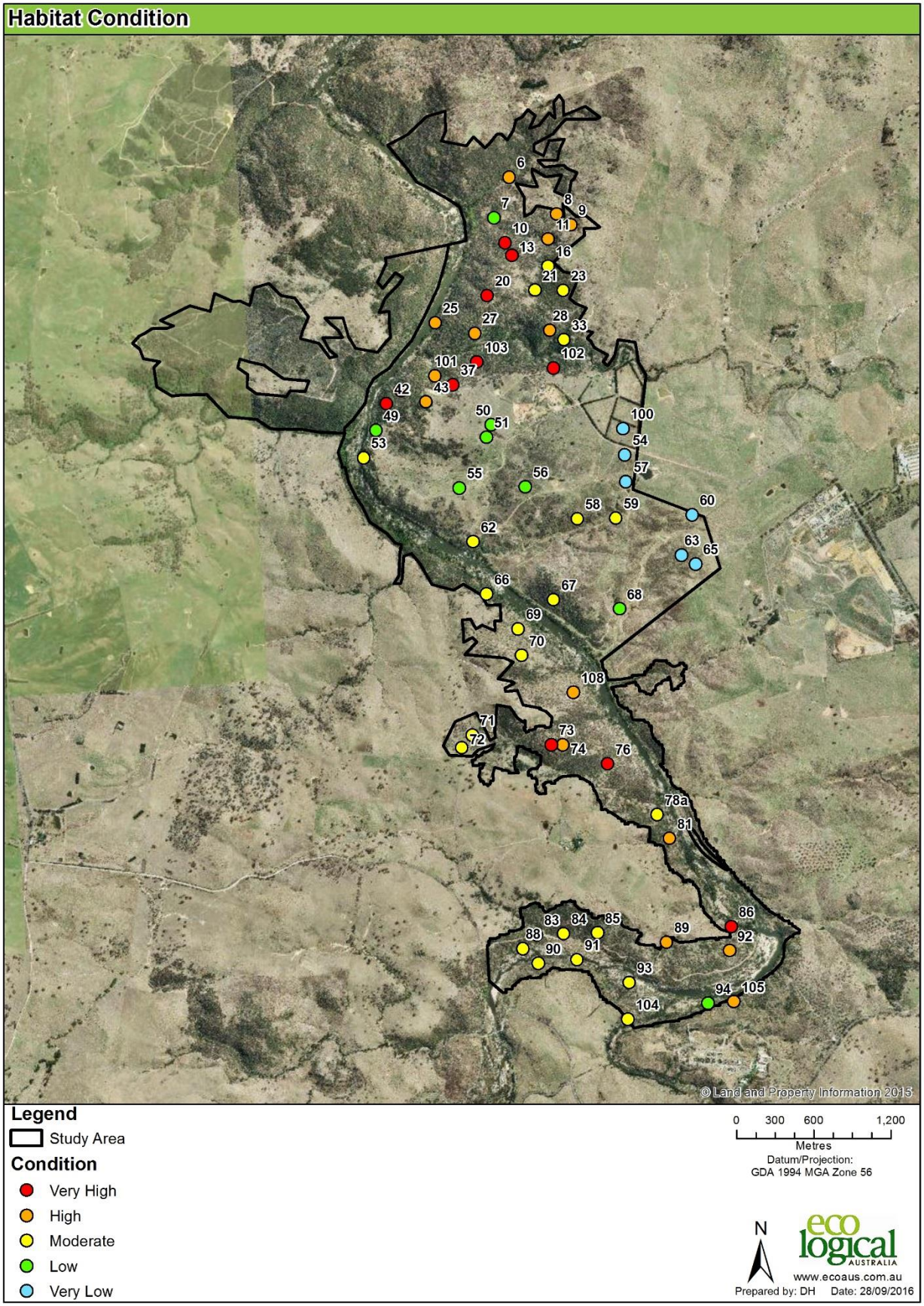

Figure 4: Location of assessed quadrats and their relative habitat condition.

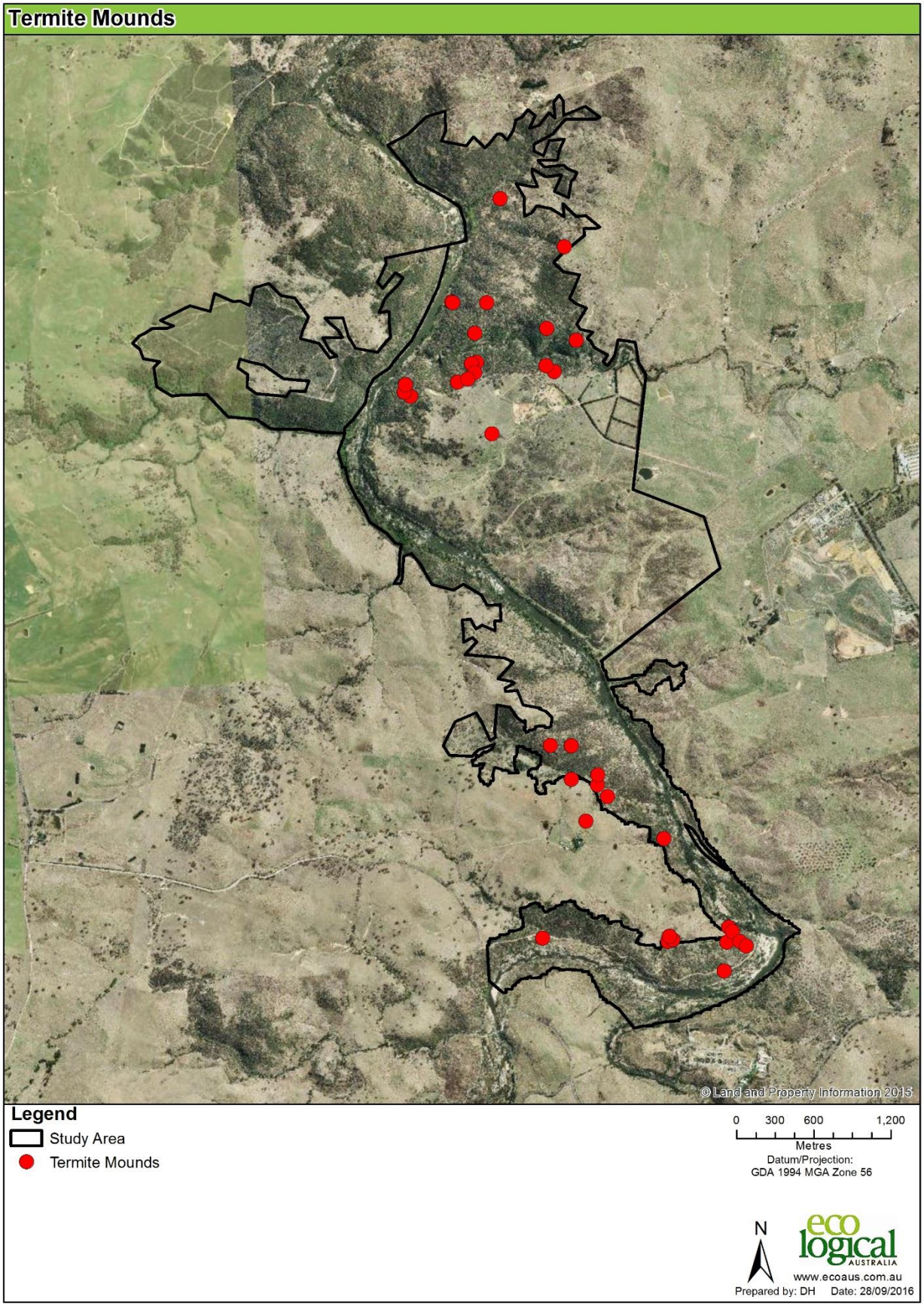

Figure 5: Termite mounds observed in the study area either in quadrats or incidentally. Note this does not represent all termite mounds present within the study area.

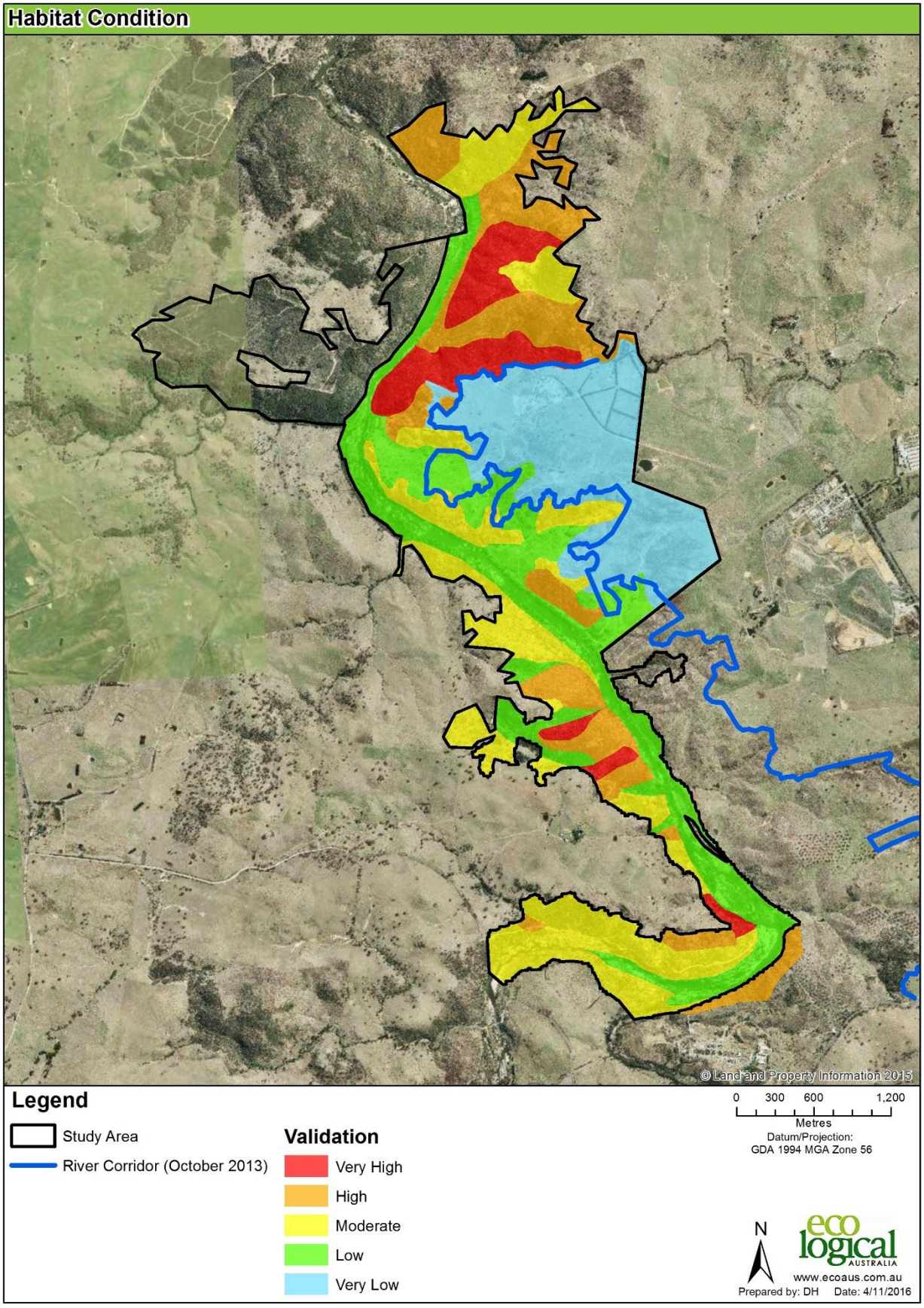

Figure 6: Rosenberg's Goanna relative habitat condition mapping across the study area surveyed.

4 Potential impacts of development

The generally accepted viewpoint is that many species of Varanid fare poorly when exposed to urbanisation; White and Burgin (2004) make some generalisations about the demise of Lace Monitors in and around urban Sydney and Shea (2010) suggests that the only reason Lace Monitors intrude into urban areas is due to their considerable powers of movement. The Lace Monitor does have a large home range (mean home range 64 ha, Weavers 1993) and individuals move large distances over short periods (up to 1.6 km in a day and 2.9 km over four days (Stebbins and Barwick 1968; Weavers 1993). It is likely that some suburban records in recent decades represent intrusions of individuals from large bushland reserves up to a few kilometres distance (Shea 2010). Whilst making valid comparisons between the two species, Shea (2010) also suggests that the Rosenberg's Monitor's apparent disappearance from some suburban environments is likely to be due to similar factors to those identified for the Lace Monitor, i.e. road mortality and predation by dogs. Yet there are many situations where Lace Monitor persists at the urban-bushland and rural-bushland interface around Sydney where there are substantial habitat remnants, sufficient resources and connectivity values (Ehmann et al. 1991). Within many National Parks and Council Reserves, on the eastern sea board at least, Lace Monitors not only survive at the urban interface but have also appeared to flourish, in some circumstances, surrounding BBQ/picnic facilities, surrounding rubbish dumps and along major roads where the species has been observed to take advantage of the road mortality on native and introduced fauna (pers. obs., R. Wells pers. comm.).

In the northern suburbs of Sydney and on the NSW Central Coast the Rosenberg's Goanna has appeared to benefit in some areas and flourished at the urban interface around Terrey Hills, Frenchs Forest, Davidson, Beacon Hill and Woy Woy where small 'hotspots' of distribution occur, and even where both this and Lace Monitors are sympatric (R. Wellington pers. obs.; R. Wells pers. comm.). In these locations the general observation that can be made is that such areas have been long developed. They tend to be adjacent to rocky ridgelines and/or gorges with associated creek-lines that have escaped development. Consequently, they have survived in areas where substantial suitable habitat and associated connectivity values have been retained and/or allowed to regenerate. Many of these urban areas have been developed slowly and without total removal of associated native vegetation all at once. This has likely facilitated the species survival and persistence at these locations. By contrast, urbanisation of areas that have been long cleared for agriculture purposes lack the contiguous habitat and resources required to support species with large home range requirements.

Consequently, the Belconnen situation might well be informed by examining successful interface zones elsewhere and perhaps allow the application of favourable design and ameliorative measures that enhance the likelihood of Rosenberg's Goanna persistence within the conservation lands.

Urban development at Ginninderry could thus result in a number of positive and negative impacts. Some of these impacts are typical of urbanisation. However, the conservation of habitat, ranging in condition from very low to very high presents an opportunity to increase the overall condition of Rosenberg's Monitor habitat.

Likely impacts on Rosenberg's Goanna include:

- Predation by domestic animals, particularly dogs
- Increased road mortality
- Increased disturbance to habitat, this includes changes in bushfire frequency, bush rock and fire wood collection, weed invasion, anthropogenic disturbance, changes to the diversity and abundance of prey

- Restriction to dispersal pathways
- Increased areas of habitat set aside and managed for conservation within the riparian corridor
- Improved habitat connectivity along drainage lines across the region
- Greater public awareness of the species and the purposes of the conservation area.
- An improved understanding of their requirements and other strategic connectivity initiatives to provide for the species more broadly at a wider locality and regional level.

5 Habitat management and recommendations

While urbanisation can negatively affect native species, it can also provide a mechanism to fund conservation initiatives that improve habitat management. The establishment of a conservation area that encompasses the Ginninderra Gorge and Murrumbidgee River riparian zone would be an excellent conservation outcome.

This report has identified a significant distribution of habitat elements to support a viable population of Rosenberg's Goanna in the study area. The following section outlines short, medium and long term management actions to benefit Rosenberg's Goanna.

The current conservation area retains all very high condition habitat, and the majority of high condition habitat. Large areas of the corridor are in low to moderate condition that could be improved under appropriate management. While a large portion of the corridor faces south west, and is of low over-wintering value, it has potential to provide foraging habitat and dispersal pathways.

Factors driving the low to moderate habitat condition score include vegetative cover, connectivity, lack of fallen timber, absence of termitaria and aspect. Many of the features can be enhanced through appropriate management. However, management is also required to ensure that areas of very high and high condition habitat are not negatively affected by development.

5.1 Short term management

Stage	Action
Current land use	Protect existing habitat values within the corridor
	Restrict access
Precinct planning	Minimise edge to area ratio of conservation area, and maintain a minimum width of 300 m from the edge of a permanent water courses (Murrumbidgee River and Ginninderra Creek – below the falls) which are bordered by potential habitat (**Figure 7**). Note, that the majority of the current River Corridor satisfies this action.
	Reduce the potential for edge effects on mapped very high and high condition habitat with appropriate setbacks for residential development
	Speed restrictions to limit road kill, particularly near high and very high condition habitat
Prior to construction	Construct fences to prevent Rosenberg's Goanna from entering the residential area
	Identify, mark and protect termite mounds and key rock crevices within the conservation area
	Construct signage educating residents about Rosenberg's Goanna, and the importance of termite mounds and pet control

Stage	Action
	Prepare habitat restoration plan and threatened species management plan for the conservation area, which includes monitoring
	Commence baseline monitoring of Ginninderra Creek Catchment Rosenberg's Goanna population
	Prepare a Construction Environmental Management Plan (CEMP) that includes sediment and erosion controls

5.2 Medium term management – construction phase

Stage	Action
Enhancement	Habitat enhancement/enrichment of conservation area in accordance with habitat restoration plan/threatened species management plan (cognisant of all species on site)
	Relocate loose bush rock and timber (especially hollow logs) within the proposed residential area to the conservation area as per the habitat restoration plan/threatened species management plan
Design	Ensure access roads for construction do not fragment retained habitat
	Clearly demarcate the boundary of the conservation area
	Locate site office, plant equipment and laydown areas outside conservation area

5.3 Long term management (post construction)

Stage	Action
Maintenance and management	Maintenance and management of the habitat values and threats to biodiversity in the conservation area
	Control access within the conservation area
Monitoring	Monitor implementation of habitat restoration, including use of restored habitat by Rosenberg's Goanna
	Monitor status of Rosenberg's Goanna population and habitat values (along with other important species)
Conservation covenants	Restrict cat and dog ownership in some areas of the development adjacent to the conservation area

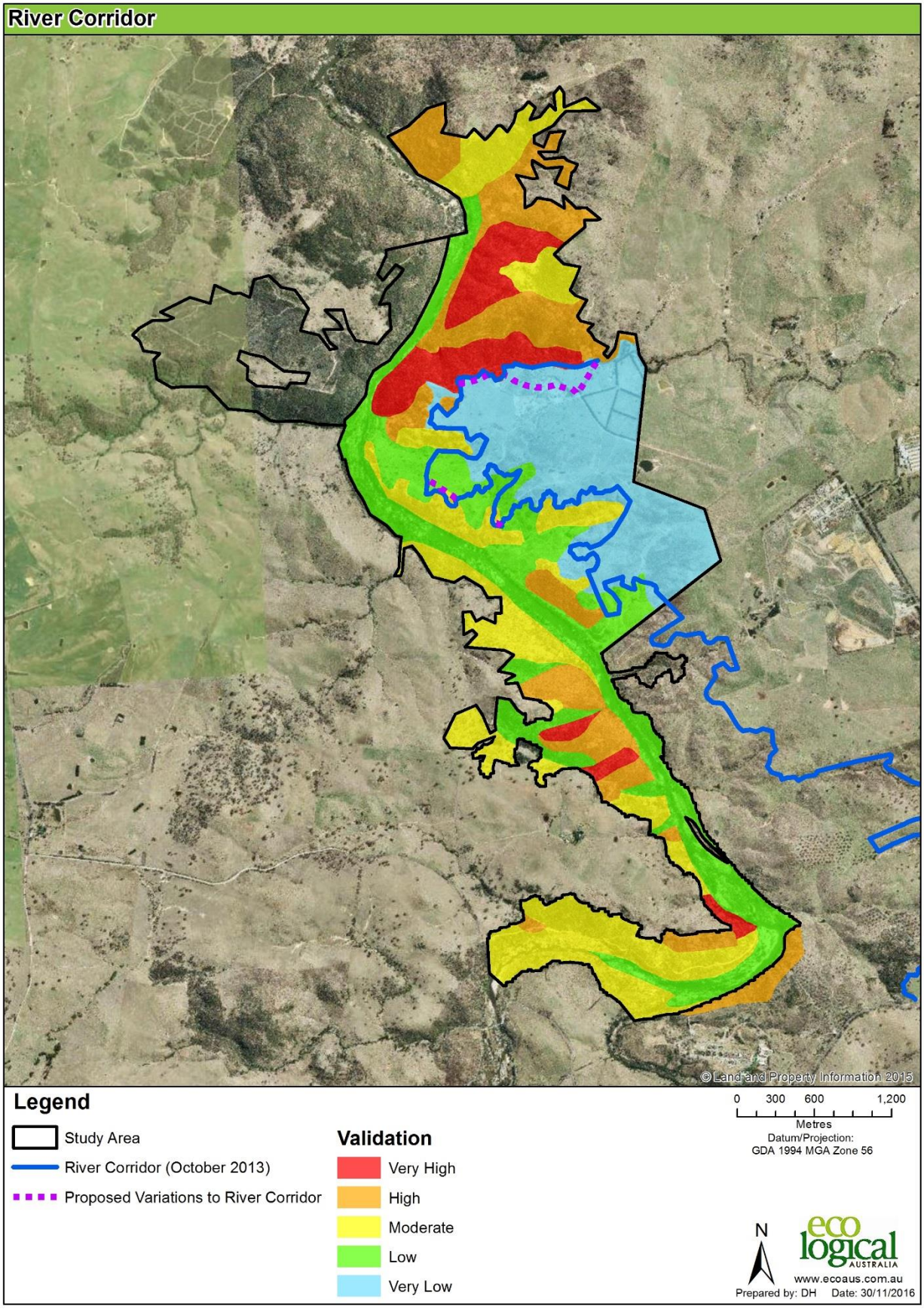

Figure 7: Proposed alteration to River Corridor (refer to Section 5.1)

5.4 Further study and research opportunities

A large area of wooded vegetation west of the Murrumbidgee River was inaccessible during the field survey. A better understanding of the regional extent of habitat would be gained by collecting data from this area.

In addition, data could be gathered from the conservation area situated in the ACT. Having an understanding of habitat condition for Rosenberg's Goanna in this area will aid future habitat restoration and enhancement programs.

The NSW Office for Environment and Heritage has published a Species Action Statement for the Rosenberg's Goanna that contains a list of actions for the species that should be addressed for the Ginninderra Creek population of the species. These actions are:

- In known occupied habitat and key movement areas, install signs to warn motorists of the species' presence and significance, and investigate underpass options where appropriate.
- Undertake investigations into taxonomic/genetic differences between the various forms of the 'species', between the Sydney Basin and Southern Slopes and Tablelands where habitat utilisation differs.
- Negotiate conservation agreements to protect known habitat, preferably perpetual, funded mechanisms such as BioBanking agreements. Note different requirements between Sydney Basin (sandstone communities) and Southern Slopes and Tablelands (grassy/shrubby woodlands). Retention of fallen timber, bush rock and termite mounds to form standard management actions.
- Initiate community education program with a focus on important habitat elements such as termite mounds and fallen timber: development of landholder guidelines; and community education and awareness-raising action.

Of broader relevance and interest to a fuller understanding of this species, the population at Ginninderry and implications for conservation management are suggestions by the IUCN Red List for further research into the localised threats and habitat status to ensure localised population declines do not increase. As with many Varanid species, gene sequencing studies are also needed to resolve whether this species is in fact a complex of two or more species. This is particularly important since habitat loss may particularly affect the distinct eastern populations.

To address these information gaps and research directions a draft research proposal has been prepared by Dr David Shorthouse and Dr Will Osborne (**Appendix A**)

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Appendix A : Further study and research opportunities

Rosenbergs goanna (*Varanus rosenbergi*) at Ginninderra Creek

Background

(Extract from) IUCN Red List of Threatened Species http://www.iucnredlist.org/details/full/178031/0

Justification for Red List listing

Varanus rosenbergi has been listed as Least Concern due to its wide distribution, in some parts of which it is said to be common. Currently, it is not likely to be under any major threat. However, further research and monitoring is needed as the minor threat of habitat degradation could cause a decline in the population in the future. This may have particularly serious effects on the conservation status of eastern populations, if these are recognised as a distinct species in the future.

Conservation Action

This species has a level of protection in Australia through legislation, since all Australian varanids are banned from export (S. Sweet pers. comm.). Further research into the localised threats and habitat status is suggested to ensure localised population declines do not increase. As with many Varanid species, gene sequencing studies are needed to resolve whether this species is in fact a complex of two or more species (E. Pianka pers. comm.). This is particularly important since habitat loss may particularly affect the distinct eastern populations.

(Extract from) NSW Office of Environment and Heritage Species Action Statement http://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10826

Proportion of the species' distribution on reserve

58% of the species' distribution occurs on reserve (within NSW National Parks and Wildlife Service estate).

Critical actions for this species

The key threats to the viability of landscape-managed species are loss, fragmentation and degradation of habitat, and widespread pervasive factors such as impacts of climate change and disease. Many of these threats are addressed by NSW planning, native vegetation, and biodiversity legislation, policy and programs including the offsets program (BioBanking, NSW Biodiversity Offsets Policy for Major Projects), Biodiversity Certification, management of environmental water and reservation under the *National Parks and Wildlife Act 1974*.

Action toolbox

- In known occupied habitat and key movement areas, install signs to warn motorists of the species' presence and significance, and investigate underpass options where appropriate.
- Undertake investigations into taxonomic/genetic differences between the various forms of the 'species', between the Sydney Basin and Southern Slopes and Tablelands where habitat utilisation differs.
- Negotiate conservation agreements to protect known habitat, preferably perpetual, funded mechanisms such as BioBanking agreements. Note different requirements between Sydney Basin (sandstone communities) and Southern Slopes and Tablelands (grassy/shrubby woodlands). Retention of fallen timber, bush rock and termite mounds to form standard management actions.
- Initiate community education program with a focus on important habitat elements such as termite mounds and fallen timber: development of landholder guidelines; and community education and awareness-raising action.

The actions listed in the action toolbox are supplementary to NSW legislation, policy and programs and can be used by stakeholders, where applicable to guide management at a site, regional or state scale.

Research and further study proposal for Riverview

A large part of the NSW Action Toolbox relates to planning and management of land and activities in the vicinity of Ginninderra Creek and Murrumbidgee River and adjacent land. These are already covered in the existing management plan for the River Corridor conservation area and planning arrangements for future development of urban land.

However, there are opportunities for Riverview to initiate and support research efforts to conserve Rosenberg's Goanna as part of the environment along the Murrumbidgee River Corridor at Ginninderry. These opportunities arise from both the Red List and NSW government action statements.

The fundamental issues to be resolved to support conservation of this species will be understanding the extent of its occurrence and safe movement within the riverine corridor areas, and the extent to which it can still access habitat which will support breeding resources such as termite mounds, refuge sites and suitable prey. Related to this is the question of the extent of connectivity of the Ginninderra Creek population with any populations in the ACT section of the corridor and other occurrences of the species in the region.

1. Population status and habitat use

Further research into the localised threats and habitat status is proposed to ensure localised population declines do not increase (IUCN Red List above). The key threats to the viability of landscape-managed species are loss, fragmentation and degradation of habitat, and widespread pervasive factors such as impacts of climate change and disease (NSW Species Action Statement).

1(a) Regional context

There are several records of Rosenberg's Goanna in and around the ACT within a series of landscape elements that may exhibit a gradient in level of threats: (1) extensive riverine conserved systems i.e. Murrumbidgee and Molonglo Rivers Corridors and landscapes contiguous with the Googong Dam and Cotter dams), (2) remote reserved areas in the ACT and region (large forest and woodland reserves, or private property if relatively undisturbed. Namadgi NP and other similar fairly remote reserves (like

Cummbeyun NR, Munddonen NR) seem suitable. (3) forest and woodland reserves within urban Canberra (Ainslie Majura etc). (4) rural and other un-protected lands that may surround protected areas.

In addition to conducting actual surveys with remote cameras or by radio-tracking, research methods might include some form of citizen science (goanna watch, interviews, questionnaires, sand track surveys).

1(b) Habitat use and distribution in the Ginninderry area

Understanding the home range and use of habitat elements in the Ginninderry area will be fundamental to planning and management of land use within the conservation area and adjacent rural and urban land. This goes beyond delineating of development boundaries to location and intensity of human activities, management of access and usage patterns, predator control and other issues. Studies should include

- Home range studies, including radio-tracking of Ginninderry animals, with the aim of identifying the extent of occupied habitat, determining the extent of connectivity in the landscape associated with the Ginninderra creek animals.
- Documenting seasonal movements, habitat use, choice of overwintering sites, diet (including change as urban development progresses and/or recovery of native animal prey as a result of conservation management), use of termite mounds and other habitat features (e.g. rock overhangs) for key life stages.
- Understanding implications of any movement of animals from core habitat into adjacent urban land in order to estimate the impact of any losses on the protected population and determining ways to prevent such losses.

1(c) Pro-active implementation of management and monitoring protocols contained in the management plan for the conservation area and adjacent land.

- Facilitating conservation near the urban edge can use the outcomes from the (above) radio-tracking/camera study with the objective of developing approaches to guide lizard movements and reduce mortality near developed areas. Measures such as physical barriers and underpasses to prevent or guide lizard movement away from (or through) high-risk areas.
- Consideration could be given to collaborating with others researching the interaction between native fauna and transport infrastructure, including the use of barriers that could be used to prevent the lizards from moving onto roads or into suburbs.

2. Genetic studies

As with many Varanid species, gene-sequencing studies are needed to resolve whether this species is in fact a complex of two or more species.

- Support research into genetic status of Rosenberg's Goanna found near Ginninderry. Opportunities may include: collection of biological material for gene studies; funding specific gene sequencing work.

3. Promote and participate in coordinated regional threatened species recovery

Given the Ginninderry development straddles the ACT and NSW border and there is a strong bias towards taking coordinated approaches to conservation and management of threatened species and conservation in this region, support for a cross-border initiative is likely to benefit the Ginninderry population.

Action: Support establishment of a recovery team for Rosenberg's Goanna that is focused on conservation of the species in the southern tablelands region of NSW and the ACT.

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