Goyder South Hybrid Renewable Energy Facility

Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan

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25 January 2024

Version 2

Prepared by EBS Ecology for NEOEN Australia Pty Ltd

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DECLARATION OF ACCURACY

Declaration of Accuracy

In making this declaration, I am aware that section 491 of the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) make it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the Environment Protection and Biodiversity Conservation Regulation 2000 (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this decision.

Signed:

Full name: Louis de Sambucy
Position: Managing Director
Organisation (please print): Neoen Australia Pty Ltd
EPBC Referral Number: 2021/8958; 2021/8957
Name of Action Management Plan this document and declaration refers to: Goyder South Hybrid Renewable Energy Facility Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan.
Date: 25 January 2024

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GLOSSARY AND ABBREVIATION OF TERMS

BDBSA	Biological Databases of South Australia
brumation	A state of torpor (see torpor) exhibited by reptiles.
business days	A day that is not a Saturday, a Sunday or a public holiday in the state or territory of the action.
cm	centimetres
compliance report	means written reports: i. providing accurate and complete details of compliance, incidents, and non-compliance with the conditions and the plans; ii. consistent with the Annual Compliance Report Guidelines, Commonwealth of Australia 2014; iii. include a shapefile of any clearance of any protected matters, or their habitat, undertaken within the relevant 12 month period; iv. annexing a schedule of all plans prepared and in existence in relation to the conditions during the relevant 12 month period; and v. advising of the identity and current contact details of all persons authorised to act for the approval holder in relation to this approval.
Cth	Commonwealth
DCCEEW	Department for Climate Change, Energy, the Environment and Water
Department	The Australian Government agency responsible for administering the EPBC Act. At the time of writing this PBTL Research Plan, DCCEEW is the Department.
DEW	Department for Environment and Water (South Australian Government)
DoE	Department of the Environment (now DCCEEW) (Australian Government)
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities (Australian Government; now DCCEEW)
EBS Ecology	Environment and Biodiversity Services Pty Ltd – trading as EBS Ecology
environmental offset	A measure that compensates for the residual adverse impacts of an action on the environment (DSEWPC 2012a).
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
Goyder South Hybrid Renewable Energy Facility	A renewable energy development located between Burra and Robertstown in the Mid North of South Australia. The Goyder South Hybrid Renewable Energy Facility includes the proposed actions described in EPBC Act referrals 2021/8957, 2021/8958, 2021/8959 and 2021/8960.
Goyder South	Goyder South Hybrid Renewable Energy Facility
GPS	Global Positioning System (a satellite based radio navigation system)

ha	hectare(s)
IUCN	International Union for Conservation of Nature
km	kilometre(s)
m	metre(s)
mm	millimetres
MNES	Matter(s) of national environmental significance
MW	Megawatt
NEOEN	NEOEN Australia Pty Ltd
NPW Act	*National Parks and Wildlife Act 1972* (South Australian)
OMP	Offset Management Plan
PBTL	Pygmy Blue-tongue Lizard (*Tiliqua adelaidensis*)
PBTL Recovery Plan	*Recovery Plan for the Pygmy Bluetongue Lizard Tiliqua adelaidensis* (Duffy *et al.* 2012)
PBTL Research Plan	the Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan, required under condition 9 of **EPBC Act** approval 2021/8958, and aimed at monitoring and better understanding the potential long-term impacts to the **Pygmy Blue-tongue Lizard** resulting from wind turbine noise, vibration and shadow flickering.
Project	The Goyder South Project (incorporating Stage 1A, Stage 1B and the Overhead Transmission Line and Substation)
Project Area	The area (or boundary) in which the Project will be located, as shown in mapping.
Project Owner	NEOEN Australia Pty Ltd
residual impact	The remaining, unavoidable impacts (DSEWPC 2012a).
SA	South Australia / South Australian
Significant impact	As defined in Matters of National Environmental Significance: Significant impact guidelines 1.1 (DoE 2013).
sp.	species (singular)
spp.	species (plural)
SPRAT	Species Profile and Threats
WTG(s)	Wind Turbine Generator(s)

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1 INTRODUCTION

NEOEN Pty Ltd (NEOEN) is contracted by Goyder Wind Farm 1 Pty Ltd; Goyder Wind Farm 1B Pty Ltd and Goyder Wind Farm Common Asset Pty Ltd to ensure compliance with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approvals on behalf of the Goyder South Hybrid Renewable Energy Facility (the Goyder South Project; the Project). EPBC Act approval has been obtained to impact Pygmy Blue-tongue Lizard (PBTL; *Tiliqua adelaidensis*) habitat within the Stage 1A (EPBC 2021/8958), Stage 1B (EPBC 2021/8957) and Common Asset (Overhead Transmission Line (OTL) and Substation) (EPBC 2021/8959) components of the Goyder South Project.

The Stage 1A and Stage 1B EPBC Act approvals include conditions that require a Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan to be developed and implemented to monitor and better understand the potential long-term impacts to the PBTL resulting from wind turbine noise, vibration and shadow flickering. As such, this Goyder South Hybrid Renewable Energy Facility Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan (PBTL Research Plan) has been prepared to guide the establishment, implementation and management of the required research and meet the EPBC Act approval conditions.

The potential impacts of wind turbine noise, vibration and shadow flickering, on PBTLs is currently not well understood. Initial research on PBTL's and potential impacts of wind farms on the species has been undertaken at the Hornsdale Wind Farm. However, this research was too short in duration and there were not enough lizards in close proximity to wind turbines to undertake effective and robust research.

The aim of this PBTL Scientific Monitoring and Research Plan is to establish a long term research project, in conjunction with a recognised research organisation, to investigate the potential impacts of wind farms on PBTL in the mid north region of SA.

2 BACKGROUND

NEOEN is developing the Goyder South Project between Burra and Robertstown in the Mid North of South Australia (SA). The Project combines wind, solar and energy storage in one integrated project and will be capable of delivering a steady, reliable, dispatchable output of power throughout the day and night. The Goyder South Project will generate more than 4,800,000 MWh of power annually and is comprised of:

- A wind farm of up to 163 turbines with a capacity of up to 1200 Megawatts (MW), a maximum hub height of 121 metres (m), a maximum blade length of 78 m and an overall maximum height (tip height) of 199 m;
- A solar farm (across two sites) of up to 3000 hectares (ha) of solar panels with a capacity of up to 600 MW;
- An energy storage facility (lithium-ion battery) with a capacity of up to 900 MW / 1,800 MWh (2 hours);
- Associated infrastructure for connection to the electricity grid including three substations, access tracks, underground connection cabling and overhead transmission lines;
- Permanent operations and maintenance compounds;
- Temporary construction compounds for both wind and solar components, including concrete batching plants; and
- A number of meteorological masts (in addition to those already on the site) to record wind speed and other meteorological data, both pre- and post- construction.

As the Goyder South Project will total up to $3 billion in investment, NEOEN propose to implement the Project in stages, with each stage having its own legal entity, construction contracts and financing packages. An overview of each stage currently proposed for development, along with the corresponding EPBC Act approvals sought and obtained is outlined in Table 1. Note that a variation to the conditions attached to the EPBC Act approval for the Common Asset (Overhead Transmission Line (OTL) and Substation) was received, as outlined in Table 1.

Table 1. Current proposed stages and corresponding EPBC Act approvals for the Goyder South Project.

Project Stage / Proposed Action	Legal entity	EPBC Referral Reference	EPBC Referral Decision	Date EPBC Approval Received
Stage 1A (38 WTGs and associated infrastructure)	Goyder Wind Farm 1 Pty Ltd	2021/8958	Controlled Action	5/07/2022
Stage 1B (37 WTGs and associated infrastructure)	Goyder Wind Farm 1B Pty Ltd	2021/8957	Controlled Action	15/08/2022
Common Asset (OTL and Substation)	Goyder Wind Farm Common Asset Pty Ltd	2021/8959	Controlled Action	22/08/2022
			Variation of conditions attached to approval	Variation received 19/12/2022
Battery	NEOEN Australia Pty Ltd	2021/8960	Not a Controlled Action	N/A

Eash of the currently proposed stages of the Project are shown in Figure 1. Other components of the Goyder South Project, including the remaining wind farm areas, the two solar farms, overhead transmission lines and substations are considered to be potential future stages as they are not currently commercially viable and there is currently no immediate prospect of these components/stages proceeding to construction.

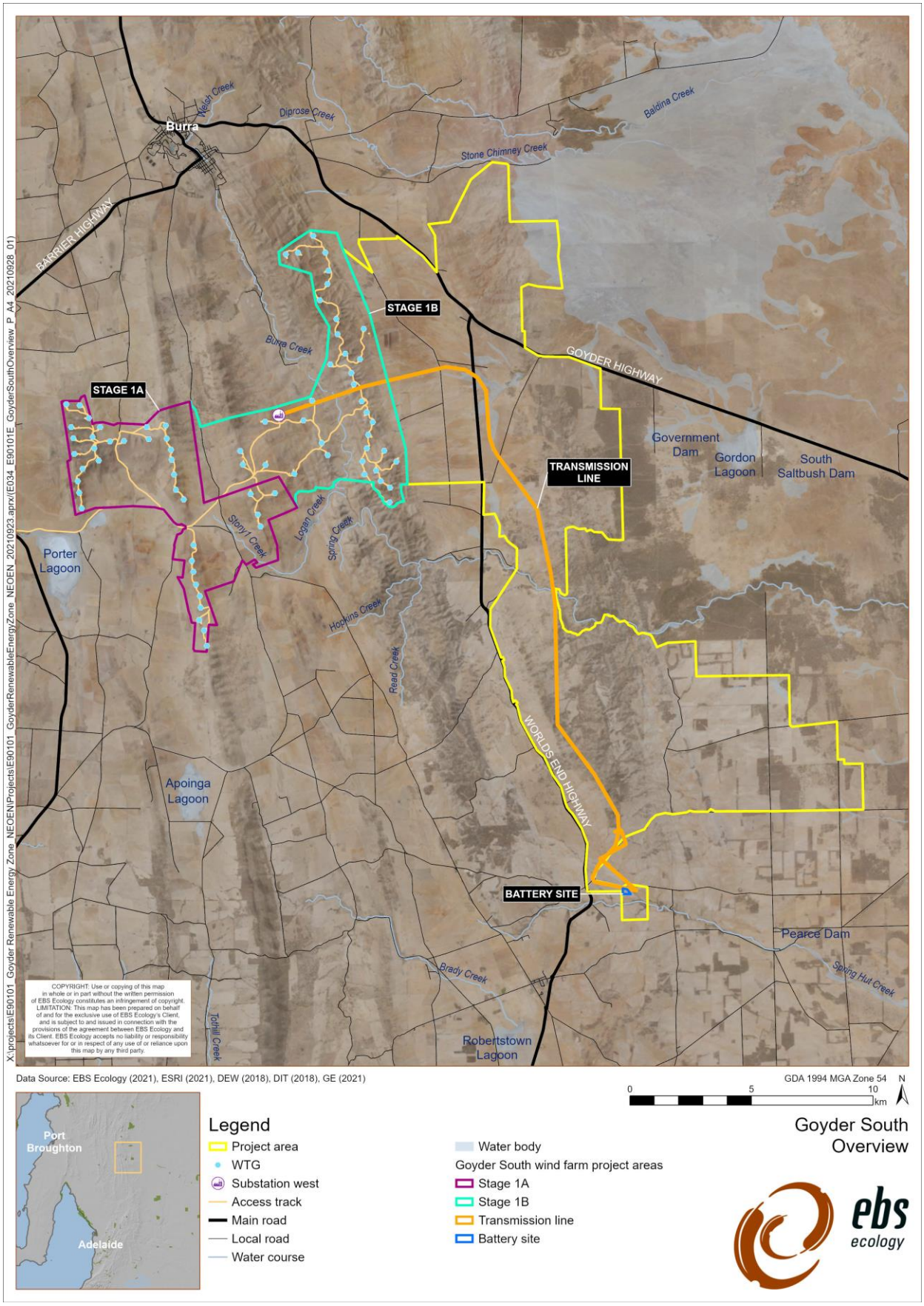

Figure 1. Current proposed stages of the Goyder South Project.

2.1 Previous reports

The following reports and documentation should be referred to for important background and supporting information:

- *Goyder South Hybrid Renewable Energy Facility Flora and Fauna Assessment* (EBS Ecology 2020)
- *Goyder – Pygmy Bluetongue Lizard Survey March 2021* (EBS Ecology 2021)
- *Goyder South Hybrid Renewable Energy Facility: Stage 1A Preliminary Documentation* (EPBC 2021/8958) (EBS Ecology 2022a)
- *Goyder South Hybrid Renewable Energy Facility: Stage 1B Preliminary Documentation* (EPBC 2021/8957) (EBS Ecology 2022b)
- *Goyder South Hybrid Renewable Energy Facility Pygmy Blue-tongue Lizard Management Plan* (PBTL Management Plan) (EBS Ecology 2023)

2.2 EPBC Act approval conditions

A series of approval conditions were detailed in the approval notification for each component of the project. Two of the key approval conditions for Stage 1A and Stage 1B was for NEOEN to develop and implement a PBTL Scientific Monitoring and Research Plan. The exact wording of the two relevant approval conditions (Condition 9 and 10) are provided below. The Stage 1A (2021/8958) and Stage 1B (2021/8957) EPBC Act approvals have specific conditions of approval outlining the requirement for a Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan, which are provided in Table 2 and Table 3 respectively. As such, this document has been prepared to satisfy the approval conditions and guide the establishment, implementation and management of the required research.

Table 2. Relevant conditions of approval associated with the Stage 1A (2021/8958) EPBC Act approval.

Approval Condition	Summary	Reference
Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan 9. To monitor and better understand the potential long-term **impacts** to the **Pygmy Blue-tongue Lizard** resulting from wind turbine noise, vibration and shadow flickering, the approval holder must submit to the **Department** for the **Minister**'s approval a Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan (PBTL Research Plan) within 12 months of the date of this approval. The PBTL Research Plan must:		
a. be prepared by a **suitably qualified researcher**;	Dr Travis How and Professor Mike Gardner have prepared this document. Dr Travis How is currently the Director and Principal Ecologist at EBS Ecology. Travis has undertaken extensive PBTL surveys and assessments, was the co-author of the PBTL Recovery Plan (2012) and is currently a member the PBTL Recovery Team. Professor Mike Gardner is the Professor of Biodiversity / Ecology at Flinders University, the current Chair of the PBTL Recovery Team, has / is supervisor of a number of PhD and Honours students researching PBTL and coordinating several large grants focused on PBTL research.	Refer to Appendix 1 for CV's
b. be designed, primarily, to generate and analyse a decade of data to improve the understanding of the long-term **impacts** of wind turbine noise, vibration and shadow flickering on **Pygmy Blue-tongue Lizard**;	The research design is outlined in Section 4 and focuses on measuring impacts of wind turbines on PBTL. The research will be undertaken over a 10-year period to provide the timeframe required to determine long term impacts to the species. The research has a variety of long-term aims, focused both directly on PBTL ecology and behaviour and indirectly on key PBTL habitat requirements (spiders and spider holes). As PBTL rely on spider holes for refuges, this is a key element to the species persistence in an area.	Refer to Section 4

Approval Condition	Summary	Reference
	The collection of data, over a 10-year period, will allow a significant amount of data analysis to be undertaken on a very robust dataset. As a result of the long-term data collection, seasonal variation and influence will be reduced substantially and any impacts from the wind turbines will be clear. The data collected over a 10-year research period will be statistically analysed to a standard that will allow publication in international scientific research journals.	
c. clearly specify research objectives and methodologies;	The overall aim of the research program is to understand the impact of wind farms on PBTL. The research plan further breaks this down into a series of questions / aims associated with the potential impacts from turbines (vibration, noise, shadow flicker) and development (human activity, habitat fragmentation). The questions raised are best answered by implementing field-based studies investigating PBTL at varying distances to wind turbines. Three wind turbines have been identified as the most appropriate for this research due to their proximity to known PBTL populations and the most likely to be impacted by wind turbines and associated infrastructure.	Refer to Section 4.1 and Section 4.2
d. specify timelines and/or milestones for delivery of findings, reports and scientific paper publication;	The research program will commence in Year 0 (July 2024) which will allow time to complete the research agreement between Flinders University and Neoen. Year 0 will commence with the recruitment of research students, the collection of baseline data and refinement of methodologies. Years 0 through to 6 will employ a research assistant to coordinate data collection supervised by Prof Gardner. Casual field assistants will also be employed to collect data and post-graduate studies will commence. Any discreet projects within the program that have been completed will be published as they are completed, primarily through Honours and PhD research. Years 7 to 10 will continue the data collection, however two post-doctoral researchers will be employed to analyse the data and prepare scientific research papers. This will occur in conjunction with PhD and Honours students. An annual research report will be prepared in line with Annual Compliance Reporting required for the Goyder South Hybrid Renewable Energy Project. This will provide an annual update on the progress of the research program over the life the project.	Refer to Section 4.4 and Table 8

Approval Condition	Summary	Reference
e. incorporate contemporary experimental design and methodologies including, but not limited to, those applied by the **PBTL Recovery Team**	The PBTL Recovery Team does not undertake research or experiments on PBTL. The group is focused on coordinating on-ground activities associated with PBTL that different organisations and agencies are undertaking. To date, all research and experimental design developed for the PBTL has been undertaken by Flinders University staff and students, while SA Museum had involvement previously (when Dr Mark Hutchinson was the Curator of Reptiles, now retired). The experimental design and methodologies were therefore developed by Prof mike Gardner (Flinders University) and Dr Travis How (EBS Ecology). The research objectives and aims as well as the broad approach were discussed at a PBTL Recovery Team meeting. This discussion was valuable and received input from a variety of agencies and organisations. The majority of the Recovery Team members, outside of Flinders University staff, are not academic researchers and therefore had limited input into the detailed design and methods that will be implemented.	Refer to Section 4.3
f. contain detailed costings and a commitment by the approval holder to fully fund at least 87 percent (Stage 1A) and 13% (Stage 1B) of the total cost of implementation of the PBTL Research Plan for at least 11 years	Stage 1A will fund $4,150,073.83 (87%) plus 10% contingency (if required) of the research program. Stage 1B will fund $620,125.97 (13%) plus 10% contingency (if required) of the research program. Neoen Australia will commit the funding for the research program for the full duration of this program (11 years).	Refer to Section 4.7, Section 5.3 and Table 8
The approval holder must not **commission** unless the PBTL Research Plan has been approved by the **Minister** in writing.		

Approval Condition	Summary	Reference
10. In relation to the PBTL Research Plan required under condition 9, the approval holder must provide to the **Department:**		
a. signed contracts exchanged between a **suitably qualified researcher** and the approval holder committing both parties to implement the PBTL Research Plan within 24 months of the date of this approval;	Neoen Australia will commit the funding for the research program for the full duration of this program (11 years). An agreement between Flinders University and Neoen Australia will be signed and exchanged prior to the commencement of the research program in July 2024.	Refer to Section 5.2
b. reports describing the work undertaken as part of the PBTL Research Plan in each **compliance report** until the final assessment report of the findings of the PBTL Research Plan has been published;	An annual research report will be prepared in line with Annual Compliance Reporting required for the Goyder South Hybrid Renewable Energy Project. This will provide an annual update on the progress of the research program over the life the project.	Refer to Section 4.5 and Section 4.6
c. a detailed preliminary assessment report of the findings of the PBTL Research Plan within 90 months of the date of this approval;	A preliminary assessment report of the findings of the research program will be completed and submitted to DCCEEW within 90 months (7.5 years) of the approval date.	Refer to Section 4.5
d. a final assessment report of the findings of the PBTL Research Plan within 13 years of the date of this approval, and submit the findings of the PBTL Research Plan for publication in a relevant, reputable, peer-reviewed scientific journal.	A final assessment report of the findings of the research program will be completed and submitted to DCCEEW within 13 years of the approval date. This will include copies of all peer-reviewed scientific journal articles published that are associated with the PBTL research program.	Refer to Section 4.5

Table 3. Relevant condition of approval associated with the Stage 1B (2021/8957) EPBC Act approval.

Approval Condition	Summary	Reference
8. The approval holder must make a financial contribution to fund the undertaking of the PBTL Research Plan for the purpose of providing an offset for impacts of this action on the Pygmy Blue-tongue Lizard. The approval holder's financial contribution must represent approximately 13% of the total cost of undertaking all aspects of the PBTL Research Plan. The approval holder must provide documentary evidence to the Department showing all financial contributions to the undertaking of the PBTL Research Plan in each compliance report and in a report of the financing and expenditure of the PBTL Research Plan which must be submitted to the Department within 30 business days of completing the PBTL Research Plan and in any case at least 60 business days prior to the expiry of this approval.	Stage 1A will fund $4,150,073.83 (87%) plus 10% contingency (if required) of the research program. Stage 1B will fund $620,125.97 (13%) plus 10% contingency (if required) of the research program. Neoen Australia will commit the funding for the research program for the full duration of this program (11 years).	Refer to Section 4.7, Section 5.3, Table 9

2.3 Objectives

The overarching aim of this PBTL Research Plan is to gain a thorough understanding of the potential indirect impacts of wind farms on PBTLs, including but not limited to, noise, vibration and shadow flicker. More specific objectives of this PBTL Research Plan include:

- Guide the establishment, implementation and management of the PBTL Research Plan to ensure the EPBC Act approval conditions are met;
- Provide general information on the ecology and biology of the PBTL and factors to consider, including behaviour and occurrence within the Project Area, when establishing and implementing the PBTL Research Plan;
- Outline proposed design for the research
- Outline a timeline for the research
- Outline a methodology for the research
- Outline proposed outcomes and deliverables for the research
- Outline a budget for the research

2.4 Relevant policies and documents

This PBTL Research Plan has been prepared in accordance with the following relevant policies and documents:

- *Recovery Plan for the Pygmy Bluetongue Lizard Tiliqua adelaidensis* (Duffy *et al.* 2012) referred to herein as the PBTL Recovery Plan;
- *Pygmy Bluetongue Lizards: Best Practice Management Guidelines for Landholders* (Schofield 2006);
- *Survey guidelines for Australia's threatened reptiles: Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (DSEWPC 2011);
- *Guidelines for biological survey and mapped data* (Commonwealth of Australia 2018);
- *Guide to providing maps and boundary data for EPBC Act projects* (DAWE 2021).
- A significant number of published papers on PBTL ecology.

A brief overview of the PBTL Recovery Plan is provided below.

2.5 PBTL Recovery Plan

The PBTL Recovery Plan lists the development of wind farms and associated infrastructure as a threat to the species. The recovery plan also identifies weed invasion, habitat fragmentation, changes to hydrology and turbine impacts (shadow flicker, noise and vibration) as potential threats to the species (Duffy *et al.* 2012).

The long-term vision of the PBTL Recovery Plan is to achieve down-listing of the PBTL to conservation dependent (Duffy *et al.* 2012). As such, the PBTL Recovery Plan contains specific objectives and associated actions, including the objective to fill critical knowledge gaps to help guide adaptive management and recovery of the species and action to conduct key research projects.

This research plan will deliver valuable long-term data and information in relation to the impacts of windfarms on PBTL and PBTL habitat. The results of this research will provide a significant amount of reliable data and published literature that can be utilised for future assessment of windfarm proposals in areas containing PBTL and PBTL habitat. The research will also contribute significant data and understanding to the ecology and habitat of PBTL.

The research plan is in line with the PBTL Recovery Plan, the key objectives of the plan and aims to address data deficiencies regarding a key threat highlighted in the recovery plan (windfarms).

3 PYGMY BLUE-TONGUE LIZARD

3.1 Conservation status

The PBTL (Figure 2) is listed as Endangered under the EPBC Act and Endangered under the South Australian *National Parks and Wildlife Act 1972* (NPW Act). These classifications are consistent with the International Union for Conservation of Nature (IUCN) (2001) criteria for listing species on the IUCN Red List System (Duffy *et al.* 2012).

Figure 2. A Pygmy Blue-tongue Lizard (*Tiliqua adelaidensis*). Photo by EBS Ecology.

3.2 EPBC legal status and associated documents

The EPBC Act legal status and associated documents for PBTL, as provided within the Department's Species Profile and Threats (SPRAT) Database (online) SPRAT Profile for PBTL, are presented in Table 4.

Table 4. EPBC Act legal status and associated documents for PBTL.

EPBC Act Listing Status	Listed as Endangered
Approved Conservation Advice	Department of Climate Change, Energy, the Environment and Water (2023). *Conservation Advice for* Tiliqua adelaidensis *(pygmy blue-tongue lizard)*. Canberra: Department of Climate Change, Energy, the Environment and Water. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1270-conservation-advice-31082023.pdf. In effect under the EPBC Act from 31-Aug-2023.
Listing Advice	Listing advice information is available in the approved Conservation Advice.
Recovery Plan Decision	Recovery Plan required, this species had a recovery plan in force at the time the legislation provided for the Minister to decide whether or not to have a recovery plan (19/02/2007).

Adopted/Made Recovery Plans	Duffy, A., L. Pound & T. How (2012). Recovery Plan for the Pygmy Bluetongue Lizard Tiliqua adelaidensis. Department of Environment and Natural Resources, South Australia. In effect under the EPBC Act from 24 July 2012.
Adopted/Made Threat Abatement Plans	No Threat Abatement Plan has been identified as being relevant for this species.

Source: DoE 2023.

3.3 Ecology and biology

3.3.1 Description

The PBTL is the smallest member of the genus *Tiliqua*, which consists of seven terrestrial lizard species commonly known as Bluetongues. The PBTL is a moderate sized skink that has a total length of less than 20 cm and a relatively heavy body, large head and short limbs. Its body colour varies from grey brown to orange brown and may include a series of black flecks along the back and flanks. The distinct orange coloured eye and black pupil are other distinguishing features of the species. Unlike other members of its genus, the PBTL has a pink tongue (Hutchinson *et al.* 1994; Duffy *et al.* 2012).

3.3.2 Distribution

The PBTL is endemic to South Australia, where its population is severely fragmented and occupies less than 500 square km (Duffy *et al.* 2012). The PBTL is now known from 31 sites extending from Peterborough in the north to Kapunda in the south, and to the South Hummocks (north of Port Wakefield) in the west (Duffy *et al.* 2012). The full extent of most populations is yet to be determined. Therefore, it is possible that some apparently isolated populations may occur within larger, more contiguous populations (Schofield 2007).

Very little information exists on the past distribution of the species. The relative abundance of PBTL in European collections of specimens in the 19th century suggests that the species was formerly more common and has undergone a marked decrease in distribution (Shea 1992).

3.3.3 Habitat

PBTLs are known to occupy native grassland habitats. Even highly degraded grasslands (dominated by exotic species) are potential habitat, providing that the area is un-ploughed, and the soil structure remains intact (Milne 1999). The species has been recorded at sites dominated by species including *Austrostipa* spp. (Spear-grasses), *Rytidosperma* spp. (Wallaby Grasses), *Maireana* spp. (Bluebush), *Aristida behriana* (Brush Wire-grass) and *Lomandra* spp. (Iron-grasses) (Hutchinson *et al.* 1994, Souter *et al.* 2007). All known habitat is considered critical to the survival of the species (Duffy *et al.* 2012).

3.3.4 Populations

The total population size of the PBTL is uncertain. Prior to 2000, the population was estimated to be around 5,000 lizards, based on 10 known populations (Milne *et al.* 2000). Since this time, there are now 31 known PBTL populations (Duffy *et al.* 2012). Suitable habitats are largely on private land, and historically may have been under-surveyed due to access considerations. All PBTL populations are considered important due to the restricted and fragmented distribution of the species (Duffy *et al.* 2012).

More recently, due to the PBTL Recovery Plan efforts, university studies and proposed wind farm flora and fauna assessments, surveys of PBTLs have increased. Despite this, overall population size is hard to estimate due to natural fluctuations.

3.3.5 Behaviour

PBTLs use unoccupied burrows of trapdoor (Mygalomorphae) and wolf (Lycosidae) spiders as refuges, basking sites and ambush points (Milne, Bull & Hutchinson 2003). The burrow entrances are circular in cross section, up to 20 millimetres (mm) in diameter, and lack any sign of excavated soil at the entrances (Hutchinson *et al.* 1994). The average depth of burrows is approximately 25 centimetres (cm), ranging from 10 to 75 cm (Souter *et al*. 2007).

PBTLs make no obvious external modifications to the burrows, except for a slight bevelling of the edges caused by their movement in and out of the burrows (Hutchinson *et al.* 1994). Burrow entrances are used as vantage points from which PBTLs are able to make short forays after any prey detected nearby. PBTLs are extremely sensitive to both movement and noise, retreating to their burrow if disturbed. They may deposit scats near the perimeter of the burrow entrance (Fenner & Bull 2010). Only one adult PBTL is found in each active burrow and individuals may utilise the same burrow for extended periods of time, with one study observing burrows occupied by the same individual for at least a two-year period (Bull *et al.* 2015).

Figure 3. A PBTL at the entrance of its burrow.

Figure 4. Adult and two juvenile PBTLs in a burrow.

3.3.6 Diet

PBTLs are omnivorous, mostly feeding on medium-sized arthropods that they ambush from their burrow (Hutchinson *et al.* 1994). Analyses of scats and stomach contents have recorded the remains of grasshoppers, ants, small spiders, beetles, snails, cockroaches and plant material (including *Dianella* spp. seed, possible chenopod material, and several leaves and flowers of introduced *Medicago* spp.) (Ehmann 1982; Hutchinson *et al.* 1994; Milne 1999; Fenner *et al.* 2007). PBTLs have been found to change their prey items opportunistically over spring and summer, with plant material incorporated in the diet to a greater extent as summer progresses (Fenner *et al.* 2007). Based on these dietary studies, it is likely that PBTLs

require a high abundance of arthropod prey, habitat where efficient prey capture is possible, and particular plant species which form part of their diet (Fenner *et al.* 2007).

3.3.7 Reproduction

The PBTL has a spring mating season (October and November) (Milne and Bull 2000) and bears live young, like the other *Tiliqua* species. Males can reproduce from one year of age and females are sexually mature from approximately three years of age, and can have up to four young each season. Young are born between January and March, and disperse from the mother's burrow within weeks of their birth to find burrows of their own (Clarke 2000; Duffy *et al.* 2012; Milne and Bull 2000).

3.3.8 Activity timeframes

PBTL activity varies significantly throughout the year and is summarised in Table 5 and explained further below.

Table 5. PBTL activity throughout the year.

PBTL activity	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mating season												
Females heavily gravid												
Females with young												
Neonate dispersal												
Winter brumation												

The PBTL mating season is October to November. Females are heavily gravid (pregnant) in January and have young with them in their burrows from mid-January to mid-March. Neonate dispersal occurs in February and March. PBTLs go into brumation (a state of torpor exhibited by reptiles) over winter (June to August).

Males are more active during the mating season, moving away from their burrows to seek female mating partners (Schofield *et al.* 2012). Neonates and females are more active during late summer (February and March) as they disperse, with females shifting burrows if neonates do not leave the maternal burrow.

3.4 Known and/or potential threats

The PBTL Recovery Plan (Duffy *et al.* 2012) documents known and potential threats to the PBTL, which are summarised in Table 6.

Table 6. Known and potential threats to the PBTL and associated impacts (adapted from Duffy *et al.* 2012).

Known and/or potential threat	Known and/or potential impact
Changed land use - Ploughing	Direct mortality and displacement of both PBTLs and spiders.
	Destruction of PBTL and spider burrows.
	Soil destabilisation making any burrows subsequently dug by spiders (likely to be very few) unstable and unsuitable for PBTLs.

Known and/or potential threat	Known and/or potential impact
Changed land use - Inappropriate grazing regimes	Heavy grazing by hard-hoofed stock may lead to soil destabilisation, the filling of burrows in the dry season and the collapse of burrows in the wet season.
	Heavy grazing may also increase PBTL exposure to predators and/or reduce the availability of PBTL prey.
	Complete removal of grazing may lead to increased weed growth and/or a reduction in inter-tussock spaces, which may impact foraging and basking opportunities.
Changed land use - Ripping	Destruction of PBTLs and their burrows in the direct path of the ripping lines.
Changed land use - Other agricultural development	Any changes in areas occupied by PBTLs involving soil disturbance, clearing or habitat modification (e.g. establishment of saltbush pasture and viticulture) may be detrimental to the species.
Changed land use - Urban, industrial and infrastructure development	The establishment of buildings, roads, wind farms and telecommunications infrastructure may directly destroy PBTLs and their burrows, or disturb their native grassland habitat.
	Although wind farm WTGs are typically installed on hill slopes and crests, which are often not optimal PBTL habitat, access roads, underground cabling and other associated infrastructure, which are often developed on flats and lower slopes, have the potential to cause further loss and fragmentation of PBTL habitat, weed invasion and hydrological changes such as extra water runoff affecting soil structure.
	Shadow flicker, vibration and noise from WTGs may affect the ability of PBTLs to bask, feed and move around.
Weeds	High and dense growth of Wild Oats (*Avena barbata*) and other weeds may reduce opportunities for PBTLs to bask, catch insects and find mates.
	May render habitat unsuitable for burrowing spiders (Souter *et al.* 2003).
	High disturbance weed control or control that affects native plant species may be detrimental to PBTL habitat.
Pesticides (Insecticides)	While direct impacts of insecticides on PBTLs are unknown, insecticides are known to cause illness or death in some reptiles (Khan & Law 2005; Pauli *et al.* 2010).
	Indirect impacts could include a reduction in the main food source group for PBTLs, which could affect their survivorship or reproduction rates; cumulative secondary poisoning; or a reduction in the abundance of burrowing spiders, which may reduce the availability of burrows suitable for PBTLs.
Herbicides	While direct impacts of herbicides on PBTLs are unknown, herbicides are known to cause fertility problems for small vertebrates (Pauli *et al.* 2010), and are therefore a potential threat to PBTLs.
Inappropriate fire regimes	Fires that occur in spring, when males are active, or in late summer and early autumn, when juveniles are dispersing, could be particularly detrimental.
	Fires at other times of the year (mid-summer, late autumn, early spring) may be of less consequence. Indeed, PBTLs have been found to take refuge from fire in their deep burrows, as a fire in December 2005 did not kill adult lizards or affect the subsequent fecundity of females. Declines initially observed in activity, foraging, body condition and juvenile survivorship following the fire were short lived, with no adverse impacts in subsequent years (Fenner & Bull 2007).
Habitat fragmentation	Small, isolated populations may suffer from inbreeding and are vulnerable to extinction from stochastic events (Smith 2006; Smith *et al.* 2009).
Planting (tall trees and shrubs)	There are no records of PBTLs living under trees, even in areas adjacent to open grassland where the species occurs. Furthermore, experiments have shown that artificial burrows established under trees quickly fill with soil and debris (Souter *et al.* 2003).
	Planting trees and shrubs will alter the characteristics of the soil, litter and understorey plant community beneath their canopy, which may be detrimental to PBTLs.
	May increase predation risks for PBTLs by providing perches for birds to stalk burrows (compared to only hovering birds in open grassland).

Known and/or potential threat	Known and/or potential impact
	Will reduce the level of sunlight at ground level, which may result in PBTLs having to move further away from their burrows to bask, increasing predation risk.
Predators	Domestic dogs are known to take PBTLs.
	Foxes and cats are potential predators.
	Natural predators include Nankeen Kestrels (*Falco cenchroides*) and Eastern Brown Snakes (*Pseudonaja textilis*).
Fertilisers	May affect PBTLs by encouraging weed growth at the expense of native grasses.
Poaching	Despite the large fines and/or jail terms associated with poaching and smuggling threatened species, there is a risk that poachers could target PBTLs as Australian reptiles are generally in demand.
Climate change	Higher temperatures and altered rainfall regimes that are predicted under climate change may impact PBTLs, their prey and habitat.
	While the effects of climatic conditions on PBTLs remains largely unknown, surveys have recorded significantly lower fecundity, lower grass cover and more bare earth in 2007 and 2008 than in 2006, which may be linked to the prolonged drought in the region (A. Fenner *pers. comm.*, J. Schofield *pers. comm.*, in Duffy *et al.* 2012).
	PBTLs may be particularly vulnerable due to the isolation and small extent of the remaining populations and suitable habitat, and the very limited opportunities for dispersal if the current area of occupancy becomes unsuitable.

All PBTL habitats and populations, apart from one population which is formally protected (Tiliqua Nature Reserve), are considered to be potentially at risk from all of the threats summarised in Table 6 (Duffy *et al.*, 2012).

3.5 PBTL occurrence within the Goyder South Project Area

Habitat within the Goyder South Project Area was characterised as either 'likely', 'potential' or 'unlikely' PBTL habitat by EBS Ecology during initial flora and fauna assessment for the Project during autumn and spring 2019 surveys based on suitable habitat attributes (EBS Ecology 2020). Suitable PBTL habitat attributes include spider burrows within native grasslands with or without an exotic component (PBTLs have also been detected in highly modified treeless grasslands), soil of heavy sandy loam (red-brown earth), footslopes of hills and sheltered areas of footslopes.

Likely PBTL habitat is classified based on several criteria. Firstly, any areas where PBTL have been recorded are considered Likely habitat. These known habitat areas are extended to incorporate adjacent areas that generally contain numerous spider burrows of suitable size and depth and are contiguous with known PBTL locations. If no PBTL are found within an area but the habitat is considered to be good – high quality PBTL habitat (consisting of grassland vegetation and extensive suitable spider burrows), the areas are also marked as Likely habitat.

Potential PBTL habitat is recorded in areas where no PBTL have been found. However, a low number of suitable spider holes are present in the area. The vegetation is considered to be poor-moderate quality for PBTL. Therefore, the likelihood of finding PBTL in these areas is lower and if found, it is likely to be scattered individuals.

Unlikely PBTL habitat includes areas that have been cropped/ploughed (including within the previous 5-10 years), areas lacking spider burrows, areas containing dense ground cover vegetation, steep terrain and exposed ridgelines and overly rocky areas, as these are unsuitable habitat attributes for PBTLs.

The weather and survey conditions were optimal for the duration of both survey periods due to low grass levels and fine/sunny conditions, which are important when searching for spider/PBTL burrows. Therefore, the results from the survey locations can be reported with a high degree of confidence. Refer to the *Goyder South Hybrid Renewable Energy Project: Flora and Fauna Assessment* (EBS Ecology 2020) for more detail on the habitat assessment.

. A follow up PBTL survey, which targeted locations where the proposed infrastructure layout (at the time of the survey) impacted mapped PBTL habitat, including three areas of likely PBTL habitat and six areas of Potential PBTL habitat, was undertaken in March 2021 by EBS Ecology.

Refer to the *Goyder – Pygmy Bluetongue Lizard Survey March 2021* (EBS Ecology 2021) report for more detail on the targeted PBTL survey. However, understanding of PBTL occurrence and habitat within the Goyder South Project Area has evolved significantly over time, particularly after EPBC Act approvals were received (in July 2022) and more detailed and targeted pre-clearance check (PCC) surveys and micro-siting surveys were undertaken. Additional PBTLs and PBTL habitat were found within the Stage 1A, Stage 1B and Common Asset Project Areas during PCC and micro-siting surveys.

All PBTL records identified within the Project Area to date are shown in Figure 5, while details on the amount of PBTL habitat found are provided in Table 7.

Table 7. All PBTL habitat identified within the Project Area to date.

Project Stage / Proposed Action	Area of additional PBTL habitat found post EPBC Act approvals (ha)		
	Potential	Likely	Total
Stage 1A	[redacted]	[redacted]	[redacted]
Stage 1B	[redacted]	[redacted]	[redacted]
Common Asset (OTL and Substation)	[redacted]	[redacted]	[redacted]

Note that the data in Table 7 has only been derived from the PCC and micro-siting surveys of the proposed infrastructure footprint, and as such, not all areas within the Goyder South Project Area have been surveyed (many areas outside of the proposed infrastructure footprint have not been surveyed for PBTLs). As such, it is highly likely that additional PBTLs and PBTL habitat, that have not been identified, occur in other areas within the Goyder South Project Area.

For more detailed information on the identification of PBTL habitat within the Project Area since the initial flora and fauna assessment for the Project during autumn and spring 2019 (EBS Ecology 2020) and targeted PBTL survey in March 2021 (EBS Ecology 2021e), and during the PCC and micro-siting surveys of the proposed infrastructure footprint, refer to the PBTL Management Plan (EBS Ecology 2023).

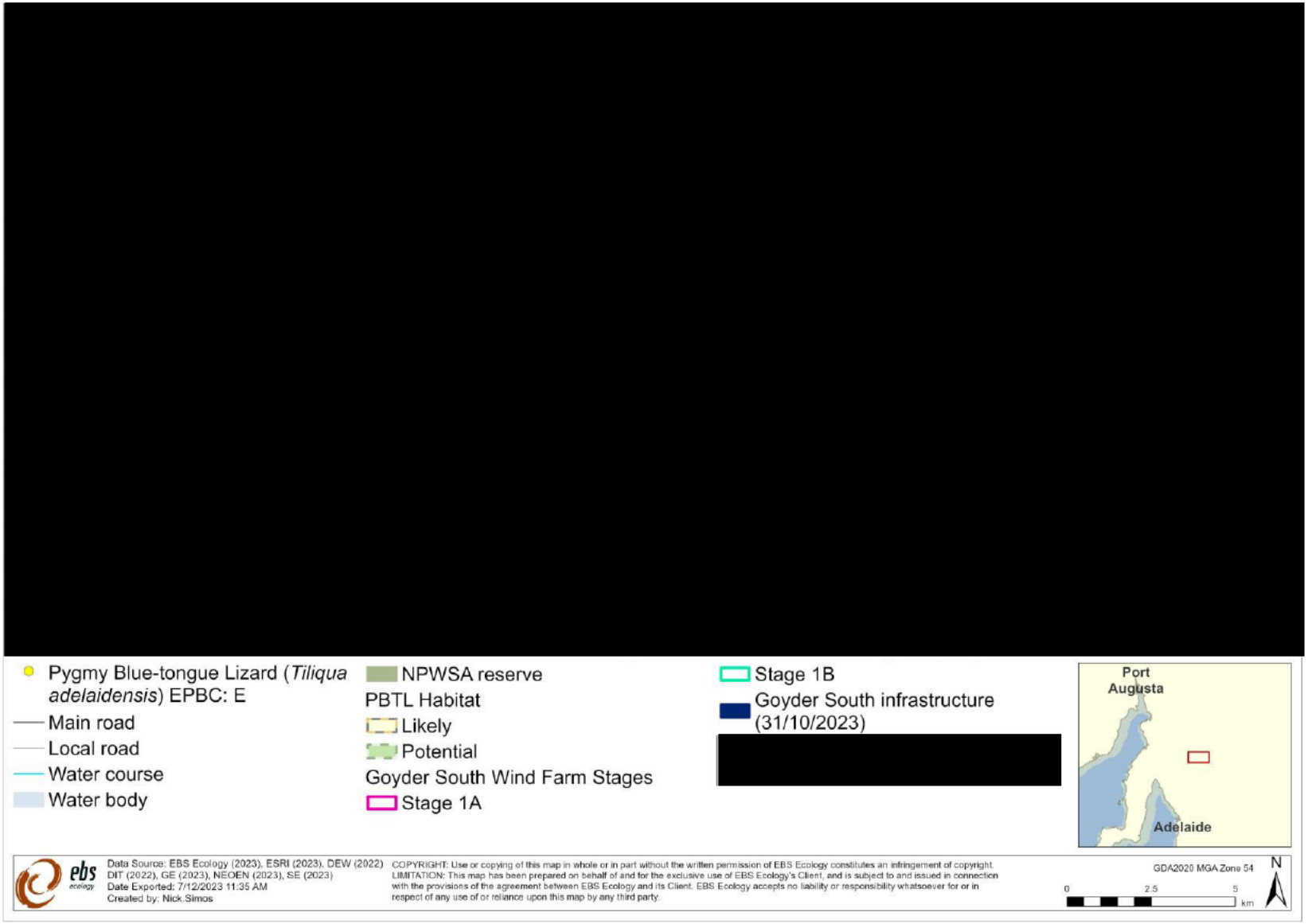

Figure 5. Location of PBTL records across the Goyder South Hybrid Renewable Energy Project.

4 PROPOSED PBTL RESEARCH PLAN

4.1 Research objectives

The key research objective of the PBTL Monitoring and Scientific Research plan is determine whether wind turbines and associated infrastructure have a long-term impact on populations of Pygmy Blue-tongue Lizards. Potential impacts to PBTL may occur as a result of the following:

- Human disturbance
- Noise
- Vibration
- Shadow Flicker
- Habitat Fragmentation

These potential impacts have been discussed over a number of years with wind farms occurring throughout the Mid North region SA where the PBTL occurs. However, no real data or answers have been generated to date as previous studies have been short in duration and there was a lack of PBTL in close proximity (within 200m) of wind farm infrastructure, particularly wind turbines.

This research plan aims to collect long-term (10 years) data to assess the impacts of wind turbines on PBTL both directly and indirectly. The primary focus of the 10 years of data collection will be to measure the impacts of vibration, noise and shadow flicker generated by wind turbines on PBTL. In addition, the research will also collect long-term data on spiders and spider-burrows which are a critical habitat component for PBTL. The spiders may be more sensitive to some of these impacts, which may indirectly impact PBTL in the long term if spiders are not as abundant or move away from areas close to wind turbines. This may lead to a decrease in available spider holes which may reduce the density of PBTL in an area.

Year 0 of the research program will allow the project to be established and baseline data collected. The following 10 years will involve collecting a significant amount of data to allow for scientifically robust data to be analysed. The 10-year timeframe reduces the variation caused by seasonal conditions and will allow the long-term impacts of wind turbines on PBTL to be analysed. The statistical analysis that will be undertaken will be to the standard required for research papers to be published in peer-reviewed international science journals.

In collaboration with Professor Mike Gardner at Flinders University, the following research questions have been developed. The research has been divided into understanding the direct impact of wind farms on PBTLs and understanding the indirect impact of wind farms on PBTL on changing spider behaviour and ecology.

Data generated by the long -term research will be analysed and used to contribute a greater understanding of the impacts of windfarms to PBTL. The research will make a significant contribution to future impact assessments of infrastructure projects, particularly windfarms, in areas where PBTL and PBTL habitat are present. The research program will provide a greater confidence that the assumptions made during the impact assessment process are correct or need to be adjusted. Windfarms have been identified in the PBTL Recovery Plan and this research is focused on gaining a greater understanding of this potential

threat. The research will also allow for the delivery of an overall conservation outcome, a greater understanding of the species and will improve the viability of PBTL populations which occur within proposed and constructed wind farms.

4.1.1 Understanding the direct impact of windfarms on PBTLs.

To gain a better understanding of the potential direct impacts of windfarms on PBTLs, a series of research questions have been developed. These are aligned with the overall objectives of the research plan detailed in Section 4.1. Table 8 details the impacts, the potential consequence of the impact and the relevant questions that have been posed in this research plan.

This can be broken to several smaller questions:
Q1: Do lizards closer to the turbines have reduced body condition?
Q2: Do individuals live for longer when they are further way from the turbines?
Q3: Do lizards abandon their burrows or move more frequently closer to turbines?
Q4: Is the growth rate of lizards closer to turbines less than those further away?
Q5: Do lizards closer to the turbines reproduce less than others further away?
Q6: Do lizards closer to turbines have reduced number of mates resulting in reduced genetic diversity of offspring?
Q7: Do lizards closer to windfarms have reduced responses to aerial predators?
Q8: Will lizards move across wind farm access tracks?

These questions are best answered by field-based studies investigating lizards at varying distances to established wind turbines but could be supplemented with research examining before and after wind turbines are installed. The 10 year phase of data collection is imperative to allow long-term changes to be detected and account for changes as a result of seasonal conditions. The data analysis for the research plan will focus on clearly answering the questions posed above.

4.1.2 Understanding the indirect impacts of windfarms on PBTL burrows

Spider holes are a critical component of PBTL habitat, without them, the PBTL will not occupy an area. The wind turbines may impact on the species of spiders that dig the suitable burrows for PBTL. Whilst not a direct impact on PBTL, a reduction or absence of spiders in an area may have long-term consequences for the viability of a PBTL population. To gain a better understanding of the potential indirect impacts of windfarms on the burrows utilised PBTLs, a series of research questions have been developed. These are aligned with the overall objectives of the research plan detailed in Section 4.1 and focus on the spiders, their abundance and the impacts that wind turbines may have on them. Table 8 details the impacts, the potential consequence of the impact and the relevant questions that have been posed in this research plan.

Q9: Is recruitment/number of spiderlings close to turbines less than further away?
Q10: Is the survival of individuals reduced close to the turbines?
Q11: Do spiders abandon their burrows more when they are closer to turbines?

Q12: Is the growth rate of spider closer to turbines reduced compared to those further away?

Q13: Is the body condition of spiders closer to turbines reduced compared to those further away?

Q14: Is the rate of burrow development decreased close to turbines compared to further away?

Q15: Do spiders closer to the turbines defend the burrow less vigorously (which would simulate defence from predators or parasitoid wasps) than spiders further from the turbines?

Q16: Is the composition of spider communities different in turbine areas compared to turbine free areas?

Q17: Will spiders move across wind farm access tracks?

Q18: Do spiders re-colonise areas that have been utilised during wind farm construction where topsoil has not been striped (Eg either side of cable install)?

Q19: Is the rate of burrow development decreased close to turbines compared to further away?

Q20: Is the composition of spider communities different in turbine areas compared to turbine free areas?

Table 8. Potential consequences of the wind farm impacts to PBTL and associated research questions.

Impact	Potential consequence	Relevant Questions
Human disturbance	• Human disturbance may impact PBTL behaviour as they may feed / bask less, which may lead to a reduction in health / condition / breeding success. • Human disturbance may result in PBTL moving away from the source therefore reducing area of occupancy.	Q1 to Q6
Noise	• PBTL may move away from disturbance areas. • Impact to spiders which reduces spider / spider hole density in the long-term leading to a reduction in PBTL population numbers.	Q3, Q9 to Q16, Q19, Q20
Shadow flicker	• PBTL may not be as vigilant to predators. • PBTL may move away from disturbed areas. • PBTL may not bask / feed as much which may reduce health / body condition / breeding success.	Q1 to Q7
Vibration	• Impact to spiders which may reduce spiders / spider hole density in the long-term leading to a reduction in PBTL population numbers.	Q1 to Q6 and Q9 to Q16, Q19, Q20
Habitat fragmentation	• Movement of PBTL restricted by access tracks / hard stand areas which may lead to a reduction in genetic fitness of populations of PBTL. • In areas where construction activities have been undertaken, but topsoil has not been permanently removed (e.g. cable alignment), spiders may not recolonise, thereby reducing the area of occupancy / movement of PBTL	Q8, Q17, Q18

4.2 Research Methodologies

The proposed research methodologies provided in this section are broad and further refinement and detail will be required as part of the early phases of the project. As a portion of the research will be undertaken by PhD students, the methods required will be developed by the students as part of their projects. The methods will also evolve over the life of the project as methods are developed and tested, data is collected and results start to be analysed.

Data analysis will be undertaken across the 10 years of the research program. Specific smaller research projects (eg Honours projects) may be completed within the research program with data analysed and

published separately. However, the key research questions will involve statistically analysing the 10 years worth of data collected to gain a much greater understanding of the impact of wind turbines on PBTL.

The research will consist of a combination of ground surveys at the proposed turbine locations plus experimental and genomic studies to compliment the empirical ground survey work. Alongside the research, it will be important to identify the level of light flicker and vibrations within the soil, caused by the wind turbines. We propose to use a series of light meters and bioacoustics monitors to record this information. An approach is provided below for each of the questions posed in sections 4.1.1 and 4.1.2.

4.2.1 Shadow flicker, Noise, Vibration and Human disturbance

A transect sampling methodology will be utilised to collect data for at least three turbines where PBTL occur within close proximity to the turbines. This method will be used to investigate the impacts of shadow flicker, noise, vibration and human disturbance. The relevant questions detailed in Section 4.1.1 and 4.1.2 are Questions 1 to 6 and Questions 19 and 20.

The sampling framework will be comprised of 10 x 50 m transects (Figure 6) that will be surveyed for both spiders and lizards for two months of the year, September or October and again in March or April. It is important to do the survey work twice, as the spider holes are visibly cryptic and therefore difficult to find depending on the weather conditions, as well as allowing for fluctuations that might be more evident on a seasonal timeframe.

To determine if distance from turbines affects lizards and spiders, we will undertake surveys at 50 m distances from each of [redacted] up to 500 m and then again at 750 m and 1 km (Figure 1Figure 6). These areas will be compared to three control areas (each 50 x 50 m) further away from turbines (at least 2 km) but within 5 km of the windfarm. Sampling between [redacted] will allow a combined effect of two turbines to be investigated.

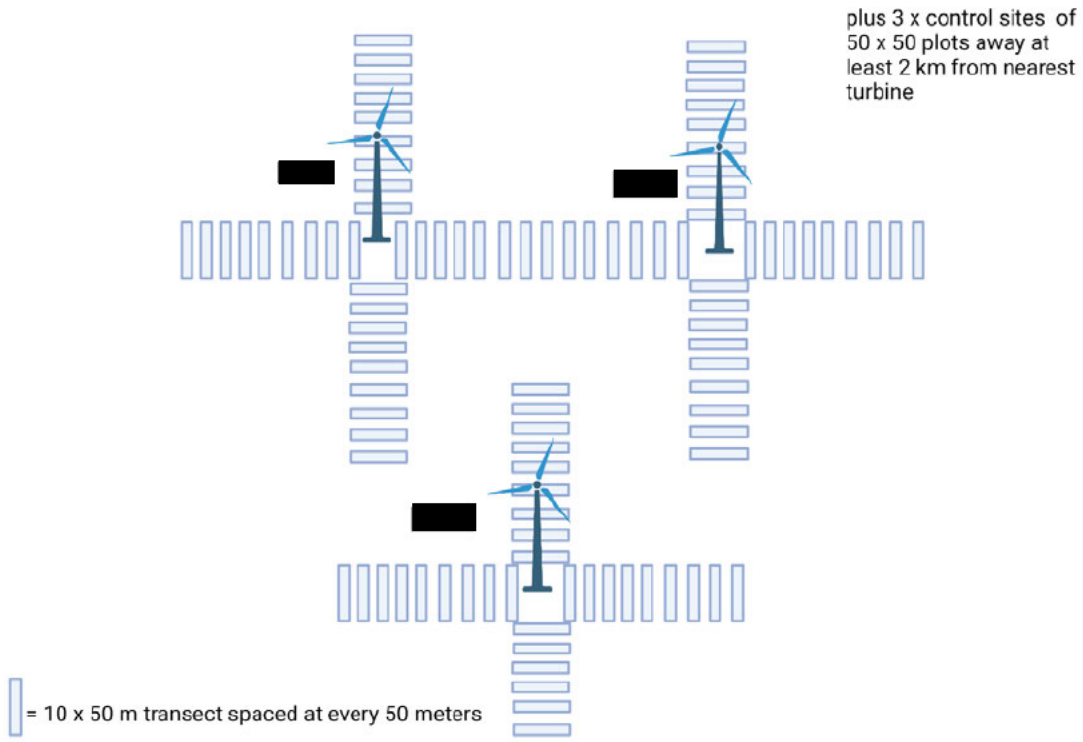

Figure 6. Indicative survey transects surrounding turbines.

During each seasonal (bi-annual) survey, spider burrows will be located, marked with pegs, and GPS coordinates taken using a Catalyst 1 GPS instrument which measures down to 1 cm accuracy. All burrows will be recorded, and the length, diameter, angle and occupancy will be noted. The occupancy of the burrows (spider or lizard) will be checked with a Yateks M615FM optiscope. If not occupied by a PBTL or a spider, burrows will be rated according to their potential suitability as PBTL burrows based on published criteria (Fellows et al. 2009). Vegetation will also be recorded using parameters such as distance from burrow to vegetation, vegetation cover and type to determine if these factors change across the time frames of the study around turbines, hence influencing the lizards (Souter et al. 2007). Within each area, lizards will be caught via established methods (Milne 1999) marked by toe clipping to establish identity and secure genetic samples for later analysis. Lizards will be weighed, measured, and photographed. From these data we will generate body condition indices (e.g. Shamiminoori et al 2014) and a database of lizard identities and their initial capture locations.

The data for Q1-6 will be generated primarily from these bi-annual surveys however we also propose to use techniques to age lizards based on either telomere (e.g. Dupoué et al. 2022) or epigenetic markers (e.g. Cossette et al. 2023). This aging work will be done after five years and in the final year of the research.

In addition to these bi-annual surveys, it will be important to record and sample lizard and spider offspring (Q5 and Q6) as close as possible to when they are born to ensure a comparable indicator of breeding success. Therefore, a February survey will be required as PBTLs give birth in late January/early February. This survey would be less comprehensive and be focused on juvenile capture. Juvenile PBTLs stay with their mother for a week or so before dispersing and we need to capture the lizards before dispersal to ensure we have all the offspring born. Genomic analysis via DArTseq will be undertaken to determine paternity of offspring (Q6).

Similarly, a survey to examine spider recruitment (Q5) will occur in November. Here we will examine all the spider occupied burrows for egg sacks to determine who and how many spiders have bred. Egg sacs will be left in situ but will be measured by taking photos using a Yateks M615FM optiscope. Another survey will be taken in December to capture, once they hatch, 20 offspring of each of 10 female spiders individuals. This will allow an investigation of the level of multiple paternity of the spiders (Q6). This research will be conducted for each spider species (wolf and trapdoor). Offspring will be sent for sequencing using the DArTseq protocols.

To explore burrow development (Q19), within the survey areas spider holes around established female spiders will be recorded by randomly placing three 1^2 m quadrates in each of the 10 x 50 m transect area and recording the number of small (<1 cm) burrows. These burrows are too small to be counted in the overall survey and require separate scrutiny.

To understand spider diversity (Q20) within these surveys we will record different species of spiders encountered and sequence a selection for mtDNA barcoding genes to understand if there is any cryptic diversity within the spiders. We expect two main species of wolf (Lycosidae) spiders, *Tasmanicosa gilberta* and *T. ramosa* and one trapdoor (mygalomorph), *Blakistonia aurea,* however the species diversity of these spiders is not well known, and more may occur at the site.

4.2.2 Shadow flicker

To further investigate the potential impacts of shadow flicker on PBTL and whether PBTL develop a reduce response to aerial predators (Q7), a series of experiments with drones will be undertaken. We will examine how quickly lizards, at the different distances from the turbines, respond to a drone flown directly above them. This work will take place at a different time to the main survey work to ensure the effect of human presence and capture do not influence the results. Here we will undertake the work in November/December alongside the trips associated with Q5 and Q6. The reaction of lizards in areas directly in line with the shadow of the turbines will be compared to those in areas around the turbines not in the shadow zone. To score the reaction to the drone flights we will film lizards using Brinno BCC200 Construction Cameras. We will set up 20 cameras at a time and score the video with JWatcher for how long it takes lizards to retreat into their burrows when a drone flies overhead.

Alongside this fieldwork will be experiments conducted at Flinders University on a semi-wild captive colony. Here individual lizards will be conditioned with small model wild turbines to simulate the shadow flicker of turbines. This will provide an independent assessment of this phenomenon.

Vibration is maybe more relevant for spiders, thus we will compare how readily spiders attack an intrusion to their burrows. This will be done by simulating an attack by inserting the scope into burrows when inspecting the burrows. The time and number of provokes it take for an attack to occur will be measured/counted. This research will occur during the normal survey work described above for Q1-6.

4.2.3 Habitat fragmentation

To determine if roads are impediment to lizard movement (Q8), three sets of 50 x 50 m areas on either side of road areas will be surveyed. This will occur as dedicated surveys [redacted]. Lizards will be toe clipped, weighed etc and released. Potential movement of lizards across the roads will be monitored over time (each sampling period) in the lizards via mark-release-recapture methods. In addition, samples of DNA will be sent off for single nucleotide analysis via the DArTseq company and genomic differences will be analysed to see if the genetic signature of areas across road differs over time. Data from these areas will be compared to two contiguous 50 x 100 m areas.

To understand spider movement (Q17), from the same areas we will take legs from individuals to provide a genetic sample and do a comparison using similar genomic methods. We will also radio track with ATS trackers to twenty male spiders, 10 from either side of an access road. This will provide a direct measurement as spiders are difficult to individually mark for identification purposes. This will be done each year to understand how long it takes for movement to occur freely. We will compare the movement here to control sites.

To determine if spiders re-colonise areas that have been used during wind farm construction (Q18), we will conduct surveys within three transects of 50 m on previously disturbed areas not stripped of soil cover. Here spider holes and spider occupancy will be counted and recorded over time.

4.3 Research Locations

There is a large and significant population of PBTL that occurs close to a variety of wind farm infrastructure within the Goyder South Renewable Energy project. This occurs [redacted]. Whilst specific research locations have not been identified, it is considered that this general location would be suitable as it is known that PBTL occur within [redacted]. Refer to Figure 7 for general location.

Figure 7. Location of PBTL Research Area

4.4 Research Timetable

Table 9 provides a Project Timetable that is reflective of the yearly summary provided below. The commencement date of the project is planned for July 2024. This provides sufficient time to develop and finalise the agreement between Flinders University and Neoen after the approval of this Research Plan by DCCEEW.

Key milestones include:

Year 0 – July 2024

Recruitment of research assistants, postdoctoral researchers, and two Phd plus two honours students. Establishment of transects and conduct the baseline surveys pre-turbine.

Year 1

Recruitment of honours student. Conduct of initial post-turbine surveys. Draft publication. Establishment of second colony of PBTLs at Flinders University. Outline of both PhD projects. Preliminary Assessment Report.

Year 2

Recruitment of honours student. Conduct of second post-turbine surveys. Draft publication and submission of publication. Methods developed for aging the lizards.

Year 3

Recruitment of honours student. Conduct of third post-turbine surveys. Draft publication and submission of publication. Submission of two PhD theses. Recruitment of two PhD students.

Year 4

Recruitment of honours student. Conduct of fourth post-turbine surveys. Draft publication and submission of a publication. Outline of both PhD projects.

Year 5

Recruitment of honours student. Conduct of fifth post-turbine surveys. Draft publication and submission of a publication.

Year 6

Recruitment of honours student. Conduct of sixth post-turbine surveys. Draft publication and submission of publication.

Year 7

Recruitment of honours student. Conduct of seventh post-turbine surveys. Draft publication and submission of publication. Submission of two PhD theses. Recruitment of two PhD students.

Year 8

Recruitment of honours student. Conduct of eighth post-turbine surveys. Draft publication and submission of publication. Outline of both PhD projects.

Year 9

Recruitment of honours student. Conduct of ninth post-turbine surveys. Draft publication and submission of publication.

Year 10

Recruitment of honours student. Conduct of last post-turbine surveys. Conduct aging analysis of lizards. Draft publication and submission of publication. Submission of two PhD theses.

4.5 Research Reporting Requirements

An annual research report will be provided as part of the EPBC Annual Compliance Reporting that is required for the Goyder South Hybrid Renewable Energy Project. The approval conditions require the reporting below to be submitted (within specified timeframes) as per below:

- Inclusion of research progress in annual Project compliance report – annual report
- Preliminary Assessment Report within 90 months of approval date – this will include preliminary analysis of data collected to date.
- Final assessment report within 13 years of the approval date – this will include the analysis of the 10 years of collected data and copies of all published peer reviewed scientific articles associated with the research program.

The annual compliance report will include:

- Summary of the research undertaken within the 12 month reporting period
- Summary of progressive findings based on the work completed

The Preliminary Assessment Report will include:

- Summary of research completed
- Summary of updates / changes to methods being implemented
- Preliminary assessment / summary of data collected to date

- Preliminary recommendations on assessment / management of windfarms where PBTL and PBTL habitat is present if the data collected to date shows clear trends.

The Final Assessment Report will include:

- Summary of research completed
- Summary of data collected and analysed (10 years of data)
- List of all published articles in peer reviewed journals generated from the research project
- Review of the long-term impacts of human disturbance, habitat fragmentation, wind turbine noise, vibration and shadow flicker on PBTL from the 10 year research program
- Discussion on assessment and management considerations for windfarm projects where PBTL / PBTL habitat is present
- Recommendations that can be implemented to improve the assessment and management of windfarm projects where PBTL / PBTL habitat is present

4.6 Research Publications

The research undertaken will result in a series of publications over the life of the project. At least four PhD thesis will be produced as part of the project. In addition, research will be published in high quality scientific research journals. This research should result in publications in journals such as Molecular Ecology (IF 6.6); Conservation Biology (IF 7.6); Animal Behaviour (IF 3.04) Biological Conservation (IF 7.5); and open access journals such as Frontiers in Ecology and Environment (IF 13.8), Frontiers in Ecology and Evolution (IF 4.5). Findings may also be suitable for multidisciplinary journals such as Proceedings of the Royal Society of London B (IF 5.5); Proceedings of the National Academy of Science USA (IF 12.8).

4.7 Research Resources Costs

Table 9 details the resources required to undertake the research successfully including the researchers required, the facilities required and the equipment required. Details of when the resources (including PhD students, post-doc researchers and equipment) are required has also been determined.

The funding required to undertake the project has been developed by Flinders University, based on the research requirements of the approval conditions. Funding is based on undertaking research over an 11 year period and utilises a variety of approaches to ensure the research aims of the project are met. Given the significance of the project, Flinders University will provide in-kind contributions to ensure the requirements of the University (which go above and beyond the research requirements of the approval condition) will be met.

The funding of the research project will be sourced from Stage 1A (87%) and Stage 1B (13%) as detailed in the approval conditions.

5 DELIVERY OF THE PBTL RESEARCH PLAN

5.1 Roles and responsibilities

A project team will be developed for the implementation of the research plan. The project team will oversee the delivery of the research, supervision of the students and staff and ensure the research objectives (and subsequently approval conditions) are met.

The project team will consist of Flinders University (Professor Mike Gardner and Dr Bruno Buzatto), EBS Ecology (Dr Travis How) and Neoen Australia (to be advised). Refer to Section 7 for CV's of Professor Mike Gardner and Dr Travis How.

5.2 Partnership with Flinders University

Once this research plan is approved by DCCEEW and the project details finalised, a standard agreement between Flinders University and Neoen Australia will be developed. The agreement to be used is a standard agreement that the University utilises when undertaking projects through industry participation. It will include all project details, deliverables and funding arrangements.

5.3 Project Timetable and Costing

The project timetable, personnel and equipment requirements of the project has been developed in conjunction with Flinders University (Table 9). The costings have been provided by Flinders University and reflect the resources and funding required to undertake research toa level that is scientifically robust. The approach will meet the requirements of the approval condition and allow results to be published in the appropriate scientific journals.

A 10% contingency has been calculated (Table 9) which will be funded by Neoen Australia if required.

Stage 1A will fund $4,150,073.83 (87%) plus 10% contingency (if required) of the research program.

Stage 1B will fund $620,125.97 (13%) plus 10% contingency (if required) of the research program

Table 9. PBTL Scientific Monitoring and Research Project Timetable and Cost.

PBTL Research Project Resources and Timeframes

Description	Rate/details	Total years	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Personnel													
Postdoctoral Researcher PBTL and spiders	1.0 FTE	4								$140,075.00	$145,678.00	$151,505.12	$157,565.32
Postdoctoral Researcher PBTL and spiders	1.0 FTE	4								$140,075.00	$145,678.00	$151,505.12	$157,565.32
Research Assistant	1.0 FTE	7	$112,708.00	$107,559.00	$113,118.00	$117,642.72	$125,515.00	$130,535.60	$135,757.02				
Casual field assistant PBTL (x2)	2 positions, 2-3 months per year	All	$35,832.00	$37,265.28	$38,755.89	$40,306.13	$41,918.37	$43,595.11	$45,338.91	$47,152.47	$49,038.57	$51,000.11	$53,040.11
Casual Field Assistant spiders (x2)	3 positions, 2-3 months per year	All	$35,832.00	$37,265.28	$38,755.89	$40,306.13	$41,918.37	$43,595.11	$45,338.91	$47,152.47	$49,038.57	$51,000.11	$53,040.11
PhD Student	2 PhD students in total	8		$38,000.00	$38,000.00	$38,000.00	$19,000.00			$38,000.00	$38,000.00	$38,000.00	$19,000.00
Flinders PhD scholarship	2 PhD students in total	8											
Professor Mike Gardner	Project / Student Supervision - 0.25%FTE	All											
Doctor Bruno Buzatto	Project / Student Supervision - 0.15%FTE	All											
Equipment and facilities													
Lizard enclosure Flinders University	Set up	Year 0 and Year 5						$35,000					
Lizard enclosure	Maintenance	All											
Yateks M615FM optiscopes (x4)	4 units in Year 0 and 4 units in Year 5	Year 0 and Year 5	$12,420.00					$12,420.00					
Brinno BCC200 Construction Cameras (x20)	20 units in Year 0 and 20 units in Year 5	Year 0 and Year 5	$11,000.00					$11,000.00					
Drone for predator simulation	2 units	Year 0 and Year 6						$5,000.00					
Software licence for Catalyst	one user for 3 months/year	All	$2,250.00	$2,340.00	$2,433.60	$2,530.94	$2,632.18	$2,737.47	$2,846.97	$2,960.85	$3,079.28	$3,202.45	$3,330.55
T15 Tiny Transmitter	20 units for measuring per year	All	$9,000.00	$9,360.00	$9,734.40	$10,123.78	$10,528.73	$10,949.88	$11,387.87	$11,843.39	$12,317.12	$12,809.81	$13,322.20
Receiver and antennae for Transmitters	1 unit in Year 0 and 1 unit in Year 5	Year 0 and 5	$3,400.00					$3,400.00					
Equipment to measure vibrations	1 unit in year 0 and 1 unit in Year 5	Year 0 and Year 5	$7,800.00					$8,112.00					
Accomodation / Travel	As required for field survey	All	$ 55,620.00	$ 57,844.80	$ 60,158.59	$ 62,564.94	$ 65,067.53	$ 67,670.23	$ 70,377.04	$ 73,192.13	$ 76,119.81	$ 79,164.60	$ 82,331.19
Consumables	Pegs, star pickets, tubes, scales for weighing, calico bags	All	$2,000.00	$2,080.00	$2,163.20	$2,249.73	$2,339.72	$2,433.31	$2,530.64	$2,631.86	$2,737.14	$2,846.62	$2,960.49
Laboratory Sampling	Up to 1000 samples per year	All	$ 27,500.00	$ 53,600.00	$ 29,744.00	$ 30,933.76	$ 32,171.11	$ 33,457.95	$ 34,796.27	$ 36,188.12	$ 37,635.65	$ 65,141.07	$ 40,706.72
Open access publication cost	Publishing costs for access to increase distribution/reach	Years 2-10			$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00
Laboratory and Office access	Office / Lab space	All											

Funding Source													
PTBL Research Project Funding		**PBTL Research Project Funding**	$315,362.00	$345,314.36	$337,863.57	$349,658.12	$346,091.01	$414,906.65	$353,373.64	$544,271.28	$564,322.13	$611,175.02	$587,862.02	**$4,770,199.81**
		10% Contingency costs	$31,536.20	$34,531.44	$33,786.36	$34,965.81	$34,609.10	$41,490.67	$35,337.36	$54,427.13	$56,432.21	$61,117.50	$58,786.20	**$477,019.98**
Flinders Univeristy In-kind		**15% Univeristy Levy**	$52,034.73	$56,976.87	$55,747.49	$57,693.59	$57,105.02	$68,459.60	$58,306.65	$89,804.76	$93,113.15	$100,843.88	$96,997.23	**$787,082.97**
		TOTAL Project Funding Required	**$398,932.93**	**$436,822.67**	**$427,397.42**	**$442,317.52**	**$437,805.13**	**$524,856.92**	**$447,017.65**	**$688,503.17**	**$713,867.50**	**$773,136.40**	**$743,645.45**	**$6,034,302.75**

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7 APPENDIX 1 – CURRICULUM VITAE

BIOGRAPHICAL DATA: **Current Appointment** January 2022 – current: Professor Biodiversity/Ecology, College of Science and Engineering, Flinders University (1.0 FTE). Balanced role**. Academic Pedigree** 1996-2000 PhD Flinders University, Adelaide. A genetic investigation of sociality in the group living lizard *Egernia stokesii*; 1990-1991 B.Sc (Honours in Life Science). Queensland University of Technology, Brisbane QLD 1988-1991 B.Sc (Life Science); Queensland University of Technology, Brisbane QLD.

RELEVANT CHAIRING: Chair of the Pygmy Bluetongue Recovery Team (2017- current).

SUPERVISION OF PYGMY BLUETONGUE RELATED STUDENT PROJECTS: **Postgraduate students advised, primary supervisor:** *Current students:* Ms Dee Trewartha (PhD); Miss Emily Bowyer (Honours); Miss Carmel Maher (PhD 2016 – submitted). *Past students:* Hayden Kiley (Honours 2A 2023); Dee Trewartha (Honours 1st class 2021); Connor Panozzo (Honours 2022, 2A class); Alice Biggins Baker (Honours 2022, 2A class); Kendall Whittaker Honours 2020/2021,1st class); Dr Tara Daniell (PhD awarded 2021); Dr Bonnie Derne (PhD awarded 2021 no changes to submitted version); Mr Carl Watson (Honours 2018/2019 2A class); Dr Lucy Clive (PhD 2019) Dr Jessica Clayton (Impacts of sheep grazing on burrow use by spiders and pygmy bluetongue lizards (*Tiliqua adelaidensis*), PhD awarded 2018); Dr Torben Nielsen (PhD awarded 2017); Mr James Seidel (Honours 2017/2018 2A class); Miss Carmel Maher (Honours, 2015 1st class). **Postgraduate students advised, co-supervisor:** *Past students:* Briannah Blatchford (Honours 2A); Mr Jordan Harries (Honours, 2017 2A); Dr Julie Schofield (PhD 2014 awarded); Ms Annabel Smith (Honours, 2008, 1st class).

PUBLICATIONS: I have 194 Peer-reviewed publications, My H index is 34, and my I-10 index is 91 (Google Scholar, accessed 16/01/2024). **A selection of Pygmy bluetongue and endangered species related publications: Gardner, M.G.,** L. Delphs, A. Smith, R. Dudaniec, J. Sanchez. (2008) *Tiliqua rugosa* microsatellites: isolation via enrichment and characterisation of loci for multiplex PCR in *T. rugosa* and the endangered *T. adelaidensis*. *Conservation Genetics.* **9**, 233–237. Smith A.L., Fenner A.L., Bull C.M., **Gardner M.G.** (2009) Genotypes and nematode infections in an endangered lizard, *Tiliqua adelaidensis*. *Applied Herpetology* **6**, 300–305; Smith, A.L, **Gardner, M.G.**, Fenner, A., Bull C. M., (2009) Restricted gene flow in the endangered pygmy bluetongue lizard (*Tiliqua adelaidensis*) in a fragmented agricultural landscape. *Wildlife Research* **36**, 466–478; Schofield, J.A., **Gardner, M.G.**, Fenner, A., Bull, C.M. (2014) Promiscuous mating in the endangered Australian lizard *Tiliqua adelaidensis*: a potential windfall for its conservation. *Conservation Genetics* 15: 177-185; Treilibs, C., Pavey, C.R., **Gardner, M.G.,** Ansari, T.H., Bull, C.M. (2019) Spatial dynamics and burrow occupancy in a desert floodplain specialist, *Liopholis slateri*. *Journal of Arid Environments*. **167**: 8-17; Derne, B., Halliday R.B. Weinstein, P., Hutchinson, M., Bull, C.M. **Gardner M.G.** (2019) Parasite in peril? A new species of mite in the genus *Ophiomegistus* (Banks) (Acari: Paramegistidae) on an endangered host, the pygmy blue tongue lizard *Tiliqua adelaidensis* (Peters) (Squamata: Scincidae). *Austral Ecology* **44:**420-432; Clive, L., Hutchinson, M., **Gardner M.G,** Bull, C.M. (2019) Preliminary studies on the effects of population augmentation on conspecifics or co-occurring lizard species in a native grassland community *Austral Ecology*; Clayton, J., Bull, C.M., Hutchinson, M., Fenner, A., **Gardner, M.G.** (2020) Co-occupancy of spider engineered burrows within a grassland community changes temporally. *Austral Ecology* 45, 454-459; Daniell T.L., Baring R., Hutchinson M.N., Ainsley P. & **Gardner M.G.** (2020) Translocation for conservation: Neonates are less suitable than adults. Austral Ecology 45, 468-477; Geyle, **et al.** (2021) Reptiles on the brink: identifying the Australian terrestrial snake and lizard species most at risk of extinction. *Pacific Conservation Biology*. 27, 3–12; Daniell, T., Hutchinson, M., Ainsley, P., **Gardner, M.G.** (2021) Recognition of reptile predator scent is innate in an endangered lizard species. *Australian Journal of Zoology* 68 (2), 76-84; Chapple **et al.** (2021) Conservation status of the world's skinks (Scincidae): Taxonomic and geographic patterns in extinction risk. Biol. Conserv. **257**, 109101. Melville **et al**. (2021) Return-on-investment approach for prioritization of rigorous taxonomic research needed to inform responses to the biodiversity crisis. PLoSONE 19(6) e3001210; Senior A. F., Clemann N., **Gardner M. G.**, Harrisson K. A., While G. M. & Chapple D. G. (2021) Genetic structure, diversity and distribution of a threatened lizard affected by widespread habitat fragmentation. Conservation Genetics. 1-15; Michael KH, **Gardner MG.** 2023. Hold your breath: Observations of the endangered pygmy bluetongue (Tiliqua adelaidensis) submerged in flooded burrows. Austral Ecology DOI:10.1111/aec.13 3 51.

MAJOR PYGMY BLUETONGUE GRANTS: Two pygmy bluetongue Australian Research council grants: 1) Gardner, Hutchinson, Godfrey, Bertozzi Genomics and mixed source populations in wildlife translocations. LP190100071 ARC LP19 (5 year project); 2) Gardner (formally Bull), Hutchinson Conservation management of the endangered pygmy bluetongue lizard/ ARC LP 2012 Rd 1 LP120100426.

Director

Dr Travis How

KEY STRENGTHS

- Ecological approvals and legislation
- Ecological impact assessment
- SEB Offsetting
- Flora and fauna survey and assessment
- Threatened species management
- Expert witness statements
- Habitat restoration planning and implementation
- Stakeholder engagement

QUALIFICATIONS

Doctor of Philosophy (PhD)

School of Biological Sciences, Flinders University (1997 - 2001)

Honours Degree – Bachelor of Applied Science in Natural Resource Management

The University of Adelaide (1996)

Bachelor of Applied Science in Natural Resource Management

The University of Adelaide (1993 - 1995)

RELEVANT EXPERIENCE AND SKILLS

Career summary

With more than 25 years' experience in the field in both the public and private sectors, Travis has extensive experience in flora and fauna surveys, undertaking ecological impact assessments, preparing management plans and contract management. Travis' strengths lie in project management and his ability to anticipate and understand client requirements. He has extensive ecological knowledge gained from a range of various projects during his time in the field. Travis is an accredited consultant in the Rangelands, Bushlands and Scattered Trees Assessment Methodology.

Travis has extensive knowledge of Pygmy Blue-tongue Lizards (*Tiliqua adelaidensis*), their ecology and management of the species. This has been developed over the last 20 years where he has undertaken numerous surveys and assessments of the species, co-authored the Pygmy Blue-tongue Recovery Plan (2012) and been apart of the Pygmy Blue-tongue Recovery Team for a number of years. Travis has been involved in the previous research on wind farms and Pygmy Blue-tongue Lizards at Hornsdale Wind Farm.

Travis has completed a PhD where he researched mating systems in Sleepy Lizards (*Tiliqua rugosa*), a closely related species to Pygmy Blue-tongue Lizards. Successfully completing a PhD in the herpetology field, shows that Travis has the necessary skills and experience to be involved in research programs on reptile species.

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