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Department of Planning and Environment

Threatened reptiles

Biodiversity Assessment Method survey guide

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Cover photo: Pale-headed snake, *Hoplocephalus bitorquatus*. Jake Hansen/DPE

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Shortened forms

Abbreviation	Description
assessor	accredited person
BAM	Biodiversity Assessment Method
BAM-C	Biodiversity Assessment Method Calculator
BAR	Biodiversity Assessment Report: includes Biodiversity Development Assessment Reports (BDARs); Biodiversity Certification Assessment Reports (BCARs); and Biodiversity Stewardship Site Assessment Reports (BSSARs)
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BC Regulation	Biodiversity Conservation Regulation 2017
BOS	Biodiversity Offsets Scheme
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (C'th)
GIS	Geographic Information System
GPS	global positioning system
PCT	plant community type
SAII	serious and irreversible impact/s
TBDC	Threatened Biodiversity Data Collection
TEC	collective term for threatened ecological communities (vulnerable ecological communities, endangered ecological communities, critically endangered ecological communities) listed under the BC Act and the EPBC Act
the department	Department of Planning and Environment

1. Introduction

1.1 Purpose of this guide

The NSW Biodiversity Offsets Scheme (BOS) is underpinned by the Biodiversity Assessment Method (BAM) (DPIE 2020). The BAM establishes a transparent, consistent and scientifically based approach for assessing impacts to, or improvements in, biodiversity.

The *Threatened reptiles: Biodiversity Assessment Method survey guide* (this guide) aids accredited persons (assessors) when applying the BAM to:

- survey for threatened reptiles and their habitat
- map the species polygon when presence is identified
- document required information in the Biodiversity Assessment Report (BAR).

This guide is a companion to the BAM. The Department of Planning and Environment (the department) will review and update this guide periodically to incorporate new information and reflect legislative or policy changes.

1.2 Biodiversity Offsets Scheme

Threatened reptile species include *critically endangered*, *endangered* or *vulnerable* species as listed under Schedule 1 of the NSW *Biodiversity Conservation Act 2016* (BC Act). The BOS requires a consistent approach to suitable habitat identification and targeted survey for threatened species, which forms the basis of this guide.

For a proposed development, clearing or biodiversity certification site (impact assessment sites), all direct, indirect and prescribed impacts on threatened reptiles and their habitat must be assessed and described in the BAR (BAM 2020, Chapter 8). These impacts must first be avoided and minimised – any residual impacts require offsetting (BAM 2020, Chapter 7). For biodiversity stewardship agreement (BSA) sites, presence of threatened reptiles and their habitat, and the management actions to improve these values, must be assessed and described in the Biodiversity Stewardship Site Assessment Report (BSSAR).

Interactions with other legislation protecting threatened reptiles may also require consideration. Reptile species may be listed *as critically endangered*, *endangered* or *vulnerable* under both the BC Act and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). For development in NSW, impact assessments are streamlined by the Australian Government's endorsement of the BOS. The Australian Government may set additional assessment requirements and conditions beyond the BOS.

The methods and techniques specified in the guide may inform other threatened species assessments, such as assessments of significance (section 7.3 of the BC Act) and species impact statements (Division 5 of the BC Act).

1.3 Biodiversity credits

All threatened entities are allocated to one of 2 biodiversity credit classes. Under the BAM, biodiversity credits are used to quantify the:

- loss in biodiversity values from the impacts of development, or
- gain in biodiversity values from management actions on a BSA site.

Ecosystem credits apply to entities where the likelihood of occurrence of the entity or elements of a species' habitat can be predicted by vegetation surrogates and/or landscape

features, or for which targeted survey has a low probability of detection. Ecosystem credits provide a measure of the threatened ecological communities (TECs) and/or threatened species habitat for a species that can be reliably predicted to occur with a plant community type (PCT) and other PCTs generally.

Species credits apply to species where the likelihood of occurrence, or elements of suitable habitat, cannot be confidently predicted by vegetation surrogates and/or landscape features, or that are reliably detected by targeted survey. Species credits provide a measure of the suitable habitat area for, or the number of individuals of, a threatened species.

Dual credits apply to species whose habitat is divided into ecosystem credits (e.g. foraging habitat) and species credits (e.g. breeding habitat). Dual credit species are generally those with critical habitat, such as breeding habitat, that warrant particular consideration (e.g. cave breeding bats, birds dependent on hollows of particular dimensions for breeding).

Under the BAM, threatened reptile species are ecosystem credits, species credits or dual credits. The BAM requires either a targeted species survey or an expert report to determine the presence of a species credit species (or relevant habitat component) on the subject land. Presence may be assumed at impact assessment sites.

This guide provides the minimum survey requirements for threatened reptile species identified as species credit and dual credit species (see Section 1.3.1). Two species of marine turtles (*Caretta caretta* and *Dermochelys coriacea*) listed under the BC Act are not included. They have no terrestrial habitat that could require assessment under the BAM.

Species listed only under the EPBC Act do not require survey under the BC Act. The Commonwealth has endorsed the BAM for assessment of entities listed under the EPBC Act. However, for advice on targeted survey guidance, determining impacts and appropriate offsetting of any residual impacts for entities that are only listed under the EPBC Act, please refer to Commonwealth survey guidelines and contact epbc.nsw@environment.gov.au.

1.3.1 Credit classes of threatened reptile species in this guide

Species credit species

- *Amalosia rhombifer*
- *Antaresia stimsoni*
- *Aprasia parapulchella*
- *Cacophis harriettae*
- *Chelonia mydas*
- *Coeranoscincus reticulatus*
- *Ctenophorus mirrityana*
- *Ctenotus pantherinus ocellifer*
- *Cyclodomorphus praealtus*
- *Cyclodomorphus venustus*
- *Delma impar*
- *Diplodactylus platyurus*
- *Eulamprus leuraensis*
- *Furina dunmalli*
- *Hoplocephalus bitorquatus*
- *Hoplocephalus stephensii*
- *Liopholis guthega*

- *Lucasium stenodactylum*
- *Myuchelys bellii*
- *Myuchelys georgesi*
- *Tympanocryptis lineata*
- *Tympanocryptis mccartneyi*
- *Tympanocryptis osbornei*
- *Uvidicolus sphyrurus*

Dual credit species

- *Hoplocephalus bungaroides*

EPBC Act species

- *Anomalopus mackayi*[1]
- *Delma torquate*
- *Egernia rugosa*

1.4 Scope of this guide

Under the BAM, all species surveys must be conducted in accordance with threatened species survey guides published by the Secretary of the department (BAM 2020, Section 5.3(2.b,)). Therefore, this guide must be applied, as a minimum, when conducting surveys for threatened reptiles. Any variation from these survey methods must meet the same objectives detailed in this guide (Section 2.1), employ a systematic approach (Section 2.2), be supported by evidence, and justified in the BAR; for example, peer-reviewed scientific literature or a guideline published by another jurisdiction.

The requirements for an expert report, where used as an alternative to a targeted survey, are detailed in Box 3 of BAM 2020. For threatened reptiles, an expert report should:

- address how the vegetation and/or reptile habitat has been evaluated, including reference to BAM definitions of suitable habitat (Section 3.2 of this guide)
- include the species polygon if a threatened reptile is likely to be present or use the subject land
- include reference to past surveys, field validated habitat maps, records or other information used to form their expert opinion.

[1] *Anomalopus mackayi* is an ecosystem credit species under the BC Act.

2. Targeted species surveys

2.1 Survey objectives

Under the BAM, the objectives of a targeted reptile survey are to:

- establish threatened reptile presence on the subject land with a high level of confidence
- estimate the area of habitat on the subject land, which forms the species polygon and is used to calculate species credits, where threatened reptiles are present.

The targeted survey aims to reduce the risk of false negatives (i.e. the species is reported as absent from the subject land, when it is present). A high level of confidence in the results is assumed when undertaken by an appropriately skilled person (refer to Section 2.3) in accordance with this guide.

2.2 Systematic approach

This guide describes a systematic approach to targeted threatened reptile survey. The survey approach must be considered in the planning phases of the assessment and incorporates 2 key elements:

1. survey design to maximise the likelihood of detecting threatened reptiles – including consideration of constraints (e.g. site, seasonal and temporal)
2. field survey techniques that aim to search suitable habitat at an appropriate intensity.

2.3 Surveyor skills

Threatened reptile surveys must be carried out by an appropriate threatened reptile surveyor (a surveyor). This is someone who can demonstrate their:

- strong knowledge of reptile ecology and habitat use (including the target species)
- ability to accurately detect threatened reptile species (including the target species) using the methods detailed in this guide.[2]

A surveyor's skills in threatened reptile surveys must be demonstrated in the BAR by:

- relevant training and qualifications (including licence numbers)
- a recent history of experience (in the previous 10 years) in using the relevant survey methods[2], with demonstrated success in threatened reptile identification in NSW
- employers' names and periods of employment (where relevant).

Surveyors must have the required licences and ethics approvals. Given the potential impact of diseases on reptile populations, a clear understanding of disease management protocols is also required.

The surveyor is not equivalent to an 'expert' as defined in Box 3 of BAM 2020. An expert must demonstrate specialised knowledge in relation to particular biodiversity values, as the opinion of an expert replaces the need to survey. Expert status is determined and approved by the Environment Agency Head (Appendix A). The surveyor does not need to be an assessor; however, the BAR must be submitted by an assessor.

[2] Demonstration of skills and experience in the survey methods relates only to those selected for the targeted threatened reptile survey (i.e. not all survey methods listed in this guide).

3. Survey design

A decision key for threatened reptile surveys is provided in Appendix B.

3.1 Candidate species list

Based on a series of filters and site-based information, the Biodiversity Assessment Method Calculator (BAM-C) generates a list of candidate species credit species predicted to occur on the subject land (BAM 2020, Subsection 5.2.1). For impact assessment sites, where past surveys or incidental sightings have recorded threatened reptiles on the subject land, the species must be included in the candidate species list (BAM 2020, Subsection 5.2.1(6.)).

A species may be removed from the list where (BAM 2020, Section 5.2):

- all habitat constraints[3] listed for the species in the Threatened Biodiversity Data Collection (TBDC) are absent from the subject land, or
- all habitat constraints or microhabitats on which the species depends, are sufficiently degraded such that the species is unlikely to use the subject land, or
- location of the subject land does not meet geographic limitations[4] listed for the species within the Interim Biogeographic Regionalisation for Australia (IBRA) subregion, or
- the species is considered vagrant to the IBRA subregion, or
- an expert report states the species is unlikely to be present on the subject land.

Where a species is removed from the candidate species list, no further assessment is required for that species on the subject land. **Justification for removing a species from the candidate species list must be documented in the BAR.** This should include evidence for any features being absent (e.g. field reconnaissance) and reference to any supporting information from published, peer-reviewed sources (e.g. scientific journals and research reports outlining the microhabitats used by the species). All remaining species require targeted survey to determine presence on the subject land.

For BSA sites, assessment of species credit species is optional and if not undertaken, species credits will not be generated.

3.2 Suitable habitat

Suitable habitat is that where the target species is expected to occur or to periodically use. It identifies the area where survey is required for the target species on the subject land.

Suitable habitat for threatened reptiles is:

- any PCT associated with the target threatened reptile species in the TBDC, and
- any habitat constraints listed for the species (e.g. rocky outcrops).

[3] Examples of habitat constraints include rocky areas, waterbodies and hollow bearing trees. Habitat constraints associated with a species are identified in both the TBDC and the BAM-C.

[4] Examples of geographic limitations include specific local government areas or above a defined altitude. Geographic limitations are identified in the 'Threatened Species Profile' and BAM-C.

Species-specific information for identifying suitable habitat is provided in Section 7 of this guide.

Onsite validation of desktop assessments of suitable habitat is required, because:

- mapping and digital data may not accurately represent all topographic details
- the history of the site and its disturbance cannot be reliably evaluated from imagery
- microhabitat features are not reliably or adequately evaluated remotely.

Any measurement using a GPS requires a positional accuracy of ≤10 m.[5]

3.3 Survey timing and meteorological conditions

Conduct surveys at the optimal time for detection of the target threatened reptile. General guidance on the appropriate time to survey is documented in the TBDC and displayed in the BAM-C survey matrix in the Habitat Survey tab.

Survey periods specific to each species are detailed in Section 7 of this guide. These identify when the species will be active, thus optimising detection. Typically, reptiles maintain the same territory throughout the year. They feed, shelter and reproduce within that home range. Some species, however, may move to specific breeding habitat.

Surveys may be conducted outside the identified times, but only when there is a justifiable reason; for example, due to spatial or temporal variation in temperature or breeding seasons. Adjusted survey times must be documented and justified in the BAR.

Reptiles are ectothermic and become inactive when conditions are too cold, sheltering in locations where they are not easily detected (e.g. in burrows, hollows, etc.). In NSW, surveys for reptiles are not recommended during the colder winter months and many species are typically inactive at night. For some crepuscular or nocturnal species, however, surveys are best undertaken in the early evening or into the night; for example, geckos and some elapid snake species (Cogger 2014).

Use of a reference site (where the target species is known to be present) on the same day/night of the planned survey is highly valuable for demonstrating:

- the surveyor has the necessary skills to detect the species
- the species was sufficiently active at the time of survey to expect detection if present.

In some situations, surveying at the optimum time to detect threatened reptiles may not be possible or feasible (e.g. where project timeframes are constrained). The proponent may choose to use an expert report (BAM 2020, Section 5.3) to assess the species' presence on the subject land. Alternatively, for impact assessment sites, the species may be assumed present.

The survey effort described in this guide assumes suitable conditions for the target threatened reptile species as detailed in Section 7.

The meteorological conditions on the subject land, 2 days prior to survey and each day or night of the survey, must be recorded using a portable meteorological station or the closest Bureau of Meteorology station. Document in the BAR:

- rainfall (mm)
- minimum and maximum temperature (°C)
- relative humidity (%)
- mean wind speed (km/h)
- cloud cover (oktas).

[5] As reported by the GPS accuracy estimate.

3.4 Survey effort

This guide uses **standard effort assumptions**. Unless otherwise stated, all survey effort is expressed as effort required per 50 ha of suitable habitat using a stated method (e.g. 120 person-min of habitat or spotlight surveys). Where there is:

- <50 ha of suitable habitat, the effort per 50 ha must be applied
- >50 ha of suitable habitat, a pro-rata effort must be applied (e.g. 100 ha of suitable habitat would require double the survey effort).

Survey time is the minimum minutes spent searching to reasonably expect any reptiles present will be detected. Where recommended methods are interchangeable (e.g. habitat surveys or pitfall traps), it will be clearly stated. In all instances survey effort must adequately cover suitable habitat and be documented in the BAR. Survey effort may be combined for candidate species that share similar suitable habitat and require the same survey method.

All surveys must be repeated to address locally unfavourable conditions causing low reptile activity. Each survey replicate must be independent, with the first and last survey separated by a minimum of 14 days.

3.4.1 Confirming presence

Presence of a threatened reptile species is confirmed within the subject land if the species is observed visually (or via camera trap). Once presence is confirmed further survey for the species is not required. Where more than one method is required, detection by either survey method will confirm presence. All expressions of suitable habitat on the subject land are to be included in the species polygon.

Threatened reptiles may be incidentally detected (e.g. observed) on the subject land during other assessments and/or site visits. Where suitable habitat is available on the subject land, incidental sightings confirm presence.

3.5 Field survey plan

Prepare a field survey plan based on the habitat characteristics of the subject land (Section 7 of this guide) and in accordance with the BAM (BAM 2020, Sections 5.2–5.3). The following steps outline a general method for deriving a survey plan:

1. Identify areas of the subject land considered suitable habitat for the target species (Section 7) – only these areas require survey.
2. Determine the most appropriate survey methods for the subject land, considering the limitations outlined for each method (Sections 4 and 7).
3. Determine the required survey effort based upon area of suitable habitat, as outlined for each method (Sections 4 and 7).
4. Determine survey dates appropriate for the technique, as outlined for each method (Sections 4 and 7).
5. Select survey sites based on steps 1 and 2 above.
6. Select survey dates based on steps 4 and 5 above. Allow flexibility for unfavourable conditions, which may include low light, heavy rainfall, severe weather (lightning, hail, strong winds) and difficult terrain.

3.6 Evaluate survey efficacy

Suitable reference sites can demonstrate that the surveyor's skills and survey timing are appropriate, providing confidence in the target species survey results.

Where reference sites are not available, survey adequacy can be evaluated against survey success. Preliminary surveys should be evaluated against an expected outcome to assess the efficacy of survey effort and identify any problems that will affect results (e.g. season, weather). An expected outcome can be obtained by examining the results of published surveys using equivalent methods from the same or similar regions. Ideally this evaluation should be undertaken in the field, supporting immediate adjustments to the survey design (e.g. sampling additional nights).

Examining the results of other surveys using similar methods and in similar habitats can give an indication of the results expected for target species surveys. Non-target and common reptile species can indicate survey success for the rarer target species – this is particularly true of upland reptiles. Evidence of detection probability for common Australian reptiles, using different survey methods, is limited in published literature.

Explanations of poor survey results include:

- **Weather:** survey may be affected by unsuitable weather conditions (e.g. wind, rain, temperature). *Solution: avoid surveying in unsuitable conditions and repeat any survey affected by unsuitable conditions.*
- **Day vs night:** whilst most reptiles are generally active through the day, some species (notably most geckos) are mainly or solely active at night. *Solution: undertake survey during the best detection period for the target species using the required methods.*
- **Season:** successful surveys for reptiles are highly dependent on avoiding seasons where a species is unlikely to be detected – typically winter, when most species go into aestivation. Surveys during periods when reptiles are likely to be in torpor are unlikely to detect the species as reptiles will seek deeper shelter sites that cannot easily be accessed. Surveys at such times are likely to lead to false negative outcomes. *Solution: survey in the correct season and during suitable weather. Use a reference site to demonstrate activity was occurring at the time of the survey*.
- **Unsuitable habitat selection:** each reptile species will generally have a preferred habitat (e.g. rock outcrops, spinifex clumps, ponds). Spending large periods of survey time in inappropriate habitat, while ignoring suitable habitat, will provide poor results. *Solution: understand and target the preferred habitat of the species.*
- **Equipment failure:** equipment can fail to operate as expected; for example, traps are not set properly or are the wrong size and shape. *Solution: always check equipment is functioning properly and is suitable for the task.*

Supporting information on estimating expected outcomes is provided in Appendix C. Issues with survey effectiveness, and steps taken to address these, must be documented in the BAR.

4. Survey methods

Methods in this guide refer to the following standard techniques. To address the limited understanding of survey effectiveness for threatened reptiles, a precautionary approach was used in selecting survey methods and their associated effort.

4.1 Habitat surveys

Habitat surveys require visual searches within areas of suitable habitat, observing for:

- active individuals
- non-active individuals, by checking in or under potential shelter sites.

Walk slowly (approximately 2 km/h) through the suitable habitat, alternating the above search activities. Stop every 10 m, at a minimum, to observe for moving reptiles. Concentrate on points in the landscape where they may be basking or partially hiding. Hiding reptiles will typically re-emerge shortly after the disturbance, checking for a potential threat and/or returning to bask in a sunny location. Waiting quietly at regular intervals will allow them to be identified.

Check for litter and humus dwelling species (e.g. *Coeranoscincus reticulatus* and *Anomalopus mackayi*) by gently raking through loose surface material to expose any reptiles. Return all cover to its original position. When checking in or under potential shelter sites (e.g. within grass tussocks, under logs, rock or bark, or within leaf litter), ensure habitat damage or injury to sheltering fauna is avoided.

Completing habitat surveys using both visual searches and checking potential shelter sites supports effective survey at different times of the day, in a range of conditions and for species with varying habits. During the early morning, air temperatures are likely low and the ground has yet to warm. Reptiles are more likely to select sunny patches to bask at this time. Once the air and ground temperatures have increased, individuals are likely to bask less and are more observable moving around or seeking shelter. On days with no cloud cover reptiles will bask as needed. On days with some cloud cover, reptiles can be expected to bask when the sun comes out and a surveyor will likely be most successful visually scanning sunny areas. Using typical behaviour and habitat use patterns of the target species is essential for focusing habitat surveys on the most effective search component for the given conditions and time of day.

Carrying a camera is recommended, as it is often possible to approach reptiles close enough for a photograph. This can assist target species identification without catching the individual.

One survey is a minimum of 120 person-min per 50 ha of suitable habitat, unless otherwise stated for the target species in Section 7. This can be undertaken by one (for 120 min) or 2 (for 60 min each) surveyors. Locations with greater cover, providing high quality shelter sites, will require a longer survey time than those with minimal cover.

4.2 Spotlight surveys

Spotlight surveys are undertaken to detect nocturnal reptiles via their ‘eyeshine’ (reflection of light from the eyes) or observed movement. Spotlight surveys require use of a headlamp or lightweight, hand-held spotlight powered by a suitable battery. Minimum spotlight intensity is 200 lumens. Surveyor(s) must walk slowly and quietly through habitat in which individuals would be expected to be active.

The surveyor should carry extra batteries and globes to avoid potential equipment failure.

One survey is 120 person-min per 50 ha of suitable habitat, unless otherwise stated for the target species in Section 7.

4.3 Pitfall traps

Pitfall traps are typically buckets or cylindrical pipes, buried with their top edge flush with the ground (Figure 1). Trap dimensions depend on the target species' size (detailed in Section 7). A standard pitfall trap is a 10 L bucket (26 cm x 26 cm x 27 cm). These traps are effective for capturing both nocturnal and diurnal species, cryptic species, and species that spend a large proportion of their time in litter or on the top layers of soil.

To minimise predation and exposure risk, provide cover in the trap for captured reptiles (e.g. leaf litter, soil, etc.). Check traps a minimum of twice per day or night, with timing dependent on the target species' behaviour. Care should be taken when checking traps, including the cover, to ensure any hiding reptiles are located (especially where soil is provided as cover).

To prevent reptiles climbing over the trap, clear any plants or material from the top of the trap. Ensure plants or material placed within the trap for cover cannot be used for escape.

Unless otherwise stated in Section 7, pitfall traps are used with drift fences that direct reptiles into the trap (Figure 1). Place traps tight against or bisected by the drift fence. This maximises the likelihood of an animal following the fence to the trap.

Figure 1 Example of a drift fence line with pitfall and funnel traps

The pitfall trap is flush with the ground and funnel traps are covered to provide shade and visual screening for captured reptiles.

Construct drift fences using smooth material that is not easily climbed by the target species. Bury the base at least 5 cm deep to avoid the target species digging under the fence line. Drift fence height is dependent on the target species' size and climbing ability. For reptiles with a snout–vent length of:

- <10 cm, use a drift fence with 20 cm height
- ≥10 cm, use a drift fence with 30 cm height (minimum).

Place traps at a density of **18 pitfall traps per 50 ha**, unless otherwise stated in Section 7. Set 3 pitfall trap lines, each consisting of 6 traps spaced 3 m apart on a 15 m line transect (DSEWPaC 2011). Place pitfall trap lines a minimum of 250 m apart to provide spatial separation and capture variability in each PCT being surveyed.

One trap day/night occurs when the trap is open for a full day and night, which ensures the activity pattern of the target species is covered regardless of the timing and conditions (e.g. a normally diurnal reptile being active on a warm night). The required trap days/nights are detailed in Section 7. Pitfall traps can be highly effective in detecting cryptic species not found by other methods, but often require many trap days/nights for a confident detection rate.

4.4 Terrestrial funnel traps

Terrestrial funnel traps are typically narrow mesh covered funnel traps. They are placed in the terrestrial environment at points the target species can be expected to move through; for example, along rock faces or logs, or in the gaps between grass tussocks that reptiles will follow for ease of movement whilst still being afforded cover from predators.

Where suitable 'directing cover' is not present, terrestrial funnel traps should be used with drift fences to direct reptiles into the mouth of the trap (Figure 1). Set the drift fence using the same approach as for pitfall traps. Ensure the terrestrial funnel trap is placed tightly against the drift fence and the ground to prevent reptiles escaping between the trap and the fence, or under the trap. This will maximise the potential for reptiles to be directed into the trap.

The mesh size of traps must be sufficiently small to trap the target species and the funnel entrance must be large enough for them to enter. Set the funnel entrance to sit away from the edges of the trap; that is, suspended in mid-air. Any animal entering the trap will fall 'down' into the trap and will not encounter the opening by moving along the edges of the trap walls. To increase the likelihood of reptiles entering the trap, construct a ramp that directs them into the funnel using soil, rocks or litter.

Commercially available funnel traps are typically 75 cm x 18 cm x 18 cm. These long and thin traps provide a better opportunity to collect longer reptiles, especially snakes.

Place traps at a density of **18 funnel traps per 50 ha**, unless otherwise stated in Section 7. Set 3 pitfall trap lines, each consisting of 6 traps spaced 3 m apart on a 15 m line transect. Pitfall trap lines should be placed a minimum of 250 m apart to provide spatial separation and be set to cover variability in each PCT being targeted for survey.

Check traps for captured reptiles a minimum of twice per day – every morning and every afternoon – to reduce the risk of escape. Cover traps with shade cloth, vegetation, or similar suitable material to prevent trapped reptiles from overheating.

One trap day/night occurs when the trap has been opened for a full day or night. Terrestrial funnel traps should be deployed for a minimum of 4 days unless otherwise specified in Section 7 of this guide.

4.5 Aquatic funnel traps

Aquatic funnel traps (also referred to as fyke nets or cathedral traps) are placed in water to capture aquatic reptiles (i.e. turtles).

Trap dimensions will depend on the target species' size. The trap must be sufficiently large to hold >10 adults with room to move and breathe. The mesh size of traps must be sufficiently small to trap the target species and the funnel entrance must be large enough for them to enter. Commercially available yabby traps (60 cm x 45 cm x 25 cm) are likely to be suitable for capturing target turtle species. Alternatively, traps can be constructed to provide more specific dimensions for the target species (particularly the entrance and requirement for space above the water).

Set traps in locations where the target species is likely to swim and encounter the trap. Secure the trap in place, ensuring part of the trap is clear of the water – this will allow captured turtles to breathe. For example, traps can be secured to a tree or float to ensure they remain above water. Turtles can be channelled into the mouth of the aquatic funnel trap using a drift fence system. Where this is used, ensure the trap is placed tightly against the fence to prevent the target species escaping between the trap and the fence, or under the trap. This will maximise the potential for the target species to be directed into the trap.

Set traps every 20 m in the shallows, along the edges of suitable pools, and bait with fish to attract the target species. Place bait in perforated containers, providing a scent trail.

Traps must be checked at intervals of 4–10 h, including after dark and first thing in the morning. Replace baits after approximately 24 h. Traps can be left in place for up to 48 h. Where turtle densities are high, check traps a minimum of 4 times within the first 2 h of being set, as traps may become full causing the turtles to sink and drown (DSEWPaC 2011).

One trap day occurs when the trap is open for a full 24 h.

4.6 Artificial cover

Placing artificial cover within areas of suitable habitat provides alternative habitat to check, leaving natural cover intact.

Artificial cover can consist of a range of different materials placed on a substrate (e.g. tree trunk or ground), providing a favourable shelter site for a target species. The artificial cover provides protection from predation and also a preferable thermal environment for the target species. It should be constructed from material that absorbs and radiates heat for a sheltering reptile. Materials used should be solid enough to prevent them being easily displaced by predators (e.g. roofing tiles, lengths of wood or sheets of metal). The size and depth of the artificial cover required for target species is detailed in Section 7.

Reptiles are recorded by turning over the artificial cover, observing for sheltering individuals – either visually identifying or capturing them. Optimal conditions for checking artificial cover are determined by the target species – aim for when it is likely to shelter under shallow cover (e.g. early morning). As reptiles retreat to thicker and denser cover when conditions are cold and wet, checking artificial cover in such conditions is not recommended.

Reptiles will shed their skins under cover and this can provide a second opportunity to detect a target species under artificial cover. After the initial check for target species, the area under the cover should also be checked for sloughed skins.

It is noted that reptiles may not use the artificial cover with any regularity and predictability until it is bedded into the environment to form a suitable microclimate. This can take up to several months – see Section 7 of this guide for more details.

4.7 Camera trap

A camera trap with sufficient image resolution for detecting the target species can be used to photograph individuals entering or leaving a suspected burrow or shelter site. Set the camera to face the entrance of the burrow or shelter site. It can also be baited with appropriate food to attract the target species into its photographic field (the location of which depends on the camera being used). Set the camera for a minimum of 4 days, recording for the full 24-hour cycle.

5. Species polygon

Where a targeted survey confirms presence of a threatened reptile species, a species polygon must be mapped in accordance with BAM 2020 (BAM Section 5.2.5).

Use best available ortho-rectified aerial imagery of the subject land to identify:

- locations of all detections
- all suitable habitat on the subject land
- habitat constraints, other suitable microhabitats or features associated with that species
- area of the species polygon
- any required buffer area identified for the species.

The spatial dataset attributes for each species polygon must specify the associated PCT and identify where species presence is assumed or confirmed through survey. The BAR must provide justification for any area of suitable habitat that is excluded from the species polygon.

Refer to Section 7 of this guide for species-specific requirements. Additional considerations for mapping species polygons are provided in Box 1, and examples in Figures 2–5.

For BSA sites, areas where management actions will restore suitable habitat for the species may be included in the species polygon. Where suitable habitat, or an area separating suitable habitat, is highly degraded or isolated, active restoration might be appropriate.

Box 1. Mapping a species polygon – waterbodies and geological features

The BAM will only generate biodiversity credits for impacts on, or improvements in, native vegetation condition. Where suitable habitat is defined by non-vegetative features (e.g. rocks, waterbodies, sand dunes) the species polygon must outline the boundary of the habitat feature and the associated buffer area. Biodiversity credits will only be calculated for the native vegetation within the buffer area.

For impact assessment sites, any impacts to the non-vegetative feature must be assessed as a prescribed impact in accordance with the BAM 2020 (BAM Section 8.3). Prescribed impacts do not form part of an assessment for a BSA site.

Example: *Myuchelys bellii* (western sawshelled turtle/Bell's turtle)

Habitat surveys of aquatic habitats within the subject land located the target species in 2 locations (see Figure 4).

The species polygon is mapped to the full extent of the aquatic habitat in which the species was detected plus a 50 m buffer from the top of bank (see Figure 5).

Biodiversity credits will only be calculated for the native vegetation within the 50 m buffer area. Any impacts on the waterbodies must be assessed as a prescribed impact.

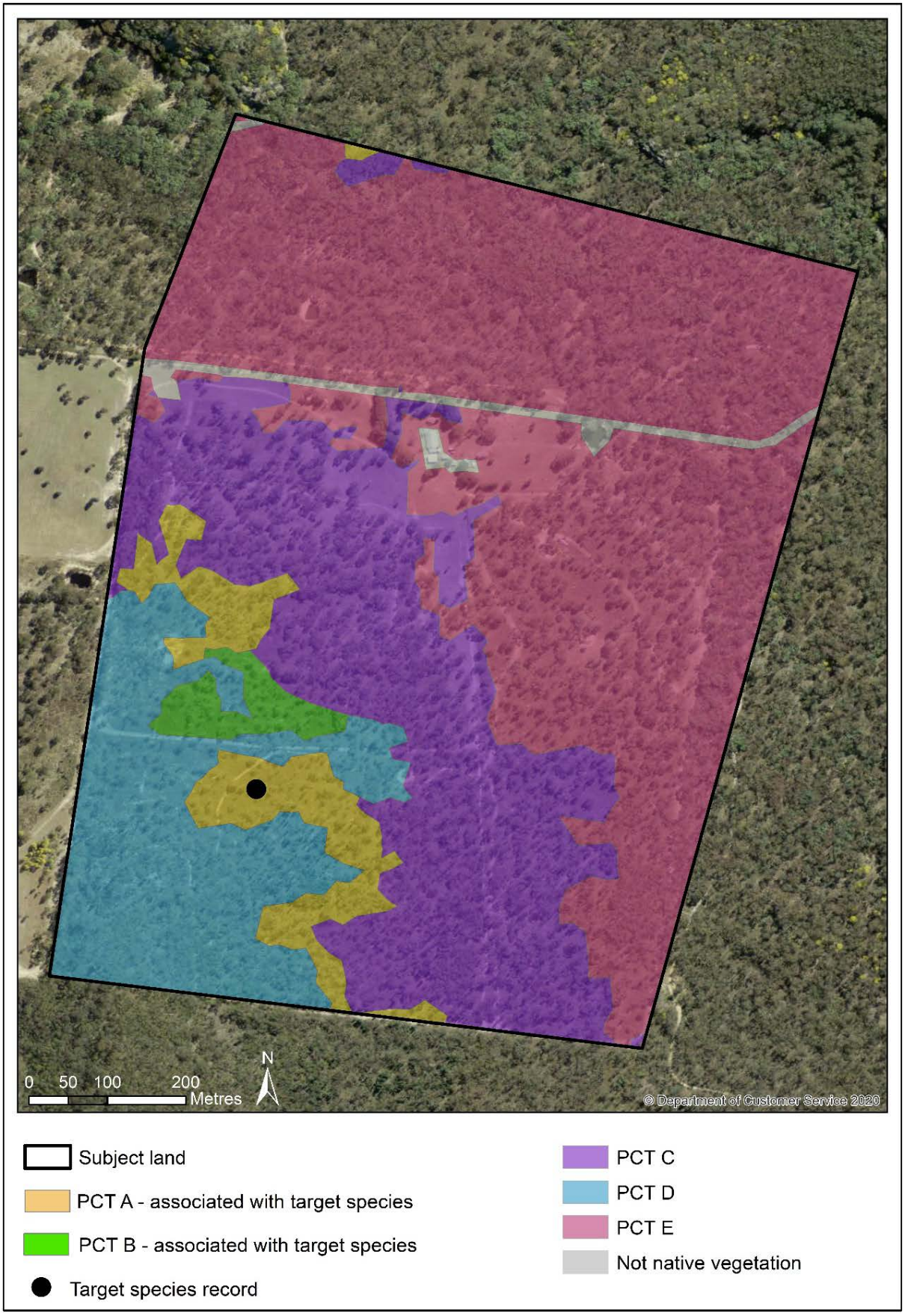

Figure 2 Mapping a species polygon – Identify the locations of all detections of the target species and all PCTs on the subject land; for this target species suitable habitat is all PCTs associated with the species in the TBDC

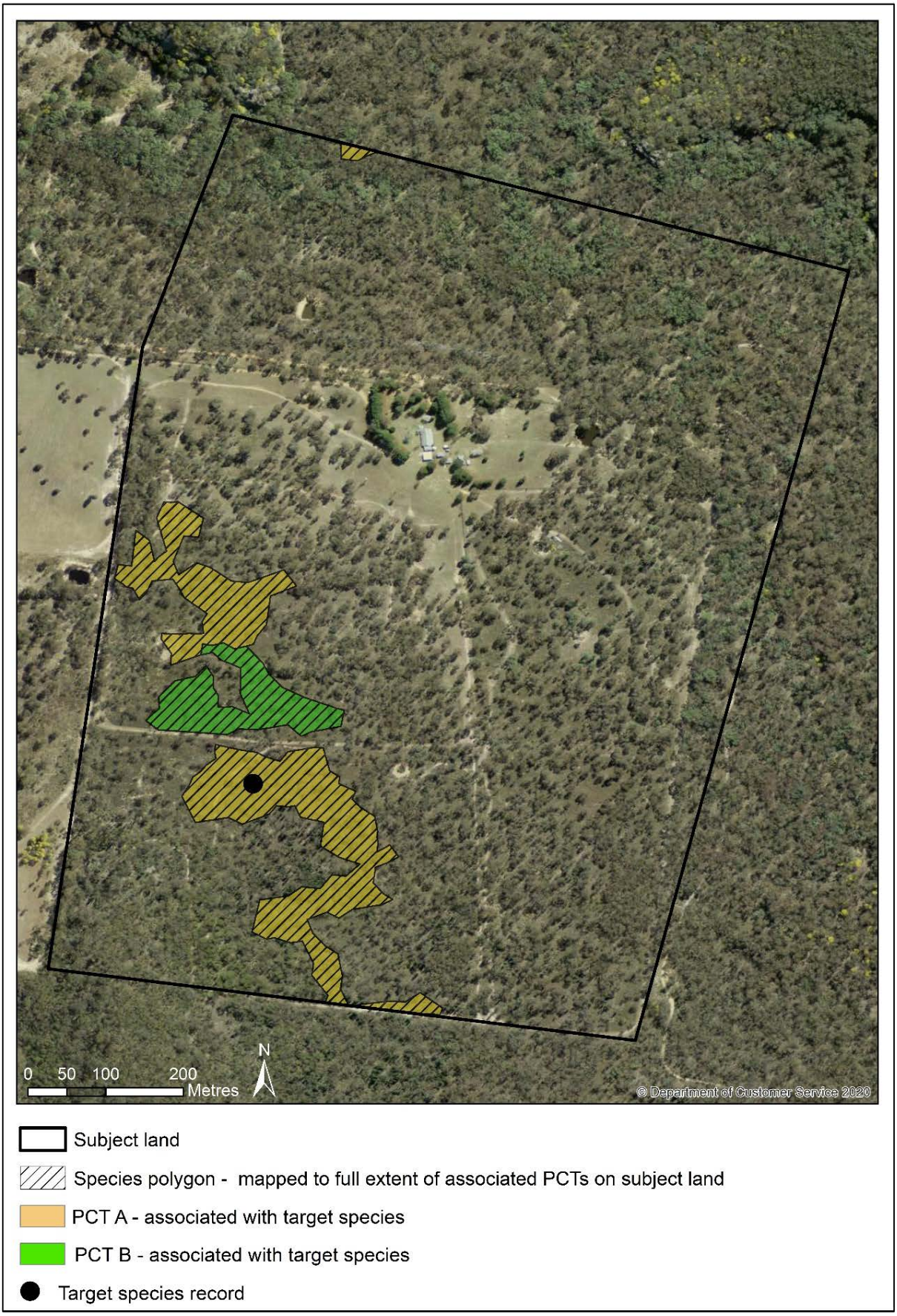

Figure 3 Mapping a species polygon – Map the species polygon to the full extent of all suitable habitat (PCTs associated with the species) on the subject land

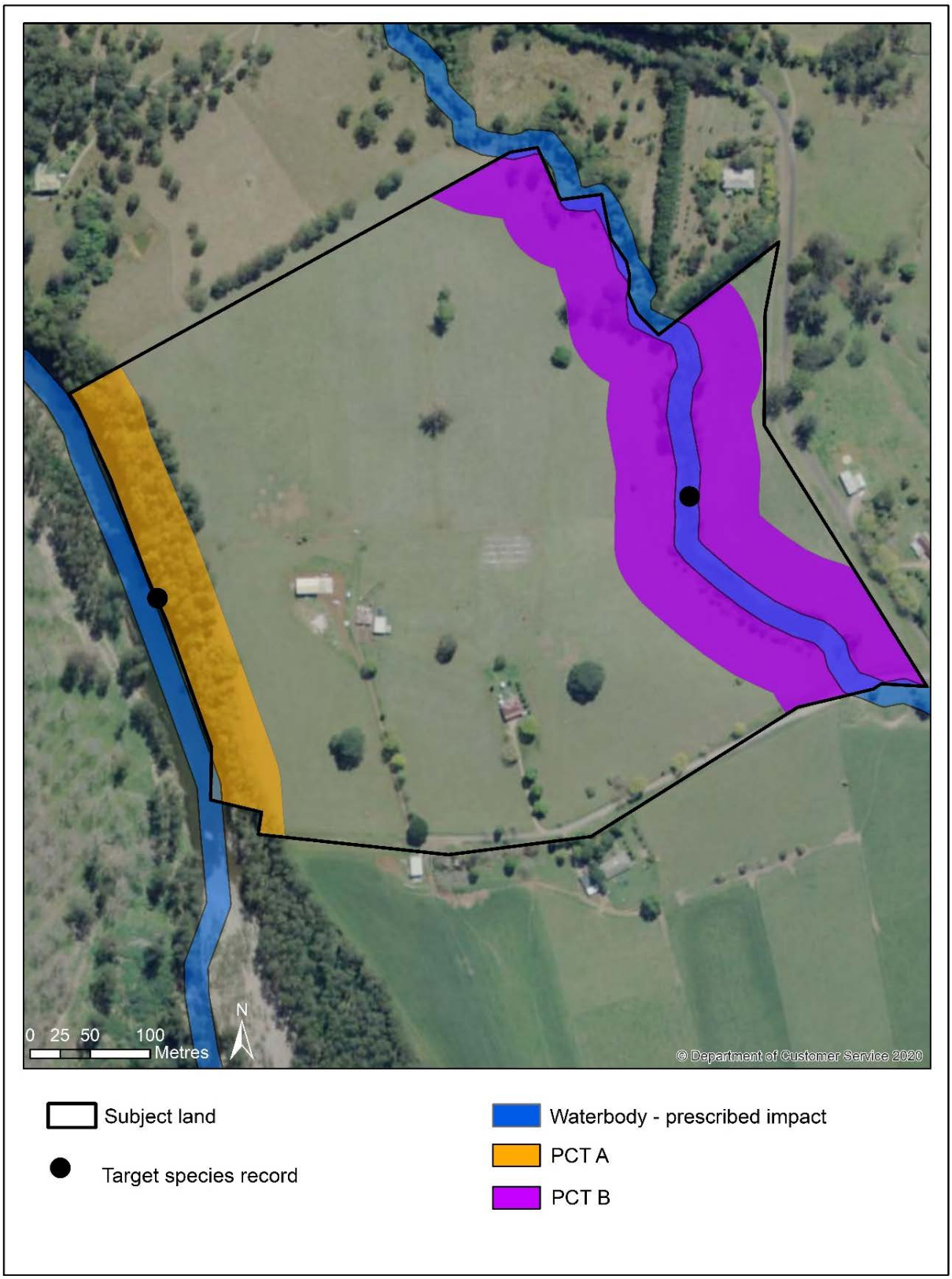

Figure 4 Mapping a species polygon for aquatic reptiles – Identify the locations of all detections of the target species and all PCTs on the subject land

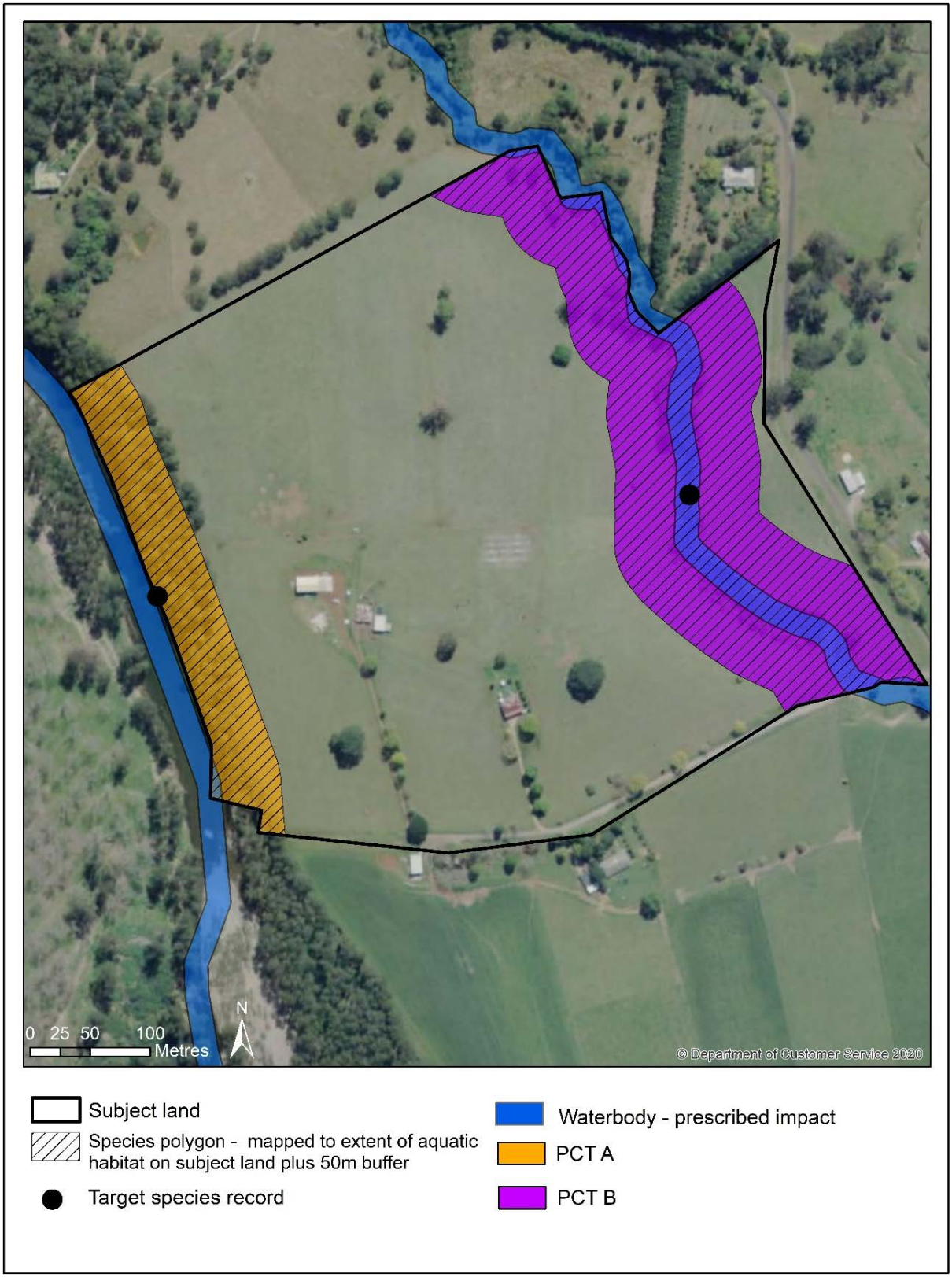

Figure 5 Mapping a species polygon for aquatic reptiles – Map the species polygon to the full extent of all suitable habitat (aquatic habitat) on the subject land; include a 50 m buffer from the top of bank

6. Documentation

The BAR must be prepared in accordance with the BAM (see BAM 2020, Appendices K and M) and the BAM Operational Manuals. For targeted species surveys, this will include reference to the design, method, timing, effort and results. A summary of the documentation required for threatened reptile survey is provided in Appendix D.

Digital GIS files (ESRI compatible) for all spatial data underpinning maps must be submitted with the BAR.

Note: where the species is at risk of a serious and irreversible impact (SAII), the assessment requirements in BAM Section 9.2 must also be addressed in the BAR. These requirements are not addressed in this guide.

7. Survey requirements – species-specific

This section outlines the minimum survey requirements – based on optimal conditions – for threatened reptile species. These requirements must be read together with Sections 3 and 4 of this guide.

In the tables below, ***AND*** indicates **both** survey methods are required, while ***OR*** indicates that **either** survey method can be used. **Survey replicates** indicate the total number of surveys required to reliably detect the species if it is present, and to reasonably conclude absence when a species is not detected.

7.1 Species listed under the BC Act

Amalosia rhombifer (zigzag velvet gecko)

Survey area:	**Per 50 ha of suitable habitat**		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Spotlight surveys	Sep. – Apr.	120 person-min	4
OR			
Artificial cover (artificial bark)	Sep. – Apr.	18 artificial bark strips	1

Survey method

Undertake spotlight surveys in suitable habitat. As the species is largely arboreal and is most commonly detected under decorticating bark, focus the search on trees with loose bark and hollows. Also check leaf litter on the ground, observing for active individuals by movement and/or eyeshine. Undertake surveys between sunset and 3 hours post-sunset. This ensures survey occurs during warmer and more humid conditions necessary for insect activity, in which the species is more likely to be active. Hand searches that remove or disturb potential shelter should be avoided.

Install artificial bark at least 4 months prior to the first survey (Michael et al. 2018). Select 6 trees within 1 ha at 3 separate sites (18 trees in total). Place a 1 m wide foil-backed strip of closed-cell foam, (5 mm think) around each tree (at 1.5 m height) with the foil facing outwards. Secure artificial bark with wire, string or elastic straps for ease of checking. Check artificial bark daily for 2 days.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Antaresia stimsoni (Stimson's python)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Spotlight surveys	Sep. – Mar.	120 person-min	4

Survey method

Undertake spotlight surveys in suitable habitat. Inspect any areas of potential shelter with care to minimise damage. The species is known to shelter in caves and deep crevices, as well as low hollows and fallen trees in watercourses and termite mounds.

Undertake spotlighting surveys on warm nights when the individuals are likely to forage or search for mates. Where roads traverse the subject land, these may form part of the surveys (McDonald et al. 2011).

Suitable habitat

Rocks or gibber (and areas within 500 m) located within PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Aprasia parapulchella (pink-tailed legless lizard)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Sep. – Nov.	≥2,000 suitable rocks	4

Survey method

Habitat surveys consist of diurnal rock searches undertaken by turning over suitably sized rocks in areas of suitable habitat. When turning rocks, ensure careful re-placement to maintain the seal between rock and ground as failure to do this is highly detrimental to species dwelling under rock surfaces.

Turn over a minimum of 200 suitably sized rocks for every 5 ha of suitable habitat (Jones 1999; Osborne et al. 1991). Suitably sized rocks are approximately:

- 300 mm wide and 50 mm deep (Wong et al. 2011)
- 100–150 mm wide, 120–220 mm long, 50–150 mm deep (Jones 1999).

Undertake surveys in the 2 hours after sunrise and 2 hours before sunset on sunny days (<50% cloud cover). This ensures a suitable thermal environment is present for the species to be sheltering under rocks at the time of survey. Cease surveys once temperatures exceed 25°C, as the species will move deeper underground where it is not detectable (Osborne et al. 1991; Jones 1999).

Suitable habitat

Rocky areas (or within 50 m of rocky areas) located within PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Cacophis harriettae (white-crowned snake)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Sep. – Apr.	120 person-min	4
OR			
Pitfall traps and/or funnel traps	Sep. – Apr.	72 trap days	4

Survey method

Undertake habitat surveys during daylight hours when the species is likely to be sheltering under or near cover and more easily targeted. Commence with a visual search of the shelter habitat edges to detect active snakes. Follow with searches under/within the shelter for inactive individuals.

Set pitfall traps and/or funnel traps with drift fences in suitable habitat for 4 days. A combination of pitfall and funnel traps may be used on a single drift fence.

Suitable habitat

Litter, rocky areas, surface rocks, fallen/standing dead timber including logs (or within 50 m of fallen timber including logs) located within PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Chelonia mydas (green turtle)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Dec. – Apr.	500 m of beach	4

Survey method

Habitat surveys for this species consist of 500 m transects searched visually for signs of turtles on the beach, such as tracks or nests. Complete the survey within 2 hours of sunrise to minimise potential for signs to be altered by the activity of people, other fauna, or increasing winds.

Suitable habitat

Elevated sand dunes located above the water table and high tide mark.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Coeranoscincus reticulatus (three-toed snake-tooth skink)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Sep. to Apr.	120 person-min	4
AND			
Pitfall traps	Sep. to Apr.	72 trap days	4

Survey method

This species is difficult to detect as it lives in the soil and humus layer of wetter forests.

Undertake habitat surveys in suitable habitat. Searches involve lifting cover and raking through leaf litter and the upper soil layers. Care should be taken when disturbing habitat during habitat searches to ensure it is not badly degraded by that activity.

Set pitfall traps with drift fences in suitable habitat for 4 days.

Suitable habitat

Leaf and bark litter, fallen/standing dead timber including logs and timber, and logs on the ground, located within PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Ctenophorus mirrityana (Barrier Range dragon)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Oct. – Mar.	120 person-min	4

Survey method

Habitat surveys are undertaken in suitable habitat. Check potential shelter sites by carefully lifting rocks or using a torch to look in rock crevices.

Suitable habitat

Rock crevices located within PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Ctenotus pantherinus ocellifer (leopard ctenotus)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Oct. – Feb.	120 person-min	4
AND			
Pitfall traps	Oct. – Feb.	72 trap days (or 36 trap days if using with funnel traps)	4
AND (optional)			
Funnel traps	Oct. – Mar.	36 trap days	4

Survey methods

Undertake habitat surveys in suitable habitat. Generally, this will involve visual surveys only, as hand searches of spinifex are not advised.

Set pitfall traps with drift fences in suitable habitat for 4 days.

As funnel traps are an effective method for detecting other species of ctenotus (F. Lemckert, pers. obs.), they are also recommended for this species. Funnel traps must be used with pitfall traps until this is confirmed (e.g. a trap line of 3 pitfalls with 3 funnel traps).

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Cyclodomorphus praealtus (alpine she-oak skink)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Oct. – Apr.	120 person-min	4
OR			
Pitfall traps	Oct. – Apr.	72 trap days	4

Survey method

Undertake habitat surveys in suitable habitat, targeting grass tussocks that form the core habitat of this species.

Set pitfall traps with drift fences in suitable habitat for 4 days.

Adequacy of artificial cover or funnel traps to detect this species is unknown. These methods may be employed to supplement the required methods but cannot be used on their own to confirm presence.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Cyclodomorphus venustus (*Cyclodomorphus venustus*)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Sep. – Mar.	120 person-min	4
AND			
Pitfall traps	Sep. – Mar.	72 trap days	4

Survey method

Undertake habitat surveys in suitable habitat, targeting grass tussocks and larger cover objects.

Set pitfall traps with drift fences in suitable habitat for 4 days.

Adequacy of artificial cover or funnel traps to detect this species is unknown. These methods may be employed to supplement the required methods but cannot be used on their own to confirm presence.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Delma impar (striped legless lizard)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Sep. – Dec.	120 person-min	Weekly for 8 weeks, or daily for 10 days
AND			
Pitfall traps	Sep. – Dec.	250 trap days	10
OR			
Artificial cover	Sep. – Dec.	≥100 tiles	Weekly for 8 weeks

Survey methods

Habitat surveys combined with either pitfall trap surveys or artificial cover are required, as a single method is unlikely to detect this species (DSEWPaC 2011).

Undertake habitat surveys in suitable habitat, concentrating the search in and around grass tussocks. Turning over rocks should be done carefully and no more than once per week, as this can adversely impact the species' habitat.

Set 25 pitfall traps for 10 days, in vegetated areas of suitable habitat. Use 5 drift fences (30 cm high) with 5 traps per fence set every 4 m along the fence. Appropriate pitfall trap size for this species is ≥30 cm deep and ≥20 cm wide at the top.

Install artificial cover boards at least 3 months prior to the first survey. Place in vegetated areas, ideally positioned on a northerly aspect. Cover boards should consist of 50 roof tiles with 5 m spacing between tiles, arranged in a grid of 10 x 5 tiles. For suitable habitat that is:

- ≤2 ha, use 2 tile grids
- >2 ha – 30 ha, use one tile grid per 3 ha of suitable habitat
- >30–50 ha, use 10 tile grids.

Check artificial cover boards once per week, when ambient temperature is ≤28°C. Check shelter sites no more than once per week, as this may cause the species to abandon the site.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Diplodactylus platyurus (eastern fat-tailed gecko)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Spotlight surveys	Oct. – Dec.	120 person-min	4
OR			
Pitfall traps	Oct. – Dec.	72 trap nights	4

Survey method

Undertake spotlight surveys in areas of suitable habitat. The species is known to shelter in underground holes, such as abandoned burrows of trap-door spiders, blocking the entrance with its fat tail to keep out predators and keep in moisture. It also uses cracks in the ground for shelter. Surveys should not be undertaken in very dry or cool conditions when gecko activity is likely to be very low.

Set pitfall traps with drift fences in suitable habitat for 4 days.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Eulamprus leuraensis (Blue Mountains water skink)

Survey area:	Per 20 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Funnel and pitfall traps	Oct. – Mar.	36 trap days	2

Survey method

Set 9 funnel traps and one pitfall trap in suitable habitat for 4 days. Traps are placed in a line and set approximately 10 m apart (Gorissen et al. 2018). A drift fence is not required but may be used. Surveys should not be conducted during rainfall events to avoid flooding of traps.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Furina dunmalli (Dunmall's snake)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Spotlight surveys	Sep. – Apr.	120 person-min	4
AND			
Pitfall traps and/or funnel traps	Sep. – Apr.	72 trap days/nights	4

Survey method

Ambient temperature must be >18°C for survey.

Undertake spotlight surveys in suitable habitat to locate active individuals, searching in areas with potential shelter sites, such as logs and rocks.

Set pitfall and/or funnel traps with drift fences in suitable habitat for 4 days.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Hoplocephalus bitorquatus (pale-headed snake)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Spotlight surveys	Nov. – Mar.	120 person-min	4
AND			
Funnel traps	Nov. – Mar.	72 trap nights	4

Survey method

Undertake spotlight surveys in suitable habitat, focusing on riparian zones where present. Target large live trees with hollows and shedding bark. Search trunks to locate foraging snakes by eyeshine or body shape as they lay waiting to ambush prey (e.g. frogs, geckos). Commence spotlighting on transects 30 min after sunset. Ambient temperature must be >18°C for survey (Shelton et al. 2018).

Set funnel traps in suitable habitat for 4 nights. Check traps twice daily, in the mornings and evenings. While this species is unlikely to be captured during the day, other fauna are. Remove any captured fauna from the trap before night. Use drift fences where there is insufficient timber on the ground to funnel snakes towards traps.

Where possible, undertake surveys 1–2 days after rainfall and on humid nights (>70% humidity).

Suitable habitat

All PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Hoplocephalus bungaroides (broad-headed snake)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Aug. – Sep.	120 person-min	4
AND			
Spotlight surveys	Dec. – Feb.	≥120 person-min	4 consecutive nights
AND/OR			
Artificial cover (artificial rocks)	Aug. – Sep.	2 rocks per 40 m^2	4

Survey methods

Undertake habitat surveys in suitable habitat. This involves:

- turning over sun-exposed sandstone rocks lying on rock substrates
- turning over logs and bark, located on top of sandstone outcrops
- inspecting crevices within the outcrops using a torch.

Care is required when returning rocks to their original position.

Conduct habitat surveys in dry weather only, to minimise damage to sandstone and for the safety of surveyors. Surveys involving turning rocks should not be undertaken on hot days when individuals will retreat into deep crevices and hollows for protection (Webb and Shine 1998).

Undertake spotlight surveys in summer over 4 consecutive nights. In these conditions, the target species may have moved from the rock outcrops into adjacent areas of eucalypts (Webb and Shine 1997a,b). Conduct surveys along 500 m transects, focusing on large trees with multiple hollows within 500 m of adjacent sandstone outcrops. Observe for foraging snakes on the trunks, in hollows and on the ground. Additional survey effort may be required where rock outcrops are extensive and/or hollow bearing trees numerous. This must be documented and justified in the BAR.

For artificial cover, place artificial rocks on bare, sun-exposed rock outcrops with less than 2 natural rocks every 40 m^2 to improve the opportunities to detect snakes. Croak et al. (2008) found that artificial rocks were rapidly colonised. Place a minimum of 2 artificial rocks per 40 m^2 of suitable habitat, at least 2 months prior to survey. Artificial rocks must be 30 cm x 30 cm pavers, 4 cm thick, with 3 sides sealed with rubber weatherstrip. Place pavers on flat rock substrates with a 10 mm gap underneath. Check artificial rocks in the morning.

Suitable habitat

Rocky areas, including escarpments, outcrops and pagodas within the Sydney Sandstone geologies within PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land. Include a 100 m buffer from the edge of the suitable habitat.

Hoplocephalus stephensii (Stephens' banded snake)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Spotlight surveys	Oct. – Mar.	120 person-min	4
OR			
Nocturnal road surveys	Oct. – Mar.	120 person-min	4

Survey methods

This species is nocturnal and either spotlight or nocturnal road surveys may be used.

Undertake spotlight surveys in areas of suitable habitat. Search for snakes climbing on trees, on the ground, or moving in open areas by using eyeshine.

The species is often detected when driving along roads as they cross the ground when moving between trees looking for shelter and/or prey (Fitzgerald et al. 2002). Undertake nocturnal road surveys in suitable habitat, by driving a vehicle at 5 km/h and observing for snakes on the road. A passenger may use a spotlight to search further ahead along the road. Where a snake is detected, stop the vehicle in a safe position to identify the snake.

Suitable habitat

Hollow bearing trees, arboreal vine tangles, fallen/standing dead timber including logs (or within 500 m of these habitats) located within PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Liopholis guthega (Guthega skink)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Oct. – Apr.	120 person-min	4
AND (if needed)			
Camera traps	Oct. – Apr.	1 camera per visible burrow	1

Survey method

Undertake habitat surveys in suitable habitat, focusing on rock outcrops and boulders. Visually search for individuals present on or around the rocks, or at the entrance of burrows. Where possible, use binoculars to observe burrow entrances from a distance, as individuals are likely to retreat into burrows if disturbed. Once the outcrop has been scanned, approach more closely to check within potential shelter sites (burrows and crevices). Do not move rocks, as this may damage habitat. Observe for sheltering individuals and scats that indicate presence of the species. Where the surveyor suspects individuals of the species are sheltering within burrows or crevices, a fishing line with insects attached may be used to draw the individual out (Atkins et al. 2015). The presence of other skinks of similar size being active during the survey should be recorded as this indicates conditions were suitable for the Guthega skink to be active.

If evidence of the species is recorded, but cannot be confirmed, place cameras facing the entrances of potential burrows or rock crevices. Leave cameras in place for a minimum of 48 hours.

Suitable habitat

Rocky areas including sub-surface boulders, granite substrate and decomposing granite soils within PCTs associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Lucasium stenodactylum (crowned gecko)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Spotlight surveys	Oct. – Mar.	120 person-min	4
OR			
Pitfall traps	Oct. – Mar.	72 trap days	4

Survey methods

Undertake spotlight surveys in suitable habitat.

Set pitfall traps with drift fences in suitable habitat for 4 days.

Ambient temperature must be >18°C and humidity >60% for spotlight and pitfall trap surveys.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Myuchelys bellii (western sawshelled turtle/Bell's turtle)

Survey area:	Per 500 m of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Oct. – Mar.	120 person-min	4
OR			
Aquatic funnel traps	Oct. – Mar.	≤50 trap days	4

Survey method

Undertake habitat surveys by searching along banks and in the water of any waterbody present on the subject land:

- Observe for individuals basking on rocks and logs on the banks or protruding out of the water, and for individuals swimming in the water (e.g. coming to the surface to breathe). A minimum of 60 person-mins of bank searches is required.
- Snorkelling is required as part of habitat surveys to locate individuals in the water. Observe underwater for individuals moving around, sitting on the bottom, or under cover such as logs. Possible detections should be observed to confirm identification, or captured and photographed if possible. A minimum of 60 person-min per 500 m of suitable habitat is required.

A total effort of 120 person-min is required for habitat surveys. From October to January, searches can also be made along sand or loam sections of bank observing for nests. Where a nest is located, it should be marked and the area monitored for females. Observe daily, for one hour, over 7 days.

Set aquatic funnel traps in suitable habitat. Minimum trap size is 60 cm x 45 cm x 25 cm.

Suitable habitat

Any aquatic habitats within the subject land.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land. Include a 50 m buffer from the top of bank.

Myuchelys georgesi (Bellinger River snapping turtle)

Survey area:	Per 500 m of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Habitat surveys	Oct. – Dec.	120 person-min	4
AND (if needed)			
Aquatic funnel traps	Oct. – Mar.	≤50 trap days	4

Survey method

Initial habitat surveys should target sandy beaches along waterbodies in the subject land to locate breeding females and their nests. Located nests should be marked and the area monitored for other females using the location to nest. Observe daily, for one hour, over 7 days. This should allow a positive identification of the species of turtle nesting on the beach.

If no female turtles or nests are observed, then any suitable rocky pools must be surveyed by snorkelling or placing aquatic funnel traps. For snorkel surveys, a minimum of 60 person-min for every 500 m of suitable habitat is required. Swim along the surface and dive to search pools, checking areas of cover such as logs and submerged snags thoroughly. This is combined with a minimum 60 person-min of beach searches to provide 120 person-min of habitat survey to locate females of the species.

The minimum size for aquatic funnel traps is 60 cm x 45 cm x 25 cm.

Suitable habitat

The species is known only from the Bellinger River catchment in northern NSW.

All riparian areas or waterbodies, or within 30 m of riparian areas or waterbodies on the subject land.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land. Include a 50 m buffer from the top of bank.

Tympanocryptis spp. (grassland earless dragons)

Survey area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Pitfall traps	Oct. – Apr.	40 trap days	4
OR			
Artificial shelter (arthropod tubes)	Oct. – Apr.	1,400 trap days	1 x 4 weeks

Survey method

As this species is difficult to detect, habitat surveys are not recommended.

Set 10 pitfall traps along 50 m of drift fence in suitable habitat for 4 days.

Alternatively, survey using PVC pipes (3 cm diameter x 14 cm deep) that approximate the arthropod burrows used by the species for shelter. Insert PVC pipes vertically into the

substrate, ensure the opening is level with the surface. Place an inner tube of the same length into the pipe, capped off at the base, to allow removal of trapped reptiles or debris. Place a metal roof over each trap to shelter reptiles from sun and rain. To assist in locating tubes, ground cover should be slashed for 1 m around each tube. Set 50 tubes at 10 m intervals along a 500 m transect. Inspect tubes by torch at least every 3 days, over 4 weeks.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

Uvidicolus sphyrurus (border thick-tailed gecko)

Survey Area:	Per 50 ha of suitable habitat		
Survey method	**Survey period**	**Effort per survey**	**Survey replicates**
Spotlight survey	Nov. – Mar.	120 person-min	4

Survey method

Undertake spotlight surveys in suitable habitat, using a headlamp to observe for active individuals. Target areas of rocky outcrop or with a ground cover of loose surface rock, fallen logs or deep litter (>5 cm depth). Do not conduct surveys in cold (<16°C) or dry (<60% humidity) conditions when the target species is likely to be inactive. The species shows greatest activity on warm humid nights with good insect activity. Habitat searches are not recommended as they can damage the rock shelter sites and other habitat features relied upon by the species.

Suitable habitat

All PCTs on the subject land associated with the species in the TBDC.

Species polygon

Map the species polygon to the full extent of all suitable habitat on the subject land.

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Appendix A. Websites and online resources

Assessor resources

https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/accredited-assessors/assessor-resources

Biodiversity Assessment Method (BAM)

https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/biodiversity-assessment-method

Biodiversity Assessment Method Calculator (BAM-C)

www.lmbc.nsw.gov.au/bamcalc

Biodiversity Assessment Method Calculator (BAM-C) – User Guide

www.lmbc.nsw.gov.au/bamcalc/app/assets/BAMTools_UserGuide.pdf (PDF 3.0MB)

Biodiversity Assessment Method Operational Manual – Stage 1

www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Biodiversity/biodiversity-assessment-method-operational-manual-stage-1-180276.pdf (PDF 1.3MB)

Biodiversity Assessment Method Operational Manual – Stage 2

www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Biodiversity/biodiversity-assessment-method-operational-manual-stage-2-190512.pdf (PDF 1.3MB)

Biodiversity Assessment Method Operational Manual – Stage 3

https://www.environment.nsw.gov.au/research-and-publications/publications-search/biodiversity-assessment-method-operational-manual-stage-3

Biodiversity Conservation Act 2016

www.legislation.nsw.gov.au/~/pdf/view/act/2016/63/whole (PDF 1.0MB)

Biodiversity Conservation Regulation 2017

www.legislation.nsw.gov.au/regulations/2017-432.pdf (PDF 513KB)

Biodiversity experts

https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/biodiversity-offsets-scheme/experts

BioNet Atlas

https://www.environment.nsw.gov.au/wildlifeatlas/about.htm

BioNet Atlas – Application for login access

www.environment.nsw.gov.au/atlaspublicapp/Registration.aspx

BioNet Atlas (Species Sightings) Search

www.environment.nsw.gov.au/atlaspublicapp/UI_Modules/ATLAS_/AtlasSearch.aspx

BioNet – How to access the BioNet Web Service using Excel and Power Query

www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/BioNet/bionet-access-using-excel-power-query-quick-guide-160403.pdf (PDF 1.0MB)

BioNet Systematic Flora Survey

www.environment.nsw.gov.au/research/VISplot.htm

BioNet quick guides, manuals, and datasheets

www.bionet.nsw.gov.au/bionet-guides-manuals.htm

BioNet Threatened Biodiversity Data Collection (TBDC)

www.environment.nsw.gov.au/asmslightprofileapp/Account/Login

BioNet Vegetation Classification

www.environment.nsw.gov.au/research/Visclassification.htm

BioNet Vegetation Classification user manual

www.environment.nsw.gov.au/resources/bionet/bionet-vegetation-classification-user-manual-170340.pdf (PDF 4.1MB)

BioNet Vegetation Map Collection (previously Vegetation Information System Maps)

www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/nsw-bionet/about-bionet-vegetation-classification/bionet-vegetation-maps

BioNet Web Services

https://data.bionet.nsw.gov.au/

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

www.legislation.gov.au/Series/C2004A00485

EPBC Act listed threatened species and ecological communities

www.environment.gov.au/epbc/what-is-protected/threatened-species-ecological-communities

Native Vegetation Interim Type Standard

www.environment.nsw.gov.au/resources/nativeveg/10060nvinttypestand.pdf (PDF 1.6MB)

NSW (Mitchell) Landscapes – Version 3.1

https://datasets.seed.nsw.gov.au/dataset/nsw-mitchell-landscapes-version-3-1

NSW (Mitchell) Landscapes Descriptions

www.environment.nsw.gov.au/resources/conservation/LandscapesDescriptions.pdf (PDF 1.2MB)

NSW Threatened Species

www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species

PlantNET NSW

http://plantnet.rbgsyd.nsw.gov.au/

SEED (Sharing and Enabling Environmental Data) portal

www.seed.nsw.gov.au

State Vegetation Type Map

www.environment.nsw.gov.au/vegetation/state-vegetation-type-map.htm

Streamlining NSW and Australian Government Biodiversity Assessments

https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity/assessment-bilateral-agreement

Sunrise and Sunset

www.timeanddate.com/sun/

Appendix B. Decision key – threatened reptile survey

1. Do I need to survey for a threatened reptile?

a. Is the target species predicted to occur on the subject land, as per the BAM-C candidate species list and/or an observation record? (Section 3.1)

i. No ..... survey not required

ii. Yes ..... go to 1b

b. Where habitat constraints or microhabitats are listed for the target species, are these sufficiently degraded that the species would no longer use the subject land or vegetation zone? (Section 3.1)

i. Yes ..... survey not required, document in the BAR

ii. No ..... survey required, go to 2

2. Threatened reptile survey steps

a. Choose approach for determining presence (Section 7)

i. Conduct survey ..... go to 2b

ii. Expert report ..... go to 2b

iii. Assume present (development and biocertification sites only) ..... go to 2b

b. Is the target species present?

i. Yes ..... map species polygon and document in BAR, go to 2c

ii. No ..... document in BAR

c. Is the species at risk of SAII?

i. Yes ..... address BAM 2020, Section 9.2

ii. No ..... document in BAR

Appendix C. Estimating expected results

Capture rates for standard survey methods

Very few studies have published capture and detection rates for Australian reptiles, with most focused on the pitfall trap approach.

Moseby and Read (2001) conducted pitfall trap surveys in north-western Australia. They identified 5 trap nights as the most efficient number for maximising reptile species captured. Trapping only a single pitfall site per habitat type for 5 nights captured approximately 30% of the reptile species compared with 55%, 65% and 73% for 3, 5 and 10 sites, respectively. Typically, approximately 70% of the reptile species in chenopod shrubland were captured by trapping 5 sites for 7 nights, a method recommended for thorough surveys of species present in chenopod shrublands. Standard 4-night trapping periods adopted by most surveys will fail to detect many rare species, or those that are difficult to trap. Repeated 7-night trapping sessions for up to 21 nights are recommended for surveys where more accurate species inventories are required.

Friend et al. (1989) assessed the effectiveness of pitfall trap arrangements in capturing reptiles. Each grid measured 120 cm x 20 m, comprising 6 20 m x 20 m quadrats with 4 pits established at the corners of each quadrat. Diagonally opposite pits consisted of PVC stormwater piping 16 cm in diameter and 40 cm deep. The other 2 comprised white plastic buckets, 28 cm in diameter and 39 cm deep – considered to be large pitfall traps. Drift fences consisted of fibreglass flywire 25 cm high, buried approximately 3 cm deep in the soil and held up by softwood stakes at approximately 2.5 m intervals.

Trapping effort amounted to 11,520 trap nights (5,760 large and 5,760 small trap days) for a total of 1,068 captures of 44 species. However, capture rates varied greatly between the broad species groups:

- small lizards: 121 captures in small pitfalls (P = 0.021) and 157 in the large pitfalls (P = 0.027); 278 total captures (P = 0.024)
- large lizards: 43 in small (P = 0.007) and 84 in large (P = 0.015); 127 total (P = 0.011)
- snakes and legless lizards: 15 in small (P = 0.003) and 28 in large (P = 0.005); 43 total (P = 0.004)
- geckos: 10 in small (P = 0.002) and 45 in large (P = 0.008); 55 total (P = 0.005).

For even the most common species of lizards, which were the most readily detected group, detection rates were low with *Ctenotus schomburgkii* 98 captures (P = 0.008), *Lerista dktinguenda* 50 captures (P = 0.004) and *Morethia obscura* 60 captures (P = 0.005). *Diplodactylus pulcher* was the highest captured gecko with only 18 captures (P = 0.002) and the greatest number for snakes or legless lizards was 11 for *Ramphotyphlops australis* (P < 0.001). Detection of the most common skinks could be expected once for every 120 to 250 trap nights, but for harder to trap groups potentially only once every 1,000 trap nights.

These results demonstrate that more ‘typical’ lizards (skinks and dragons) are significantly more likely to be captured in pitfall traps than the other groups, and that capture rates of reptiles are still quite low. A significant effort with pitfall traps is therefore required in most instances; hence, pitfall traps are only recommended for species known to be locally common or that are known to be relatively easily captured in pitfall trap lines.

Einoder et al. (2018) undertook a more comparative assessment of survey methods for reptiles in northern Australia, testing detection rates of pitfall traps and spotlight surveys. Survey sites consisted of a 50 m x 50 m quadrat containing three 20 L pitfall traps with 10 m of drift fence. Spotlight surveys were conducted in the same area. Detectability per day/night using pitfall traps ranged from a low of 0.02 ± 0.02 for *Heteronotia planiceps* to a high of

0.69 ± 0.11 for *Ctenotus piankaie*. Detectability during a night of spotlighting ranged from 0.10 ± 0.05 for *Gehyra nana* to 0.57 ± 0.22 for *Oedura marmorata*. Hence the methods provided broadly similar results, although pitfalls required more initial effort. Notably, of 3 reptiles detected using both methods, 2 were more detectable by spotlighting. This suggests spotlighting is relatively effective for detecting nocturnally active species.

In a study in western Victoria, Thompson (2006) examined the efficacy of artificial cover for surveying the striped legless lizard (*Delma impar*) and other reptiles (Table 1).

Table 1 Reptile survey sample – effort and results of artificial cover for different target species (Thompson 2006)

Location	Species	Method	Effort	Detection rate
Victoria	*Delma impar*	Tiles	50 tile grid	0.56
Victoria	*Egernia whitei*	Tiles	50 tile grid	0.85
Victoria	*Pseudemoia pagenstecheri*	Tiles	50 tile grid	0.67
Victoria	*Bassiana duperreyi*	Tiles	50 tile grid	0.09
Victoria	*Pseudemoia entrecasteauxii*	Tiles	50 tile grid	0.01
Victoria	*Tiliqua nigrolutea*	Tiles	50 tile grid	0.01
Victoria	*Tiliqua rugosa*	Tiles	50 tile grid	0.01
Victoria	*Austrelaps superbus*	Tiles	50 tile grid	0.24
ACT	*Suta flagellum*	Tiles	50 tile grid	0.19

Estimating expected likelihood of detecting threatened reptile species

Threatened reptiles can generally be expected to have a lower detection rate than more common species, simply because they are rare. It is also true that many threatened reptiles are cryptic and this naturally reduces detectability with many survey techniques. However, a number of studies have investigated the detectability of rarer reptiles, providing some indication of expected survey success. As the majority measured success of pitfall traps, there is more data to indicate detection rates for this method; but other methods have also been tested (Table 2).

Kutt (1992, 1993) assessed trapping success rate during the active period of the striped legless lizard (*Delma impar*) in Victoria and found a capture rate of 0.3–0.4 striped legless lizards per 100 trap days. Trapping success using pitfall traps in the ACT was found to be slightly higher with 0.1–5.65 lizards captured per 100 trap days (Dunford 1998; Rauhala 1996, 1997, 1999; Rauhala et al. 1995). This difference is most likely due to the ACT providing slightly more optimal grassland conditions, although this is not certain.

Work on the collared delma (*Delma torquata*) found pitfall trapping was less effective than turning over rocks to locate the species (Porter 1998). The study used 20 x 4 L plastic buckets, arranged in lines of 5 buckets 1 m apart, and bridged by 20 cm high aluminium mesh drift fences. The recorded capture rate was 0.306 individuals per 100 trap nights using this method, whereas rock turning produced approximately one lizard per 150–200 rocks turned (or one lizard per 1.75 hours of searching). Notably though, lizards appeared to avoid already turned rocks for 2–3 months. Conroy (1999) pitfall trapped only a single individual of this species in 6,840 trap nights.

A single pitfall trap and 9 funnel traps were used by Gorissen et al. (2015) to trap the Blue Mountains water skink (*Eulamprus leuraensis*) over 3 days (30 trap days per swamp) in 12 different swamps. The catch rate varied from 3–21 lizards with a mean 8.6 lizards caught, equating to a catch rate of 28.6 lizards per 100 trap nights (range of 10–37 lizards per 100 traps). Therefore, this species is highly detectable within its very limited swamp habitats.

Shelton et al. (2018) estimated a capture probability for the pale-headed snake (*Hoplocephalus bitorquatus*) of 0.16 ± 0.14 per session in sub-adult snakes and 0.33 ± 0.06 for adults. This was based on monitoring work carried out at 8 grid intersections with each transect measuring 250 m x 40 m. Visual encounter surveys were conducted at night using head torches, attempting to sight snakes in any component of the forest structure. Transects were traversed on foot and surveyed for the equivalent of one person-hour. All observed individuals were captured wherever possible (either in transects or opportunistically encountered whilst traversing between transects). Between November 2010 and October 2015, 87 surveys were conducted with individual transects surveyed on 2–31 occasions.

Surveys for *Tympanocryptis pinguiocola*, by turning over rocks, indicated an extreme unlikelihood of detecting this species. Only 36 detections occurred from 69,146 detection attempts across 60 sites, which provided a probability of detection of just 0.00098 (McGrath et al. 2015). However, surveys for *Aprasia parapulchella* by Jones (1999) using the same technique found that a maximum of 9.1 lizards were detected per 1,000 (P = 0.009) rocks turned over, and it was determined that 750 rocks should be turned over to obtain 95% confidence the species would be detected if present.

Table 2 Detection rates of threatened NSW reptiles

Study	Location	Species	Method	Effort	Detection rate
Shelton et al. 2018	South-west Queensland	*Hoplocephalus bitorquatus*	Spotlight transects	250 X 40 m	0.16 (sub-adults) & 0.33 (adults)
Thompson 2006	Victoria	*Delma impar*	Tiles	50 tile grid	0.56 per 50 tiles
Osborne et al. 1991	ACT	*Aprasia parapulchella*	Rock turning	150 tiles	Reasonable
Jones 1999	ACT	*Aprasia parapulchella*	Rock turning	1,000 rocks	9.1 lizards (P = 0.009)
Gorissen et al. 2015	NSW	*Eulamprus leuraensis*	Pitfall and funnel trapping	360 trap nights	29 lizards per 100 trap nights

Appendix D. Biodiversity Assessment Report – required information

Topic	Details
Threatened species	**Information:** • If any threatened reptiles are removed from the candidate species list, include justification • If any threatened reptiles are added to the candidate species list (manually), include justification • Document any threatened reptile records on the subject land (e.g. from previous surveys)
Suitable habitat	**Table.** Assessment of suitable habitat, detailing: • all PCTs on the subject land associated with target species in the TBDC • presence of any habitat constraints in each PCT (present / absent) **Map.** Suitable habitat for target species, identifying: • PCTs and vegetation zones • habitat constraints, where relevant **Information:** • If no suitable habitat is identified, include justification (for impact assessment sites)

Survey methods	**Table.** Survey summary, detailing:
	• dates
	• start and finish time
	• survey method
	• GPS coordinates of surveys
	• meteorological conditions, including:
	  ○ rainfall (mm) for the 2 days prior to survey
	  ○ rainfall (mm) for each day or night of the survey
	  ○ minimum and maximum temperature (°C) for each day or night of the survey
	  ○ relative humidity (%) for each day or night of the survey
	  ○ mean wind speed (km/h), for each day or night of the survey
	  ○ cloud cover (oktas) for each day of the survey
	  ○ moon phase for each night of the survey
	Information. Describe methods used, including:
	• justification for the survey methods selected (i.e. suitability for the subject land)
	• any limitations or assumptions for surveys and how these were overcome

Topic	Details
	• details of number, size and arrangement of any traps or artificial shelter used • details of any variations from the recommended approach, with justification and information sources • meteorological conditions – document use of weather station (include details) or portable device • groupings for any multi-species searches • threatened reptile surveyor – name and credentials (as per Section 2.3) • supporting personnel (for field surveys) – name(s) **Map.** Survey site locations, identifying: • suitable habitat (identify vegetation zones and PCTs) • survey method
Species polygon	**Map.** Target species polygon, specifying: • areas of suitable habitat representing the species polygon (identify vegetation zones and PCTs) • areas of suitable habitat confirmed from targeted survey • areas of assumed presence • location of all target species detections **Table.** Target species detection, detailing: • GPS coordinates **Information:** • Justification for area of species polygon