



Australian Government
**Department of the Environment,
Water, Heritage and the Arts**



Significant impact guidelines for the vulnerable green and golden bell frog (*Litoria aurea*)

Nationally threatened species and ecological communities
Background paper to the EPBC Act policy statement 3.19

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Introduction

This paper provides background to EPBC Act Policy Statement 3.19 – Significant Impact Guidelines for the vulnerable green and golden bell frog (*Litoria aurea*), hereafter referred to as the policy statement. This background paper provides the biological and ecological context for the habitat areas, significant impact thresholds, and mitigation measures defined for the green and golden bell frog in the policy statement. The information provided in this paper has been prepared based on the best available information, gathered from scientific literature, consultation with experts, and an understanding of the application of the Australian Government *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Increases in knowledge will be accounted for in future policy revisions.



Conservation status

The green and golden bell frog is listed as vulnerable under the EPBC Act. Listed threatened species and ecological communities are a 'matter of national environmental significance'. Under the EPBC Act, an action will require approval from the federal environment minister if the action has, will have, or is likely to have a 'significant impact' on a matter of national environmental significance.

The green and golden bell frog is also listed as endangered under the New South Wales *Threatened Species Conservation Act 1995*. Despite the species' occurrence in south-eastern Victoria, and historical occurrence in the Australian Capital Territory, there is no legislative protection for the species under the Victorian *Flora and Fauna Guarantee Act 1988* or the Australian Capital Territory's *Nature Conservation Act 1980*.

The listing of a species, subspecies or ecological community as a matter of national environmental significance recognises the importance of the matter from a national perspective, and does not replace listing under state, regional or local legislation or regulations. Judgements may differ between federal, state and local decision-making processes, due to the different scales of consideration. If your activity could affect the species or individual animals you should contact the relevant state and local authorities to find out your obligations.





About the green and golden bell frog

Description

The green and golden bell frog is a large dull olive to bright emerald-green frog reaching 85 millimetres in length (Cogger 2000). The frog has several distinguishable features that help identify it. The dorsum (back) of the frog has large irregular blotches ranging from brown to rich golden-bronze. It has a yellowish stripe running from behind the eye to the lower back which is bordered by a black stripe that can extend through the eye to the nostrils. The hind toes of the frog are almost fully webbed, but the fingers of the front feet lack webbing. The frog also has a distinct tympanum (ear membrane) (Cogger 2000).

Distribution

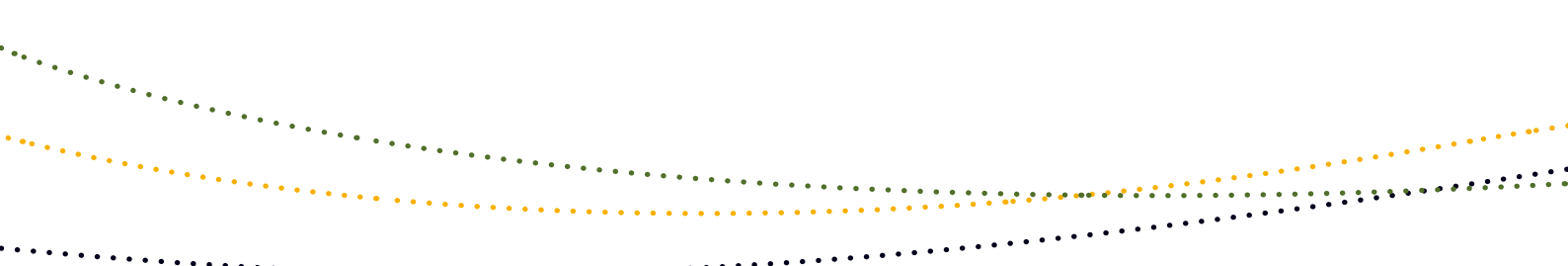
The green and golden bell frog occurs mainly along coastal lowland areas of eastern New South Wales and Victoria (DEC 2005). The most northern extent of the species' distribution is from Yuraygir National Park near Grafton on the North Coast of New South Wales (White & Pyke 2008). The most southern extent of the species' distribution is in the vicinity of Lake Wellington just west of Lakes Entrance in south eastern Victoria (Gillespie 1996). The furthest inland record of the species is a recently discovered population near Hoskinstown in the southern tablelands referred to as the Molonglo population (Osborne et al. 2008). The species was previously known from elsewhere in the southern tablelands, but is now considered to have disappeared from the Australian Capital Territory (Osborne 1990) and central slopes of Bathurst (DEC 2005).

The green and golden bell frog also occurs on three offshore islands; Bowen Island in Jervis Bay (Australian Capital Territory) (Osborne & McElhinney 1996), Kooragang Island (White & Pyke 2008) and Broughton Island, north of Port Stephens, New South Wales. The green and golden bell frog also occurs in the Pacific Islands having been introduced to New Zealand, New Caledonia and Vanuatu (DEC 2005).

Habitat

Green and golden bell frogs need various habitats for different aspects of their life cycle including foraging, breeding, over-wintering and dispersal. They will also use different habitats or habitat components on a temporal or seasonal basis. The habitat of the green and golden bell frog comprises one or more water bodies and associated terrestrial habitats (grassy areas and vegetation no higher than woodlands) within its known range.

Water bodies include, but are not limited to ponds, wetlands, farm dams, creek lines and irrigation or drainage channels. Water bodies that only contain water periodically (that is, ephemeral water bodies) are important habitat for the green and golden bell frog, as their flooding can trigger breeding or provide habitat 'stepping-stones' for dispersal between periodically disconnected water bodies. Ephemeral water bodies are also less likely to be inhabited by mosquito fish.



In New South Wales, the green and golden bell frog has been found in a wide range of water bodies except fast flowing streams (Pyke & White 1996). It inhabits many disturbed sites, including abandoned mines and quarries (Pyke et al. 2002). Breeding habitat in New South Wales includes water bodies that are still, shallow, ephemeral, unpolluted (but the frog can be found in polluted habitats), unshaded, with aquatic plants and free of mosquito fish and other predatory fish. Associated terrestrial habitats also consist of grassy areas and vegetation no higher than woodlands, and a range of diurnal shelter sites (Pyke & White 1996).

In Victoria, the green and golden bell frog has been recorded in a range of lentic and terrestrial habitats in the coastal plains and low foothills of the hinterland including lowland forest, Banksia woodland, wet heath land, riparian scrub complex, riparian forest, damp forest, shrubby dry forest, limestone box woodland and cleared pastoral areas (Gillespie 1996). Breeding habitat for the green and golden bell frog in Victoria includes dams in both forested and cleared areas, swamps in farmlands, gravel pits, billabongs, marshes, coastal lagoon wetlands, wet swale herblands and isolated streamside pools. All breeding sites are characterised by stationary water and dense emergent vegetation (Gillespie 1996).

Populations

Table 1 shows the status of the 54 populations known from New South Wales since 1990. The New South Wales Department of Environment, Climate Change and Water recently published several management plans for individual key populations, which provide the most recent status update for these populations. For all other populations, the information in Table 1 is from White & Pyke (2008).

Of the 54 populations known in New South Wales, at least three are now extinct, and several others are likely to be extinct, as no frogs have been observed for several years. White & Pyke (1996, 2008) also concluded that the green and golden bell frog has suffered a dramatic decline in distribution and abundance since 1990.

Unlike New South Wales, there is a lack of quantitative data on populations of green and golden bell frog in Victoria (Gillespie 1996). However, substantial populations are known from terraces along the Brodribb River near Orbost, Tostaree, on the Bemm River and Lake Tyers (White pers. comm. in DEC 2005). Populations are also known from river terraces along the Cann and Genoa Rivers, Ewings Marsh Flora Reserve, Sydenham Inlet and in the vicinity of Yalmy Road near the south east boundary of the Snowy River National Park (Gillespie 1996).

Most populations in New South Wales are considered to be small, with less than 20 adults. However, a few large populations are likely to have more than 1000 adults, including Homebush Bay, Broughton Island, Kooragang Island (Hamer et al. 2002).

Breeding/Reproduction

The green and golden bell frog is known to breed during late winter to early autumn but generally between September and February with a peak around January–February after heavy rain or storms (Daly 1995; White 2001). Males call mostly at night, but occasionally by day (DEC 2005). Populations at a higher altitude in the south appear to have a narrower window of opportunity for breeding than populations in the north at lower altitudes. Populations in the north are more commonly known to start breeding earlier and continue longer than southern populations which appear to have a much shorter breeding period (DEC 2005).



Table 1: Populations and subpopulations of green and golden bell frog in New South Wales

Population	Sub-population	Status	Year last recorded	Reference
Arncliffe		Extant	2008	DECC 2008a
Bellambi Lagoon		Extant	2007	W&P
Botany Swamp	Eastlakes golf course	Extinct	1993	W&P
Botany Swamp	Mascot (Engine Pond)	Extinct	1993	W&P
Botany Swamp	La Perouse	Extinct	1993	W&P
Bowen Island		Unknown	2000	W&P
Broughton Island		Extant	2007	W&P
Coomondery Swamp		Probably extinct	2007	DECC 2007a
Crookhaven River Floodplain	Currambene	Probably extinct	2000	DECC 2007b
Crookhaven River Floodplain	Brundee	Extant	2007	DECC 2007b
Crookhaven River Floodplain	Lake Wollumboola/Culburra	Probably extinct	2000	DECC 2007b
Crookhaven River Floodplain	Greenwell Point	Extant	2007	DECC 2007b
Crookhaven River Floodplain	Meroo Lake	Extant	2007	DECC 2007b
Davistown		Extant	2007	W&P
East Hills		Probably extinct	1995	W&P
Georges River	Hammondville	Extant	2008	DECC 2008b
Georges River	Holsworthy	Probably extinct	1994	DECC 2008b
Georges River	Liverpool	Probably extinct	1992	DECC 2008b
Greenacre	Cox's creek	Probably extinct	2004	DECC 2007c
Greenacre	Enfield marshalling yards	Probably extinct		
Greenacre	Juno brick pit	Extant	2007	DECC 2007c
Hat Head		Extant	2007	W&P
Jervis Bay	Murray's Beach	Probably extinct	2002	W&P
Jervis Bay	Ryan's Swamp	Extinct	1996	W&P
Killalea Lagoon		Probably extinct	1992	W&P
Kioloa		Extant	2006	W&P
Kurnell	Kurnell West	Extant	2007	DECC 2007d
Kurnell	Kurnell East	Extant	2007	DECC 2007d
Lower Hunter	Hexham Swamp and Sandgate	Extant	2007	DECC 2007d
Lower Hunter	Kooragang Is	Extant	2007	DECC 2007d
Medowie		Extant	2007	W&P
Middle Hunter	Wentworth Swamp	Probably extant	2007	DECC 2007e
Middle Hunter	Ellalong Lagoon	Extinct	2007	DECC 2007e
Milperra		Extant	1992	W&P
Molonglo		Extinct	2007	DECC 2007f
Mount Druitt		Extinct	1994	W&P
Nowra	Bens Walk	Extinct	1994	W&P

Table 1: Populations and subpopulations of green and golden bell frog in New South Wales *continued*

Population	Sub-population	Status	Year last recorded	Reference
North Ryde		Extinct	1992	W&P
Nadgee		Unknown	1993	W&P
North Avoca		Extant	2007	W&P
Parramatta	Clyde/Rosehill	Extant	2008	DECC 2008c
Parramatta	Homebush Bay	Extant	2008	DECC 2008c
Parramatta	Merrylands	Extant	2008	DECC 2008c
Port Kembla	Numerous sub-populations	Extant	2007	DECC 2007g
Port Macquarie	North Shore	Probably extant	2001	W&P
Port Macquarie	Wangi Place	Extant	2006	W&P
Ravensthorpe		Probably extant	1994	DECC 2007h
Riverstone		Extant	2007	W&P
Rosebery	Dalmeny	Extant	2008	DEC 2008a
Rosebery	State Super	Extinct	1999	W&P
Smiths Lake		Extant	2004	W&P
Sussex Inlet		Extant	2007	DECC 2007i
Woonona		Extant	2007	W&P
Yuragir	Station Creek	Extant	2006	W&P
Yuragir	Diggies Camp	Probably extant	2000	W&P

* The boundary between populations and subpopulations can be fluent, and some authors may call a specific population a subpopulation while others may call it a population on its own.

Source: W & P = White and Pyke 2008. = DECC Department of Environment, Climate Change and Water.

The green and golden bell frog has a high fecundity, with recorded clutch sizes from eight egg mass counts ranging between 2463 and 11682 eggs (Van de Mortel & Goldingay 1996). Estimations from Pyke and White (2001) suggest the average clutch size is about 3700 eggs per clutch. Spawn is laid among aquatic vegetation, and has been observed in December, January and February (Daly 1995). Eggs hatch within two to five days after ovipositing/fertilisation (Anstis 2002), and metamorphosis can take 2–11 months (Daly 1995; Pyke and White 2001; Anstis 2002); however, six weeks appears to be an average duration for the field (Goldingay pers. comm.).

Dispersal

It is difficult to be definitive about movement patterns and other behaviours of the green and golden bell frog, as dispersal patterns can vary between populations (DEC 2005). However, various studies have revealed that the species is capable of moving long distances in a single day/night of up to one and a half kilometres, and mark and recapture studies found individuals moving up to three kilometres (Pyke & White 2001). Observations suggest movements of up to five kilometres may be common, and the frog may possibly disperse as far as ten kilometres (White & Pyke 2008).



Diet

The green and golden bell frog feeds on a variety of items that include invertebrates such as insect larvae, crickets, cockroaches, dragonflies, earthworms, flies, grasshoppers, mosquito wigglers, isopods, freshwater crayfish and slugs (DEC 2005). The suggested dietary preference of tadpoles is the algal or bacterial scum growing on submerged rocks and other substrata (Pyke & White 2001).



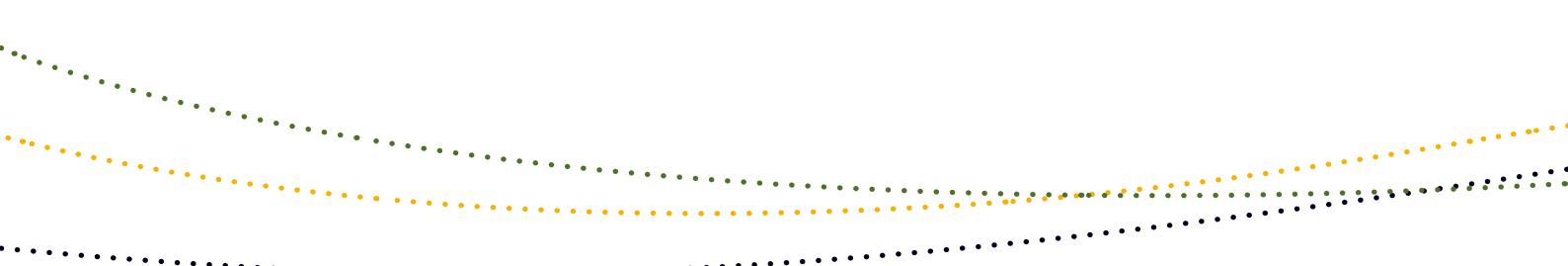
Key threats

Principal threats to the green and golden bell frog include:

- habitat removal
- habitat degradation (which includes siltation, changes to aquatic vegetation diversity or structure reducing shelter, increased light and noise, grazing, mowing, fire)
- habitat fragmentation
- reduction in water quality and hydrological changes (for example, pollution, siltation erosion and changes to timing, duration or frequency of flood events)
- disease (for example, infection of the frog with chytrid fungus (*Batrachochytrium dendrobatidis*) resulting in chytridiomycosis)
- predation (for example, by the introduced mosquito fish (*Gambusia* spp) and or cats and foxes), and
- introduction or intensification of public access to green and golden bell frog habitats.

Habitat removal, degradation and fragmentation

The distribution of the green and golden bell frog in the coastal lowlands of New South Wales, and the high development pressures associated with these areas have resulted in the large scale loss and degradation of green and golden bell frog habitat. Goodrick (1970) has estimated that 60 per cent of the wetlands in New South Wales had been extensively modified or reclaimed by 1969 and Goldingay (2008) believes that this extent of modification must have had an impact on populations of bell frogs, and cannot be ignored as a contributing factor in the decline of the species. Recent studies by White and Pyke (2008) have indicated that habitat decline



has emerged as the most significant factor in New South Wales population losses, with the likelihood of extinction increasing with greater habitat loss.

Development projects that contribute to the significant loss and ongoing degradation of green and golden bell frog habitat include:

- flood mitigation
- irrigation works
- dam construction (that has changed river flow regimes, hence flooding events sustaining floodplain wetlands)
- pasture conversion (channelling wetlands to drain)
- market gardens or turf growing
- landfill/waste disposal operations
- sewage treatment plants
- industrial developments
- golf courses
- playing fields, parklands recreation areas, and
- residential development including canal estates (DEC 2005).

The various types of development described above, particularly road projects and residential development, fragment habitat and block frog movement. Habitat fragmentation isolates populations, and over time is likely to reduce the evolutionary potential of populations through inbreeding. It also predisposes local populations to extinction (DEC 2005).

In Victoria, it is assumed that key threats to the green and golden bell frog, such as habitat loss and degradation, are relatively few compared to those in New South Wales, largely due to the very low human population in the area and smaller scale of agriculture (Gillespie 1996).

Reduction in water quality and hydrological changes

Green and golden bell frog habitat may become unsuitable from factors such as water pollution. Many populations in New South Wales are close to housing or industry, and, as a result, are subject to potential wastes or landscape changes that may alter the water quality (Goldingay 1996; Christy & Dickman 2002). Hamer et al. (2002) suggested that increased fertiliser use in the 1960s and 1970s has led to a build up of fertiliser being washed into water bodies after heavy rain, affecting tadpole development. The higher survival rates of bell frog tadpoles compared with those of common eastern froglet (*Crinia signifera*) tadpoles, however, weakened any conclusions about the effects of fertiliser (Goldingay 2008).

Possible threats to the green and golden bell frog include the artificial and natural opening of coastal lagoon estuaries, changes to flow/flooding regimes of streams and associated wetlands, spring tides and storm and flood events which introduce predatory fish and result in increases in salinity (DEC 2005). Christy and Dickman (2002) recognised saltwater intrusion in coastal wetlands as a consequence of landscape changes as a potential threat to bell frog breeding sites; however, detailed field data is required to determine the extent of this threat. It is also suspected that deteriorating run off water quality and increased soil erosion and sedimentation reduces an area's suitability for frogs, including the green and golden bell frog (DEC 2005).





Disease

Australia's native amphibians are threatened by the pathogenic fungus, *Batrachochytrium dendrobatidis*, known as amphibian chytrid fungus, which causes the infection known as chytridiomycosis (DEH 2006). The role of chytrid fungus in the decline of the green and golden bell frog is not well documented, but the disappearance of this species from other locations where causal agents could not be implicated (Osborne et al. 1996; Mahony 1999) suggests it has had an impact on the green and golden bell frog (Goldingay 2008). The chytrid fungus has only been investigated and detected in New South Wales populations (Speare & Berger 2005).

Mortality as a result chytridiomycosis has been observed in New South Wales (Penman and Lemkert 2008; Stockwell et al. 2008). However, despite its widespread infection across amphibian populations in New South Wales, some green and golden bell frog populations are free from or resistant to chytridiomycosis. It is suggested that these populations are located in areas inhospitable to the growth of the disease (Threfall et al. 2008). Possible explanations are fluctuating salinity and elevated concentrations of trace metals (Johnson et al. 2003; Osborne et al. 2008).

Predation

The predation of green and golden bell frog tadpoles by the introduced mosquito fish (*Gambusia* spp) in association with the decline of the green and golden bell frog has been well documented (Daly 1996; Goldingay 1996; White & Pyke 1996; Morgan & Buttemer 1996; Mahony 1996; Lewis & Goldingay 1999; Goldingay & Lewis 1999; Pyke & White 2001). The conclusion to be drawn from existing studies is that mosquito fish does prey on bell frog tadpoles, and is likely to be influencing bell frog population size and recovery in New South Wales (Goldingay 2008).

Despite the extensive literature about the negative effects of mosquito fish on green and golden bell frogs, it has also been discovered that bell frog breeding and persistence has occurred at sites with mosquito fish (White & Pyke 2008), and that bell frogs have disappeared from sites where mosquito fish is absent (Osborne et al. 1996; Mahony 1999). It has also been suggested that certain site conditions may partially reduce the impacts of mosquito fish. For example, submergent vegetation may have allowed tadpoles to escape predation (van de Mortal & Goldingay 1998; Hamer et al 2002).

In addition to mosquito fish, it has also been suggested that green and golden bell frogs could be exposed to predation by cats and foxes, but cats more so given the frogs' occurrence in urban areas (Goldingay 1996; Daly 1995).

Key threats to the green and golden bell frog such as those discussed above have been recognised in the draft national recovery plan for the green and golden bell frog (DEC 2005). The management of these threats is aligned with the objectives and key recovery actions of the draft recovery plan.



Recovery priorities

The key recovery actions identified in the draft recovery plan for the green and golden bell frog (DEC 2005) are consistent with key threats associated with the decline of the species, and include:

- liaising with public authorities and private landholders
- implementing strategic planning instruments
- implementing environmental impact assessment guidelines
- identifying and assessing threats
- preparing guidelines for the construction, improvement and maintenance of green and golden bell frog habitat
- undertaking habitat improvement activities
- preparing green and golden bell frog plans of management at key populations
- implementing a frog disease management strategy
- integrating the recovery plan with relevant threat abatement plans and other threat reduction initiatives
- creating a database of population localities
- implementing a systematic monitoring program on Department of Environment, Climate Change and Water lands, and
- promoting and coordinating research programs for the green and golden bell frog.

Survey guidelines

A guide to surveying the green and golden bell frog is given below. Surveys should be designed to maximise the chance of detecting the species, and should be used to determine the context of the site within the broader landscape. Consideration should be given to the timing, effort, methods and area to be covered in the context of the proposed action. In the absence of adequate surveys (that is, consistent with those described below), the species should be assumed to be present on sites where suitable habitat exists.

Surveys for the green and golden bell frog should:

- be done by a suitably qualified person with experience in frog surveys
- maximise the chance of detecting the species
- determine the context of the site within the broader landscape, and
- account for uncertainty and error.

Habitat assessment

A habitat assessment should be the first step in assessing the likelihood of green and golden bell frog presence. This habitat assessment should then be followed up with targeted field survey for the species. The following questions should be asked during habitat assessment to determine and support whether a site contains or is likely to contain suitable habitat for the green and golden bell frog:

- Is the site within the expected range of the species?
- Are there records of the species within the local area/catchment?



- Does the site support potentially suitable habitat for the species?
- Are there other frog species on site? If so, what species?
- What vegetation occurs on and around the site?
- How close is the nearest water body?
- How many water bodies occur within 10 kilometres?
- Is there habitat connectivity (terrestrial or aquatic) between water bodies on site, and between on-site water bodies and those on neighbouring sites?
- Is there any evidence of disturbance on site?
- Has this habitat been modified as a result of previous development actions?
- Are water bodies infested with mosquito fish or other predatory species that prey on green and golden bell frogs?
- Are there other threats to green and golden bell frogs occurring on site (see page 7)?

During drought, the assessment of the importance of ephemeral water bodies (likely to be dry at the time) should not be underestimated.

Field survey

Field surveys for the green and golden bell frog should be done either in conjunction with or after a habitat assessment, and should be done:

- over a minimum of four nights to increase the detection rate
- between September and March, at the time of peak activity for the species
- during warm and windless weather conditions following rainfall, and
- using a combination of diurnal surveys for basking frogs, nocturnal spotlight surveys, call detection, call playback and tadpole surveys.

Where possible, surveys should include use of a nearby reference site. This reference site should be a site where green and golden bell frogs are known to occur. They should be visited before the survey of the site of interest to confirm that green and golden bell frogs are active and calling on that particular night. Use of a reference site will provide a measure of detectability. Where imperfect detectability is a reality of the field work, detection or occupancy modelling should be included in the assessment.

Small wetlands (less than 50 metres at greatest length) should be covered in a period of about one hour by searching banks and emergent vegetation. Larger wetlands (more than 50 metres) should be searched by sampling multiple units systematically. The multiple units should be stratified by some ecological feature, and sampling based on equitable sampling of each of the units. Green and golden bell frogs use a series of water bodies, not all of which will be permanently occupied. The presence of the species in neighbouring water bodies provides an indicator of the likely use of on-site water bodies. Surveys should therefore try to include connected and surrounding suitable habitats during field surveys.





Significant impact assessment

Whether or not an action is likely to have a significant impact depends upon the sensitivity, value and quality of the environment which is impacted and upon the intensity, duration, magnitude and geographic extent of the impacts. The potential for an action to have a significant impact will therefore vary from case to case. The following thresholds have been developed to provide guidance in determining the likely significance of impacts on the green and golden bell frog.

Important populations

Current populations of green and golden bell frog are regarded as an 'important population'. This is due to the continued decline of the species, the restricted nature of all known populations in New South Wales, and the uncertainty on the current status of the Victorian populations. A current population is defined as a site where one or more green and golden bell frogs have been detected at least once since 1995, even if they have not recently been discovered at the site (due to the species' tendency towards local extinction and recolonisation cycles).

At the time of writing, 54 populations of green and golden bell frog are known in New South Wales since 1990; however, the status of these populations has changed overtime, and, in some cases, is currently unknown or presumed extinct (see table 1). Information about the location of populations in Victoria is more limited.

It is important to note that a population is to be considered a separate population if it is located more than 10 kilometres from a known or nearby population. Conversely, any discovery of a new individual within 10 kilometres of a

known site can be considered a member of a sub-population of the known population. The 10 kilometre rule may not be relevant in all cases. For example, it does not apply in built up areas where connectivity between populations does not exist, such as the Greenacre population, which is within 10 kilometres of the Sydney Olympic park population, but has no connectivity and is within different catchments.

Significant impact threshold for the green and golden bell frog

There is a possibility of a significant impact on the green and golden bell frog, and a referral under the EPBC Act should be considered, if the action results in:

1. the removal or degradation of aquatic or ephemeral habitat either where the green and golden bell frog has been recorded since 1995 or habitat that has been assessed as being suitable according to these guidelines. This can include impacts from chytrid and mosquito fish originating off-site
2. the removal or degradation of terrestrial habitat within 200 metres of habitat identified in threshold 1
3. a break in the continuity of vegetation fringing ephemeral or permanent waterways or other vegetated corridors linking habitats meeting the criteria in threshold 1.

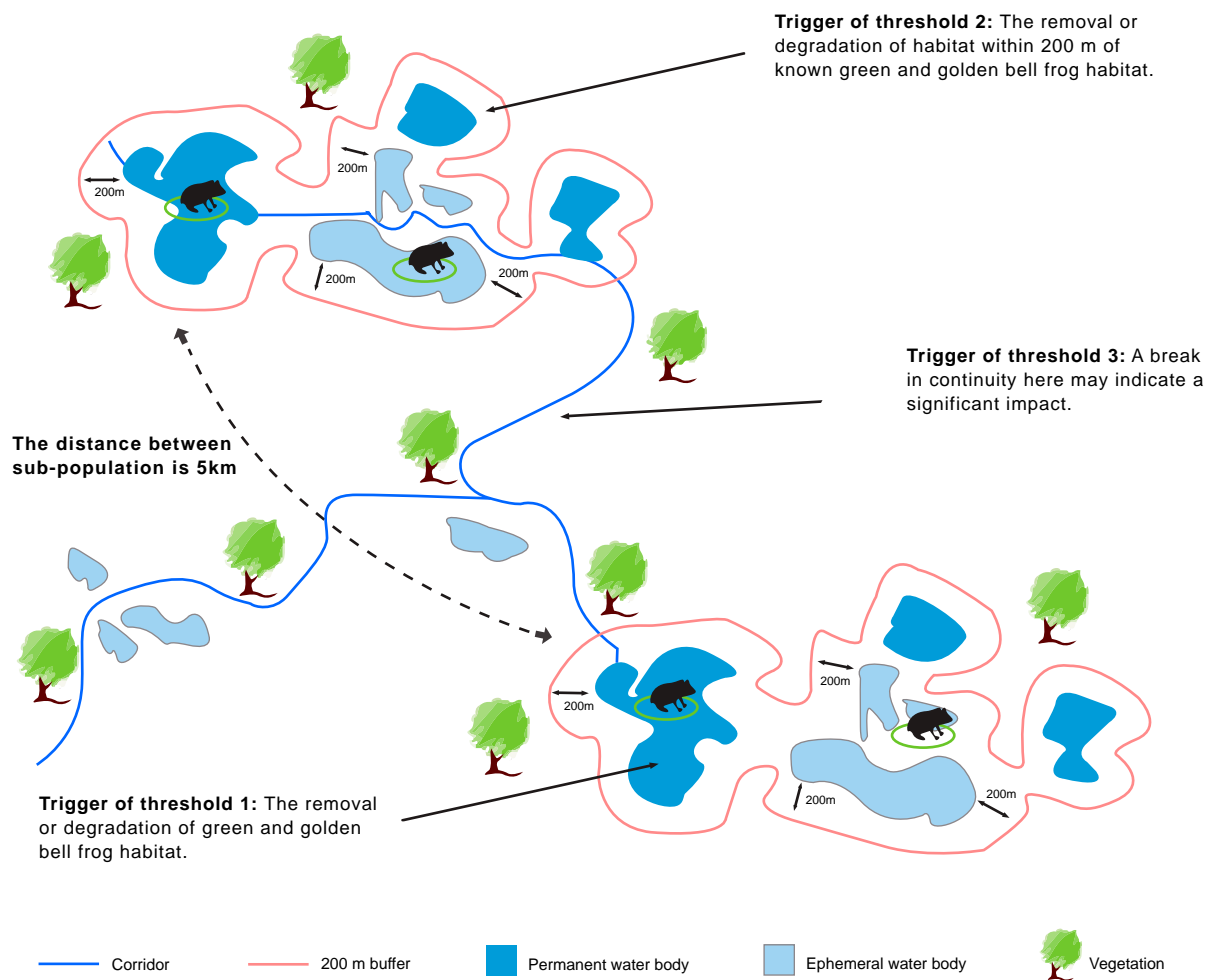
Significant impacts on the green and golden bell frog are not only limited to development-type activities that cause long-term habitat change.



They can include event-type activities of short duration, intensification of existing activities or experimental habitat management activities that will have or are likely to have serious or irreversible negative consequences for the green and golden bell frog.

The significant impact thresholds above give guidance to the level of impact that is likely to be significant for the species at a site. They are not intended to be exhaustive or prescriptive, but rather to highlight the need to maintain the ecological function of the habitat area.

Figure 1: Significant impact thresholds





Mitigation measures

Mitigation activities are generally done on the site of the development to avoid or reduce impacts. Ideally, mitigation measures should be incorporated into the design of a development so that significant impacts are unlikely to occur.

Care should be taken to ensure that any mitigation and/or management actions for the green and golden bell frog do not have a negative impact on other matters of national environmental significance present at a site. The mitigation and management proposed at a site needs to take into account the needs of all matters of national environmental significance in a project area.

The following measures may help minimise impacts on the green and golden bell frog. They should be used with the aim of reducing the impact of an action to below the thresholds laid out in this document. Avoidance measures should be considered the priority.

Measures should be incorporated into the design of the action at the conceptual and planning stage(s) to:

- avoid impacts in the first instance
- reduce the level of the impact below the significant impact thresholds outlined in this policy statement
- monitor the performance of the mitigation measures (specify the timeframe; for example, by using performance indicators measured at seasonally/annually nominated times), and
- provide feedback into an adaptive management plan, to quickly react to any changes in performance.

Mitigation and management actions must:

- prioritise impact avoidance over impact reduction measures
- avoid negative impacts on other matters of national environmental significance, and
- be consistent with relevant recovery, conservation or action plans; for example, New South Wales Department of Environment, Climate Change and Water key population management plans.

Measures that may avoid, mitigate or manage impacts on the green and golden bell frog are presented in Table 1.

Experimental management

Several additional measures are being developed and tested to reduce the impacts of habitat loss on the green and golden bell frog. Such measures will not be considered mitigation until their effectiveness is well established (for example, through demonstrated application, studies or surveys), and there is a high degree of certainty about the avoidance of impacts or the extent to which impacts will be reduced. Until such information is available and accepted, such measures should be considered experimental and done only in conjunction with accepted mitigation such as those in Table 2. Experimental measures include:

- habitat creation – constructed water bodies may appear successful in the first year or two, but their occupancy and productivity often decline in subsequent years; the reasons for these declines are unclear
- frog fencing – used to guide frogs into suitable areas or keep them out of disturbed areas



Table 2: Mitigation of significant impacts on the green and golden bell frog

Principle	Measure	Comment
Avoid impacts	Avoid actions in known and/or potential habitat, and avoid impacts to important ecosystem functions and processes including habitat connectivity and the existing hydrology.	<ul style="list-style-type: none"> Information from field surveys regarding habitat, existing threats and distribution of the green and golden bell frog should be incorporated into the early design phases of the project to ensure any impacts are avoided. Avoid creating barriers to movement or dispersal. Barriers are anything that prevents frogs from moving between local water bodies, and include hard structures that exclude frogs (for example, roads, fences, retaining walls, and buildings) and/or introduction of a break of one kilometre or more between water bodies.
Minimise impacts	Incorporate buffer zones into project design.	<ul style="list-style-type: none"> Create buffer areas of at least 200 metres around water bodies (including aquatic corridors). Buffer terrestrial movement corridors by at least 100 metres. The width of the terrestrial movement corridor buffer necessary will depend on the length of the corridor and the surrounding land uses, with wider buffers necessary for longer corridors and/or those bounded by inhospitable land uses. These buffers should not include access ways, such as road or rail reserves, recreational trails or cycle paths.
	Maintain existing hydrology.	<ul style="list-style-type: none"> This should include any appropriate flood regime, and water flow and quality. Comprehensive modelling and/or pre-construction baseline monitoring, ongoing post-construction monitoring and adaptive management measures may be required to demonstrate that existing hydrology is maintained.
	Enhance habitat quality.	<ul style="list-style-type: none"> Actively maintain or enhance balance of submergent, floating and emergent vegetation in and around water bodies. For example, introduce indigenous submergent and emergent vegetation to water bodies; maintain open areas within water bodies; manage weeds manually and without chemicals; avoid trees and maximise dense grasses in terrestrial areas. Ensure aquatic sites do not become overgrown. That is, prevent overshadowing of ponds and maintain pond water temperatures to suit the green and golden bell frog. Water temperature should be about 25 degrees celsius or higher during the breeding season. Improve terrestrial habitat through provision of logs, rocks, etc. to provide a diversity of shelter and overwintering habitat.
	Avoid undertaking works during sensitive periods.	<ul style="list-style-type: none"> Avoid works at aquatic sites during the breeding season (September to February). Frogs may also be sensitive during winter, when they are in torpor. While most green and golden bell frogs over-winter under rocks, logs, etc. on land, some over-winter in pond mud. Work should therefore be scheduled when frogs are alert, but not breeding, so they are able to move away from disturbances (that is, March and April).
	Implement frog hygiene and pest control protocols.	<ul style="list-style-type: none"> It is important to use strict hygiene protocols to prevent the spread of chytrid fungal disease. Environmental management plans must include a detailed frog hygiene protocol along with weed, predatory fish and feral animal management plans.

Table 2: Mitigation of significant impacts on the green and golden bell frog
continued

Principle	Measure	Comment
Manage impacts	Provide sufficient ongoing monitoring of population and habitat.	<ul style="list-style-type: none"> Monitoring should be done, and include measures of recruitment, population numbers, survivorship, and, if appropriate, aim to evaluate success (or failure) of impact thresholds, such as buffers put in place, disturbance regimes or stock grazing. Project managers should also budget for ongoing monitoring and management costs.
	Remove or manage exotic fish and implement control methods such as draining or poisoning.	<ul style="list-style-type: none"> This includes species such as the introduced mosquito fish or plague minnow, redfin and carp. If this is required, drainage of water bodies should occur when there are few, or no, tadpoles present.
	Implement environmental management plans and construction management plans.	<ul style="list-style-type: none"> Develop and implement environmental management plans to identify threats on site, and implement measures to address them, including control of chytrid fungal disease, weeds, predatory fish and feral animals. Develop and implement construction management plans to manage impacts such as frog mortality (may include pre-construction surveying, installation of frog exclusion fencing on construction sites, etc.), measures to manage noise, vibration and light impacts on adjacent habitat, etc. Align management objectives with those identified in any New South Wales Department of Environment, Climate Change and Water key population management plans. Management plans exist for the following key populations: Coomonderry, Crookhaven River floodplain, Sussex Inlet-Swan Lake, Upper Hunter, Greenacre, Kurnell, Lower Hunter, Georges River, Lower Cookes River and Parramatta.

- underpasses – used to overcome the need to cross roads and allow movement under roads; however, there is currently no empirical evidence indicating green and golden bell frogs use underpasses.

The application of experimental measures must be accompanied by a fully costed and funded adaptive management strategy which clearly specifies the criteria for identifying success, and identifies thresholds at which management intervention will occur. Ongoing monitoring and research should also investigate known threats to the species to inform any adaptive management done.

If these measures are proposed, they should use current best practice and make the results of monitoring and management publicly available to further refine collective knowledge of the species. If creating habitat, it should be positioned to create new links between otherwise unconnected water bodies (due to distance or unsuitable corridors), and its creation timed so that it is suitable for occupation at the time individuals are dispersing. Sufficient time should be allowed for frogs to naturally colonise created habitat before any disturbance to the original habitat occurs. Further information can be found in the best practice guidelines for green and golden bell frog habitat (DECC 2008).



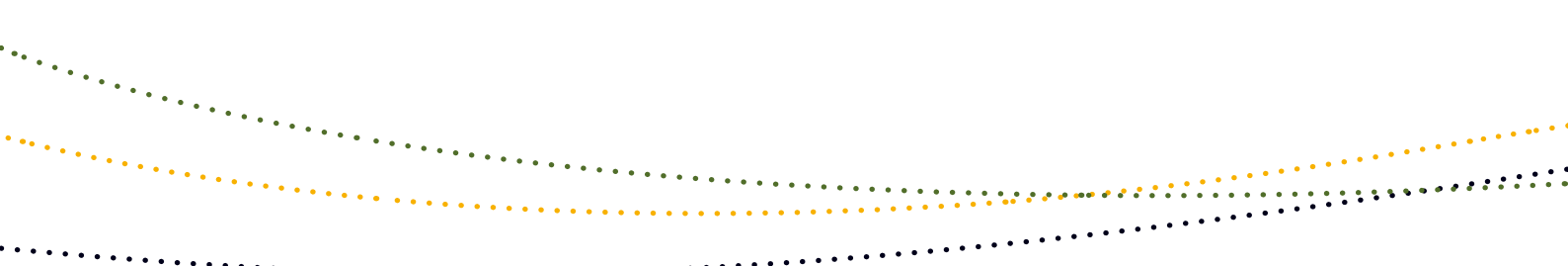
Translocation

Translocation is not a mitigation measure and does not reduce the impact of an action below the significance threshold. Translocation of the green and golden bell frog is not considered to mitigate or offset the impact of an action. In limited circumstances translocations may be done for research purposes in accordance with a recovery program aimed at conserving the species. Such translocation may be tried as an experiment and must be done in association with a fully costed and funded monitoring program and adaptive management strategy, with clearly stated criteria for identifying success. Additional permits may be required to undertake salvage translocation. In New South Wales, translocations must be planned and done in accordance with the Department of Environment, Climate Change and Water translocation policy and procedures (currently being updated).



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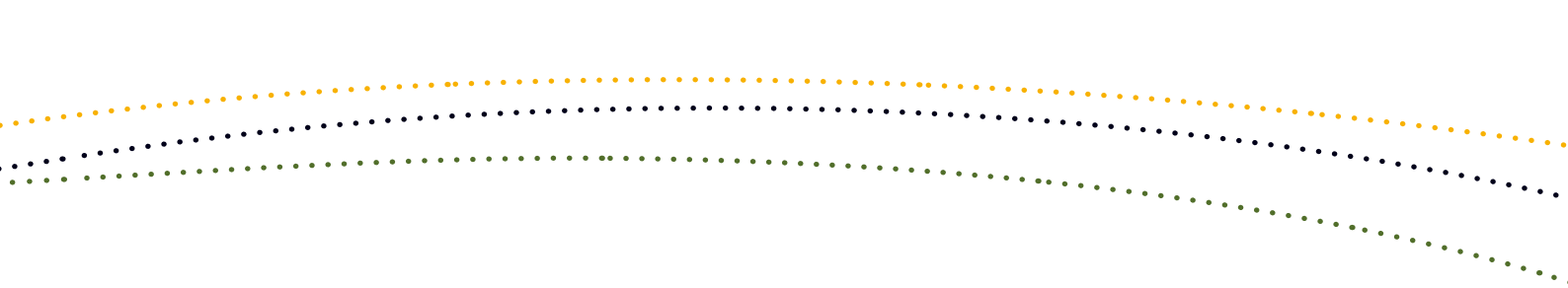
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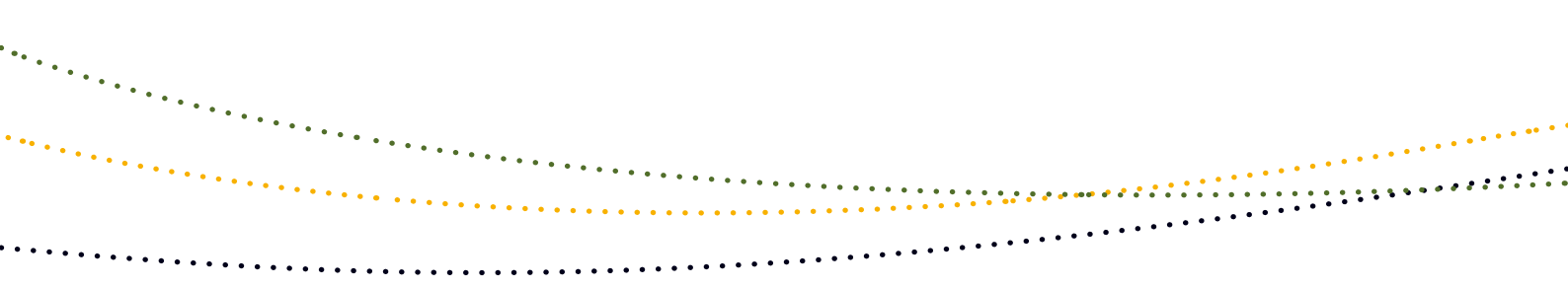
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PHOTO CREDITS

FRONT COVER IMAGES (left to right)

Green and golden bell frog *Litoria aurea* (Dave Hunter)

BACK COVER IMAGES (left to right, top to bottom)

Green and golden bell frog *Litoria aurea* (Dave Hunter)

INTERNAL IMAGES (left to right, top to bottom)

p2 Green and golden bell frog *Litoria aurea* (Dave Hunter), p7 Green and golden bell frog *Litoria aurea* (Dave Hunter), p11 Green and golden bell frog *Litoria aurea* (Frank Lemkert), p17 Green and golden bell frog *Litoria aurea* (Dave Hunter)

