Review of risk assessment (fauna) for BSF1.1; Roy Hill to Port Hedland rail line

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INTRODUCTION

Hancock Prospecting Pty Ltd (HPPL) is proposing to develop the Roy Hill 1 Iron Ore Project, comprising an iron ore mine, a railway and port facilities. The proposed Roy Hill project includes an approximately 300km railway from the Roy Hill 1 Mine to Port Hedland, for which Roy Hill Infrastructure Pty Ltd (RHI), a wholly owned subsidiary of HPPL, is the proponent. Environmental impacts of this rail route, referred to as BSF1, have been extensively addressed in the BFS1 referral document of March 2010 (WorleyParsons 2010). The assessment in that Environmental Referral document included a review of impacts and risks to fauna of conservation significance. The rail route has now been slightly modified to BSF1.1 and as part of a review of environmental impacts, Bamford Consulting was commissioned to provide both an independent assessment of impacts and risks to fauna of conservation significance, and to amend the assessments as necessary with respect to the modified rail route.

METHODS

The review of the impact assessment had the following components:

- Preparation of descriptions of the sources of impacts upon fauna that might be a consequence of both construction and operation of the rail route;
- Prediction of the consequences of impact from these sources upon each species of conservation significance; and
- Review of the risk assessment table from the earlier BFS1 referral document.

SOURCES OF IMPACTS

There are many potential impacts upon fauna from the construction and operation of a railway. These can be primary or direct impacts such as clearing and earthworks causing direct mortality, but also secondary or indirect impacts that arise from such factors as animals being struck by vehicles, a change in the fire regime, changes in hydrology or the spread of weeds altering habitat quality. Many secondary impacts may take effect during operation rather than during the construction period. Sources of impacts from the construction and operation of the railway line are described below.

Mortality during clearing and **mortality during operations** are both forms of direct mortality. Mortality during clearing results from animals being killed during vegetation clearing and/or earthworks, while mortality during operations can be due to animals being struck by vehicles. Some mortality is probably inevitable but is of concern in a conservation sense when it affects the viability of a species in an area. The significance of such mortality will depend upon aspects of a species' biology such as longevity, distribution and population size.

Habitat loss from clearing can result in a **reduction in population size** and in **population (habitat) fragmentation**. Habitat loss can lead to population decline because there is less habitat and therefore only a smaller population can persist, while fragmentation occurs because the development creates a barrier through habitat. Reduced population size may be significant if population viability is affected, and fragmentation may be significant if the fragmented populations are small, or if the fragmentation affects important patterns of movement, such as between roosting and foraging areas.

Hydrological changes. Hydrological changes due to a development can affect habitats outside the development footprint, thus affecting fauna populations in these habitats. Hydrological changes affect not only wetland ecosystems but terrestrial ecosystems that may rely on groundwater or episodic surface water flows. The significance of hydrological impacts is largely dependent upon the area of habitats affected and the conservation status of the species reliant on these habitats.

Habitat degradation due to weed invasion and **incursion of predators and competitors** are both edge effects. They are the consequence of the creation of an unnaturally abrupt edge to natural ecosystems where the ecosystem meets a development footprint. The extent of edge effects can vary with the shape of a development, with a linear infrastructure having very extensive edges compared with a discrete, compact development. Weeds can be spread along an edge by vehicles, and may establish because of the disturbance. Feral species, including introduced predators such as the fox and cat, may use tracks to access areas where they might not otherwise occur. Note that other impacting processes, such as hydrological change, dust, noise, light and disturbance may occur along the edge of a development, but they are not a consequence of the edge, but are a consequence of the nature of the development.

Dust, noise, light and disturbance. These may affect fauna populations outside the development footprint and can be of concern if large areas or significant populations are affected.

Changes in fire regime. Fire is an integral part of many Australian ecosystems but the fire regime (season, frequency and extent) of fires has major consequences, with many species adapted to particular regimes but other species tolerant of a wide range of regimes. Development can result in an increase in fire frequency due to an increase in ignition sources, but development may also provide the opportunity to manage fire regimes where management might not otherwise happen. The rail corridor may also provide a barrier to fire that can be used in fire management.

The significance of impacts ultimately relates to the consequence to the species and the area over which that consequence has effect. Mortality of individuals may be inevitable, but may be of negligible conservation significance if the population is large and widespread; or may be significant if the population is small and isolated. A change in the viability of a local population may be of significance, but this may not affect the viability of the regional population. Therefore, a range of consequences can be recognized as outlined below. Negligible and Minor consequences would be considered acceptable, Moderate consequences might be considered acceptable, but Major and Severe consequences would be unlikely to be considered acceptable.

Table 1. Criteria for consequences of impacts upon fauna

Rating	Impact Consequence	Observed Impact
0	**Negligible**	Little or no population decline
1	**Minor**	Short-term population decline within or largely within project

		area (recovery after end of project); no change in viability or conservation status of population
2	**Moderate**	Permanent population decline within, or largely within, project area. No change in viability or conservation status of population. If information is available on population size or area of habitat, then decline/loss <1% within a distance of 15km*.
3	**Major**	Permanent population decline resulting in change in viability or conservation status of population. If information is available on population size or area of habitat, then decline/loss >1% within a distance of 15km*
4	**Severe**	Extinction of distinctive population or taxon

*The figure of 1% is based upon the Ramsar convention, which recognizes a site that regularly supports >1% of a waterbird's population as being significant. The recognition of what constitutes a population is important. In the case of waterbirds under Ramsar, a population is a discrete group of birds of one species that regularly uses one geographic area; such areas can be international, such as migratory birds that travel between Australia and the Arctic. However, the 1% criterion is also used to recognize regional and local significance based on national and inter-national boundaries. The distance of 15km is based upon the EPA (2004) which suggests 15km as the basis for assessing local impacts.

CONSEQUENCES OF IMPACTS UPON EACH SPECIES

The above sources of impacts as they relate to most species of conservation significance listed by WorleyParsons (2010) are presented in Table 2. Note that one species listed by WorleyParsons is not included; the Crested Bellbird (southern race *Oreoica gutturalis gutturalis*) is listed in Table 24 of WorleyParsons (2010) and this race is recognized as Priority 4 by DEC. However, it would be the northern race of the Crested Bellbird (*Oreoica gutturalis pallescens*) in the vicinity of the rail route and this sub-species is not listed as priority. The southern sub-species occurs in the Wheatbelt and southern Murchison of southern Western Australia (Higgins and Peter 2002).

In the assignment of consequences, a precautionary approach was taken. For example, the impact of changed fire regimes upon the blind snake *Ramphotyphlops ganei* is probably Negligible (on available information reptiles appear tolerant of fire and changed fire regimes (Bamford and Roberts 2003), but it was assigned as Minor. Similarly, the Grey Falcon and Peregrine Falcon are unlikely to suffer anything more than a Negligible impact, but it is possible that changed fire regimes and incursions of predators/competitors may change the abundance of small mammals and birds on which they feed, and therefore a Minor impact has been assigned for these sources. The reasoning behind the assignment of consequences for each species is presented in Table 3.

The evaluation of the likelihood and consequences (Tables 5 and 6) are based on the realistic presumption that the development and operation of the railway will involve the implementation of at least a minimum standard of environmental protection, such as control of hydrocarbon spills, clear demarcation of areas to be cleared, culverts and/or bridges to cross watercourses and personnel education and awareness campaigns. Additional mitigation measures will be used, particularly where consequences of impacts may be a concern.

Routine measures for controlling inherent risk include:

- Flora and fauna surveys undertaken in accordance with State and Commonwealth regulatory agency guidelines;
- Vegetation condition, flora and weed mapping;
- Pre-disturbance fauna surveys, including searches for dens and burrows;
- Optimisation of construction and permanent rail footprint to avoid and/or minimise clearing of good condition conservation significant vegetation, flora, and fauna habitat, where practicable;
- Ground disturbance procedures, including demarcation of disturbance footprint and ‘no go’ areas such as identified environmentally sensitive areas;
- Surface water, sediment and erosion control, fire, weed, dust, noise, light, feral animal, waste, hydrocarbon and hazardous chemical, and groundwater management;
- Raising of employee and contractors awareness through inductions and training.

Where residual risk of impact consequences is found (see Tables 5 and 6), routine measures that need attention are identified and some additional measures may be included. Additional measures to manage residual risk include:

- Trapping and relocation of conservation significant fauna;
- Construction of underpasses (through placement and development of culverts).

Table 2. Assessment of consequence of each impact source upon each species of conservation significance. Under each impact source, the consequence is assigned a score (as in Table 1). Latin names of each species are given in Table 3.

Species	Mortality during clearing	Mortality during operations	Habitat loss (reduction in population)	Habitat loss (population fragmentation)	Hydrological change	Habitat degradation (weed invasion)	Incu prec com		
Blind snake	1	0	0	0	0	1			
Pilbara Olive Python	1	1	0	0	1	0			
Woma Python	1	1	0	0	0	0			
Fork-tailed Swift	0	0	0	0	0	0			
Eastern Great Egret	0	0	0	0	0	0			
Cattle Egret	0	0	0	0	0	0			
White-bellied Sea-Eagle	0	0	0	0	0	0			
Grey Falcon	0	0	0	0	1	0			
Peregrine Falcon	0	1	1	1	2	1			
Australian Bustard	0	1	0	0	0	0			
Bush Stone-curlew	1	1	0	0	1	1			
Migratory shorebirds	0	0	0	0	0	0			
Night Parrot	1	1	0	0	1	1			
Rainbow Bee-eater	0	0	0	0	0	0			
Barn Swallow	0	0	0	0	0	0			
Star Finch	0	1	0	0	1	1			
Mulgara	1	1	1	0	0	0			
Northern Quoll	1	1	1	0	0	0			
Long-tailed Dunnart	1	0	1	0	0	0			
Bilby	1	2	1	0	0	1			
Spectacled Hare-Wallaby	1	2	0	0	0	1			
Ghost Bat	0	0	0	0	0	0			
Pilbara leaf-nosed Bat	0	0	0	0	0	0			
Pebble-mound Mouse	1	0	0	1	0	1			
Lakeland Downs Mouse	1	0	0	1	1	1			
SRE invertebrates	1	0	1	1	2	1			
stygofauna	0	0	0	0	2	0			
Sum of consequences	13	13	6	4	12	10			

Table 3. The reasoning behind the assignment of consequences for each species as presented in Table 2. The consequence score is the sum of the consequences from each impacting process on Table 2.

Species	Consequence score	Explanation for consequence score
Blind snake *Ramphotyphlops ganei*	3	Little information is available on the biology of this species but records are all from south of the rail corridor (Newman, Pannawonica and Millstream, Storr *et al.* 2002). There are clearly extensive populations outside the rail corridor, and if the species is present most consequences are expected to be very localised and therefore Negligible. Mortality during clearing is probably inevitable while habitat alteration due to fire and weed invasion may be of concern (but still considered only Minor consequence as probably localised).
Pilbara Olive Python *Liasis olivaceus barroni*	4	Habitat (gullies, gorges and rocky ranges, particularly with watercourses) for the Pilbara Olive Python occurs in some sections of the rail corridor, particularly in the Chichester Range and possibly where major river systems (e.g. Yule and Turner Rivers) are crossed. Localised habitat loss is therefore inevitable, with some direct mortality, and the species is vulnerable to roadkill. These impacts should be localised and the species is widespread in the Pilbara, but it may occur at low population densities and therefore the death of adults from roadkill may be the greatest threat to the Pilbara Olive Python posed by the rail development.
Woma *Aspidites ramsayi*	3	The Woma may occur on sandy soils along the rail corridor, particularly around Port Hedland. Localised habitat loss is inevitable, with some direct mortality, and the species is vulnerable to roadkill. These impacts should be localised and the species is widespread, especially to the north and east
Fork-tailed Swift *(Apus pacificus)*	0	This is an almost entirely aerial species is Australia that is more or less independent of terrestrial developments. Therefore, all consequences are expected to be Negligible
Eastern Great Egret *Ardea modesta*	0	A widespread and abundant waterbird that may visit seasonal and permanent wetlands along the rail corridor. Because of its abundance, mobility and wide range of wetland types utilized, and the minimal impact expected of the rail corridor upon wetlands, all consequences are expected to be Negligible.

Table 3 (cont.).

Species	Consequence score	Explanation for consequence score
Cattle Egret *Ardea ibis*	0	A widespread and abundant waterbird across northern Australia, but an infrequent visitor in the Pilbara. Unlikely to be affected by the rail route because of its biology and the low impact upon wetlands, and impacts on individual birds would be of low importance as the species is effectively a vagrant in the region. Therefore, all consequences are expected to be Negligible.
White-bellied Sea Eagle *Haliaeetus leucogaster*	0	The White-bellied Sea-Eagle uses a variety of coastal habitats but will forage along major rivers, with records on the Fortescue Marshes (Bamford consulting database). The low impact of the rail development on broad, shallow wetlands and major rivers mean that all consequences are predicted to be Negligible.
Grey Falcon *Falco hypoleucos*	2	Occurs in low numbers along riverine woodlands in the Pilbara. Consequences of impacts are expected to be Negligible except for the possibility of hydrological change affecting Riverine trees, and fire regimes affecting the abundance of prey.
Peregrine Falcon *Falco peregrinus*	2	Occurs in low numbers along in the Pilbara, nesting on cliffs and in riverine trees. Consequences of impacts are expected to be Negligible except for the possibility of hydrological change affecting riverine trees, and fire regimes affecting the abundance of prey.
Australian Bustard *(Ardeotis australis)*	2	The Australian Bustard is very widespread and mobile, and impacts from the proposed railway arte likely to be Negligible except for roadkill, to which the species is sensitive, and possibly changed fire regimes.
Bush Stone-curlew *Burhinus grallarius*	6	The Bush Stone-curlew tends to occur along watercourses with associated dense acacia thickets in the Pilbara (M. Bamford pers. obs.). It is sensitive to roadkill and introduced predators, and possibly changed fire regimes and hydrological change. It appears to occur at low population densities and pairs may be sedentary, and therefore ongoing mortality can be a concern for local populations.

Table 3 (cont.).

Species	Consequence score	Explanation for consequence score
Migratory shorebirds sandpipers, some plovers and Oriental Pratincole	0	These shorebirds occur in large numbers along the coast near Port Hedland, and a few species occasionally occur in moderate numbers on the Fortescue Marshes (e.g. Common Greenshank and Marsh Sandpiper in this area in November 2009, Bamford Consulting database). Small numbers of migratory shorebirds could occur on wetlands anywhere in the region, while the Oriental Pratincole may occasionally occur in small numbers on grasslands. However, the low numbers, infrequent presence and low impact of the rail development on broad, shallow wetlands mean that all consequences are predicted to be Negligible.
Night Parrot *Pezoporus occidentalis*	7	Impacts upon the Night Parrot are difficult to quantify because the species is poorly-known. It has been recorded in a wide range of habitats but is possibly associated closely with the spinifex/samphire ecotone around seasonal wetlands such as the Fortescue Marshes (Higgins 1999), and such habitat lies outside the rail corridor. Impacts from changed fire regimes, introduced predators and weed invasion may be a concern, but the broad distribution of the species at apparently low densities, and its preference for habitats outside the rail corridor, mean that the consequences of these are predicted to be only Minor.
Rainbow Bee-eater *Merops ornatus*	0	A widespread and abundant species that could suffer some individual mortality, most likely from roadkill, but may also benefit from the creation of nesting habitat as it burrows in sloping banks. All consequences are expected to be Negligible.
Barn Swallow *Hirundo rustica*	0	A mostly aerial, non-breeding migrant in the Pilbara, usually seen only in coastal towns (M. Bamford pers. comm.). Consequences of any impacts therefore considered to be Negligible.
Star Finch *Neochmia ruficauda subclarescens*	4	In the Pilbara, the star finch is associated with semi-permanent or permanent creeks and ponds that support a dense vegetation of reeds. There should be little if any direct impact upon this environment, but it could be sensitive to hydrological change, while changed fire regimes can affect such riparian vegetation. The Star Finch is also at risk from roadkill as the birds will sometimes fly low, in flocks, along roads.

Table 3 (cont.).

Species	Consequence score	Explanation for consequence score
Mulgara *Dasycercus cristicauda*, *D. blythi*	6	The proposed rail corridor contains habitat (sandy soil vegetated with dense spinifex) suitable for mulgara from north of the Chichester Range to close to Port Hedland. Localised habitat loss is therefore inevitable, with some direct mortality and the species is vulnerable to roadkill. The species may also be affected by introduced predators that may move along the railway route using tracks for access, and is known to be sensitive to changed fire regimes. With the exception of fire, these impacts should be localised and the species is widespread regionally, including populations outside the Pilbara where habitat is more extensive. Changed fire regimes may be the greatest threat to the mulgara posed by the rail development.
Northern Quoll *Dasyurus hallucatus*	6	Habitat (gullies, rocky hills, gorges and rocky ranges) for the Northern Quoll occurs in some sections of the rail corridor, particularly in the Chichester Range. While the species is abundant in the Abydos and Panorama area, the rail route passes through plains between rocky hills in this area. Localised habitat loss is therefore inevitable, with some direct mortality and the species is vulnerable to roadkill. The species may also be affected by introduced predators and possibly changed fire regimes. However, these impacts should be localised and the species is widespread in the Pilbara. Incursions of introduced predators may be the greatest threat to the Northern Quoll posed by the rail development, with the route and associated service road potentially being used by predators to access areas where they might not otherwise occur.
Long-tailed Dunnart *Sminthopsis longicauda*	2	May occur in rocky environments such as the Chichester Range. Therefore small area of habitat loss and some direct mortality possible, but species is not known to be particularly sensitive to other impacting processes so consequences mostly Negligible.

Table 3 (cont.).

Species	Consequence score	Explanation for consequence score
Bilby *Macrotis lagotis*	11	The proposed rail corridor contains habitat (sandy soil vegetated with dense spinifex) suitable for the Bilby from north of the Chichester Range to close to Port Hedland, and the species is known to be patchily distributed through this region.. Localised habitat loss is therefore inevitable, with some direct mortality and the species is vulnerable to roadkill. The species is also known to be sensitive to introduced predators and changed fire regimes. While some of these impacts should be localised, the Bilby population is small and introduced predators and changed fire regimes have had Severe impacts on the species in other parts of its range. It is not thought that the rail route in isolation would have Severe impacts through introduced predators and changed fire regimes, but there may be cumulative consequences due to other projects.
Spectacled Hare-Wallaby *Lagorchestes conspicillatus*	10	The Spectacled Hare-Wallaby has declined across much of its range in Western Australia, with few recent sightings in the Pilbara. These include two recent records from the Abydos/Panorama area (Bamford Consulting database). Like the Bilby, the Spectacled Hare-Wallaby is particularly sensitive to introduced predators and changed fire regimes, although it is probably not so restricted in its distribution by soil type. With a small surviving population, mortality of individuals during operation may be significant, but changed fire regimes and incursion of introduced predators are likely to have the greatest consequence.
Ghost Bat *Macroderma gigas*	1	Roosting habitat is critical for this species in the Pilbara and there is limited roosting habitat along the rail route, although some in the general region of sections, such as around Abydos and possibly in the Chichester Range. Direct impacts are likely to be minimal but disturbance of roost caves during operation, such as from personnel visiting caves, may be a concern. When the route of the railway line is finalised, any caves likely to be disturbed should be investigated by a suitably trained and experienced zoologist to see whether they provide a roost for the species

Table 3 (cont.).

Species	Consequence score	Explanation for consequence score
Pilbara leaf-nosed Bat *Rhinonycteris aurantia*	2	Roosting habitat is critical for this species in the Pilbara and there is limited roosting habitat along the rail route, although some in the general region of sections, such as around Abydos and possibly in the Chichester Range. Direct impacts are likely to be minimal but disturbance of roost caves during operation, such as from personnel visiting caves, may be a concern, as this species is particularly sensitive to disturbance (Armstrong 2001). When the route of the railway line is finalised, any caves likely to be disturbed should be investigated by a suitably trained and experienced zoologist to see whether they provide a roost for the species.
Pebble-mound Mouse *Pseudomys chapmani*	4	The proposed rail corridor contains habitat (typically stony foothills supporting low spinifex) suitable for the Pebble-mound Mouse in several areas, and localised habitat loss and some direct mortality are inevitable. The species could also be affected by weed invasion and may be sensitive to changed fire regimes. However, it is widespread in the Pilbara and effects would be localised.
Lakeland Downs Mouse *Leggadina lakedownensis*	5	In the Pilbara, the Lakelands Downs Mouse is associated with grasslands on clay soils that may be subject to seasonal waterlogging. It may therefore be sensitive to hydrological change but other impacts, such as habitat loss, are likely to be vey localised. Suitable habitat is present along the rail corridor but is widespread across the Pilbara.
Short range endemic (SRE) invertebrates	8	Consequences of impacts upon SRE invertebrates will depend greatly upon the sorts of habitats affected along the rail corridor. Isolated and relictual mesic environments can be important for SRE biodiversity. For this reason, hydrological change and fire may be important and have a consequence of Moderate. The consequence is not considered higher than this as the rail corridor passes through often uniform landscapes and where environments are mesic, they are mostly drainage systems rather than isolated refugia. This means that the habitats they provide are extensive rather than fragmented and therefore very restricted SRE species are not expected.
stygofauna	3	Consequences mostly considered low as stygofauna should be little-affected by clearing and minor earthworks associated with a railway. However, hydrological change may be a factor to be considered, depending upon the relationship between surface and sub-surface hydrology.

INTERPRETATION OF IMPACT CONSEQUENCES

The approach taken for assessment of impact consequences in Table 2 makes it possible to determine a consequence score for each species. Species with the highest scores were the Bilby (11) and Spectacled Hare-Wallaby (10). Other taxa with high scores were SRE invertebrates (8), Night Parrot (7), Bush Stone-curlew, Night Parrot, Mulgara and Northern Quoll (6) and Lakeland Downs Mouse (5). All other species had scores <5. The scores were high for the Bilby and Spectacled Hare-Wallaby because both species are sensitive to changes in fire regime, introduced predators and to mortality during operations. SRE invertebrates had a high score because of fire and hydrological change, while the Night Parrot was moderately high mostly because of uncertainty resulting in many impacting processes being predicted to have a Minor (rather than Negligible) consequence, even though the disturbance footprint is small and the species probably relies on habitats outside the rail alignment.

The information in Table 2 can also be used to identify the impacting processes that have the greatest overall consequences to significant fauna. Changed fire regimes had a sum of consequences of 21, incursion of predators/competitors had a sum of 14, and mortality during clearing and operations each had a sum of 13. Hydrological change and habitat degradation from weed invasion also had sums of some concern (12 and 10 respectively), but habitat loss affecting population size and population fragmentation were of low concern, reflecting the linear but narrow nature of the development.

There is some uncertainty as to the likelihood of some of the consequences upon species. For example, whereas mortality during clearing is probably inevitable for many species such as the Pilbara Olive Python, and mortality during operations probably inevitable for species such as the Northern Quoll, the consequence of changed fire regimes upon the Bilby and Spectacled Hare-Wallaby is much less certain. Therefore, a risk assessment based on the risk matrix presented in Table 4 was carried out, with the results of the risk assessment, including recommended mitigation actions to reduce the risk, presented in Table 5 and Table 6. This was done for each species and for the impacting processes, as it is the impacting processes that require management. Actions specific to species are considered in the species management plans.

The risk assessment process identifies those impacting processes that can be managed, and some with residual risk. These are summarised as follows:
Mortality during clearing can be managed but some risk remains. It is unlikely that complete certainty can be achieved in, for example, relocating fauna, and survival of relocated fauna is not guaranteed.
Mortality during operation can be managed but some risk remains. Greatest risk is to Spectacled Hare-Wallaby and Bilby.
Habitat Loss leading to reduction in population. This is unavoidable within the life of the project but can be mitigated through rehabilitation.
Habitat Loss leading to population fragmentation is considered to have on Minor to Negligible consequences; it is considered unlikely to occur for most species but is possible for species that have poor powers of dispersal, such as some invertebrates.
Hydrological change. Some risk may remain of impact to stygofauna and possibly SRE invertebrates.
Habitat degradation due to weed invasion. Low inherent risk. While it should be noted there is limited information available on the consequences of weed invasion for the fauna

species, it is probable that the most aggressive weeds, such as Buffel Grass, are already present and thus the railway route may not increase the risk, particularly if hygiene can be practiced.
Incursion of predators/competitors. Can be managed but some risk remains. Greatest risk is to Spectacled Hare-Wallaby and Bilby, with risk remaining high even after mitigation.
Dust, noise, light and disturbance. Low inherent risk but some management required for the Pilbara Leaf-nosed Bat, with some risk remaining for this species even after mitigation.
Changed fire regimes. High inherent risk and some risk remains to species such as the mulgara, Bilby, Spectacled Hare-Wallaby and SRE invertebrates even after mitigation. Mitigation could be complex.

The impacting processes of greatest concern (with unmitigated risk level of High) are: hydrological change, incursion of introduced predators and changed fire regimes (Table 5). Even with mitigation, the risk levels of these remain medium and this reduction to medium is reliant on successful management. Species at greatest risk (unmitigated risk of Medium to High, mitigated risk of Medium) are: Pilbara Olive Python, Bush Stone-curlew, Night Parrot, Mulgara, Northern Quoll, Greater Bilby, Spectacled Hare-Wallaby and stygofauna (Table 6).

The Bush Stone-curlew and Night Parrot have a mitigated or residual risk of Medium because of uncertainty and because they may be vulnerable to several impacting processes, meaning there is cumulative impact to be considered. The other species at risk have fewer impacting processes of concern, with some of these in common. Processes of greatest concern and most vulnerable species are: operating mortality (Pilbara Olive Python, Greater Bilby and Spectacled Hare-Wallaby), hydrological change (stygofauna), introduced predators (Northern Quoll, Bilby and Spectacled Hare-Wallaby) and changed fire regimes (Mulgara, Bilby and Spectacled Hare-Wallaby).

Mitigation of residual impacts relies largely upon effective implementation of routine measures. Therefore, the listing of mitigation actions in Tables 5 and 6 is intended to identify the routine and some additional measures that require special attention.

Table 4. Matrix for risk assessment.

RISK ASSESSMENT RATING		LIKELIHOOD				
		A – Certain Will occur	**B – Likely** Will probably occur	**C – Possible** May occur	**D – Unlikely** Could occur, but not expected	**E – Rare** Conceivably could but not expected to occur
CONSEQUENCE	**5 – Severe** Extinction of distinctive population or taxon	Very High	Very High	High	High	Low
	4 – Major Permanent population decline resulting in change in viability or conservation status of population. If information is available on population size or area of habitat, then decline/loss >1% within a distance of 15km*	Very High	High	High	Medium	Low
	3 – Moderate Permanent population decline within or largely within project area. No change in viability or conservation status of population. If information is available on population size or area of habitat, then decline/loss <1% within a distance of 15km*.	Very High	High	Medium	Medium	Low
	2 – Minor Short-term population decline within or largely within project area (recovery after end of project); no change in viability or conservation status of population	Medium	Medium	Low	Low	Very Low
	1 – Negligible Little or no population decline	Medium	Low	Low	Very Low	Very Low

Descriptors of risk and control

Risk Level	Description	Responsibility
Very High	Generally an unacceptable risk. All feasible alternatives to have been considered. Acceptance of risk by highest level of management to be documented.	Executive Management / Board
High	Potentially tolerable risk. All practicable control measures to be employed. Formal management procedures, monitoring and review for key risks	Senior Management
Medium	Acceptable risk. Measures documented and employed to minimise risk as low as reasonably practicable.	Line Management
Low	Acceptable risk. Normal management measures sufficient.	All personnel
Very Low	Negligible risk. Normal operating practices.	All personnel

Table 5. Risk assessment based on impacting processes. For each impacting process, the inherent and mitigated risks are identified, with individual species mentioned under mitigation actions. Risk assessment for individual species appears in Table 6. Mitigation actions for species are expanded in the species management plans. Risks of concern are highlighted.

Impacting process	Number of species	Inherent			Mitigation actions	Mitigated		
		Consequence	Likelihood	Risk level		Consequence	Likelihood	Risk level
Mortality during clearing	14	0	A	**Medium**	Minimise and clearly define area to be cleared, personnel awareness. Identify habitat of significant species and avoid where possible. Relocation possible for Pilbara Olive Python, Mulgara, Northern Quoll; possibly Bilby and Spectacled Hare-Wallaby.	0	B	**Medium**
	13	1	A	**Medium**		1	B	**Medium**
Mortality during operations	17	0	C	**Low**	Mortality during operations mainly from animals being struck be vehicles. Traffic management plan to incorporate speed limits, signage and personnel awareness. Signage may need to be moved when areas of greatest risk to fauna are identified. Fauna underpasses may be considered. Bilby and Spectacled Hare-Wallaby of particular concern. Roadkill to be reported.	0	C	**Low**
	8	1	B	**Medium**		1	B	**Medium**
	2	1	A	**Medium**		1	B	**Medium**
Habitat loss (reduction in population)	22	0	A	**Medium**	Some habitat loss is unavoidable. Effective rehabilitation to restore this habitat at end of project.	0	C	**Low**
	5	1	A	**Medium**		1	C	**Low**
Habitat loss (population fragmentation)	24	0	D	**Very Low**	Low risk without mitigations. Underpasses may improve the ability of species with poor powers of dispersal to cross the railway line.	0	D	**Very Low**
	3	1	C	**Low**		1	C	**Low**

Table 5 (cont.)

Impacting process	Number of species	Inherent			Mitigation actions	Mitigated		
		Consequence	Likelihood	Risk level		Consequence	Likelihood	Risk level
Hydrological change	18	0	D	**Very Low**	Medium to High inherent risks exist for SRE invertebrates and stygofauna. Therefore, drainage management required as mitigation.	0	E	**Very Low**
	7	1	C	**Low**		1	E	**Very Low**
	1	2	C	**Medium**		2	D	**Medium**
	1	3	B	**High**		2	C	**Medium**
Habitat degradation (weed invasion)	18	0	B	**Low**	Low inherent risk of species with Negligible or Minor consequences, but hygiene can be practiced to reduced further spread of weeds.	0	B	**Low**
	9	1	C	**Low**		1	C	**Low**
Incursion of predators/ competitors	19	0	D	**Very Low**	Inherent risk considered of greatest concern for Northern Quoll, Bilby and Spectacled Hare-Wallaby. Management to involve identifying and monitoring any threatened populations, and monitoring feral species. Control of feral species necessary	0	D	**Very Low**
	5	1	C	**Low**		1	D	**Very Low**
	1	2	C	**Medium**		2	C	**Medium**
	2	3	B	**High**		2	C	**Medium**
Dust, noise, light, disturbance	24	0	E	**Very Low**	Inherent risks are Low or Very Low except for the Pilbara Leaf-nosed Bat, which is known to be sensitive to disturbance at its roosting sites. Mitigation requires identification of roosting sites, avoidance of these if possible and education to ensure these are not disturbed by personnel	0	E	**Very Low**
	2	1	D	**Low**		1	D	**Low**
	1	2	C	**Medium**		2	D	**Medium**

Table 5 (cont.)

Impacting process	Number of species	Inherent			Mitigation actions	Mitigated		
		Consequence	Likelihood	Risk level		Consequence	Likelihood	Risk level
Changed fire regimes	13	0	D	**Very Low**	Bilby, Spectacled Hare-Wallaby, mulgara and SRE invertebrates at High to Very High risk from changes in fire regime. Mitigation requires controls on ignition sources and possibly even a fire management plan to develop a conservation-printed fire regime. This would require cooperative plans with other stakeholders (pastoral leases, other railway corridors).	0	E	**Very Low**
	10	1	C	**Low**		1	D	**Low**
	2	2	C	**Medium**		2	D	**Medium**
	2	3	B	**High**		2	C	**Medium**

Table 6. Risk assessment for individual species of conservation significance. The consequence is the highest consequence from any impacting source as in Table 2. For each species, key impact processes, controls, inherent and mitigated risks are identified. Mitigation actions for species are expanded in the species management plans. Risks of concern are highlighted.

Species	Key impacting processes	Consequence	Likelihood	Risk level	Mitigation actions	Consequence	Likelihood	Risk level
Blind snake	Clearing, habitat degradation (weeds), changed fire regimes	1	A	**Medium**	Clearing controls, rehabilitation, weed management	1	C	**Low**
Pilbara Olive Python	Clearing and operations, hydrological change, predators	1	A	**Medium**	Clearing controls, traffic management, relocation, underpasses, drainage management, predator management	1	B	**Medium**
Woma Python	Clearing and operations, predators	1	A	**Medium**	Clearing controls, traffic management, underpasses, predator management	1	C	**Low**
Fork-tailed Swift	Nil	0	E	**Very Low**	Nil	0	E	**Very Low**
Eastern Great Egret	Possibly hydrological change	0	E	**Very Low**	Ni	0	E	**Very Low**
Cattle Egret	Possibly hydrological change	0	E	**Very Low**	Nil	0	E	**Very Low**
White-bellied Sea-Eagle	Possibly hydrological change	0	E	**Very Low**	Nil	0	E	**Very Low**
Grey Falcon	Hydrological and fire regime change	1	D	**Low**	Drainage and fire management	2	E	**Very Low**
Peregrine Falcon	Hydrological and fire regime change	1	D	**Low**	Drainage and fire management	2	E	**Very Low**
Australian Bustard	Operation and changed fire regimes	1	B	**Medium**	Traffic and fire management	1	C	**Low**
Bush Stone-curlew	Clearing operations, habitat loss and degradation, hydrological change, introduced predators and changed fire regimes	1	A	**Medium**	Clearing controls, rehabilitation, weed management, traffic management, predator control and fire management	1	B	**Medium**

Table 6 (cont.)

Species	Key impacting processes	Consequence	Likelihood	Risk level	Mitigation actions	Consequence	Likelihood	Risk level
Migratory shorebirds	Possibly hydrological change	0	E	**Very Low**	Nil	0	E	**Very Low**
Night Parrot	Clearing, operations, habitat loss and degradation, hydrological change, introduced predators, disturbance and changed fire regimes	1	A	**Medium**	Clearing controls, rehabilitation, weed management, traffic management, predator control, fire management and management of dust, noise, light and disturbance	1	B	**Medium**
Rainbow Bee-eater	Possibly operations	0	C	**Low**	Traffic management during breeding season	0	D	**Very Low**
Barn Swallow	Nil	0	E	**Very Low**	Nil	0	E	**Very Low**
Star Finch	Operations, hydrological change, habitat degradation (weeds) changed fire regimes	1	B	**Medium**	Weed management, traffic management and fire management	1	C	**Low**
Mulgara	Clearing, operations, habitat loss, introduced predators and changed fire regimes	2	B	**High**	Clearing controls, rehabilitation, traffic management, predator control and fire	2	D	**Medium**
Northern Quoll	Clearing, operations, habitat loss, introduced predators and changed fire regimes	2	B	**High**	Clearing controls, rehabilitation, traffic management, predator control and fire	2	C	**Medium**
Long-tailed Dunnart	Clearing, habitat loss	1	A	**Medium**	Clearing controls, rehabilitation	0	B	**Low**
Greater Bilby	Clearing, operations, habitat loss and degradation, introduced predators and changed fire regimes	3	B	**High**	Clearing controls, rehabilitation, traffic management, weed management, predator control and fire	2	C	**Medium**
Spectacled Hare-Wallaby	Clearing, operations, habitat degradation (weeds), introduced predators and changed fire regimes	3	B	**High**	Clearing controls, traffic management, weed management, predator control and fire	2	C	**Medium**

Table 6 (cont.)

Species	Key impacting processes	Consequence	Likelihood	Risk level	Mitigation actions	Consequence	Likelihood	Risk level
Ghost Bat	Disturbance	1	C	**Low**	Personnel awareness	1	D	**Low**
Pilbara leaf-nosed Bat	Disturbance	2	C	**Medium**	Personnel awareness	1	D	**Low**
Pebble-mound Mouse	Clearing, habitat fragmentation and degradation (weeds), and changed fire regimes	1	A	**Medium**	Clearing controls, weed management, fire management	1	C	**Low**
Lakeland Downs Mouse	Clearing, habitat fragmentation and degradation, hydrological change and changed fire regimes	1	A	**Medium**	Clearing controls, weed, drainage and fire management	1	C	**Low**
SRE invertebrates	Clearing, population reduction and fragmentation, hydrological change, habitat degradation (weeds), changed fire regimes	2	B	**High**	Clearing controls, weed, drainage and fire management	1	C	**Low**
stygofauna	Hydrological change	2	C	**Medium**	Drainage management	2	D	**Medium**

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