

**2018 Tree Clearing for Greens Management and
Improvement – Background to Vegetation Clearing Area
Permit Application**

Lake Karrinyup Country Club Inc.

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Executive Summary and Assessment Against the 10 Clearing Principals

This report contains background information that is used to assess the impacts of proposed clearing of 25 endemic native trees, 3 non-endemic planted Australian native trees and 1 dead tree at Lake Karrinyup Country Club that is needed to maintain the international standard of the facilities. The information is used to assess the impacts of tree clearing against the 10 Clearing Principals (Western Australian *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*).

Lake Karrinyup Country Club (Country Club) Championship Course is widely acknowledged as Western Australia's premier golf club, with its outstanding quality greens, fairways and facilities enabling it to be the venue for the Perth International Golf Championship. The Country Club grounds cover an area of over 104 ha within the urbanised suburb of Karrinyup approximately 13km north of Perth (31.8597° S, 115.7840° E). Within this region significant protected areas occur to the west of the Country Club (Trigg Bushland Reserve and Star Swamp Reserve), to the north (Carine Regional Open Space) and to the south (Lake Gwelup Reserve). The Country Club grounds contain regionally important environmental values including:

- Significant areas of large endemic tree species including *Eucalyptus gomphocephala*, *E. marginata*, *Corymbia calophylla* and *E. rudis*.
- Small remnant patches of endemic native vegetation with a simplified diversity of surviving flora dominated primarily by *Banksia grandis*, *B. attenuata*, *Xanthorrhoea preissii*, *Macrozamia riedlei*, *Acacia* spp., *Allocasuarina fraseriana* and a small richness of other understorey species.
- A very significant urban remnant of nomadic and migratory birds including protected species such as Carnaby's cockatoo (*Calyptorhynchus latirostris*), red-tailed black cockatoo (*C. banksia*), rainbow bee-eater (*Merops ornatus*) and common sandpiper (*Actitis hypoleucos*).
- Iconic bird species such as the great crested grebe (*Podiceps cristatus*), red-necked avocet (*Recurvirostra novaehollandiae*) and little eagle (*Hieraetus morphnoides*).
- An iconic remnant urban population of western grey kangaroos (*Macropus fuliginosus*).

In 2016 and 2017 changes to the condition of playing greens at the Championship Course was observed. Any decline in the condition of the greens poses a threat to the status of the Country Club as a premier golfing venue and thus required immediate management responses to ensure the facilities are maintained to a standard to continue to attract International competition to Western Australia. In response the Country Club implemented more intensive greens management and commenced investigations into probable causes, with adjacent large remnant eucalyptus trees considered the likely factor driving a decrease in condition.

In early 2017 the Country Club engaged ArborCarbon to work in partnership with the grounds management to consider the process to remove trees closest to playing greens that are likely causing deterioration in their condition. ArborCarbon are recognised national and international specialists in the management of Green Infrastructure and the ArborCarbon scientific team are internationally recognised specialists in remote sensing for management native vegetation condition, plant and forest pathology, sustainable forest management, biodiversity planning and management, conservation biology and Environmental Impact Assessment. Initially three options were considered by the entire project team:

1. Immediately seek regulatory approval to remove all trees that are potentially causing green deterioration
2. Do nothing and accept the deterioration in condition of the greens
3. Aim to minimise the tree clearing required yet maintaining the quality of the greens by undertaking further investigations that:
 - a. Better quantify the extent and cover of remnant forest and woodland within the Country Club grounds.
 - b. Avoid and minimise tree clearing by better determining the effect caused by individual trees that is leading to deterioration of greens.
 - c. Design a “2018 vegetation works plan” to mitigate any residual environmental impacts of tree clearing through planting programs that aim to establish endemic tree species on the perimeter of the country club, and within some of the native vegetation remnants that will improve their condition from additional endemic native tree establishment.

Option 2 is not viable for maintenance of the golfing facilities and Option 3 was considered the preferred approach that would avoid and minimise the extent of tree clearing required to maintain the condition of the greens and through revegetation would mitigate the effects of clearing. In 2017 ArborCarbon undertook remote-sensed canopy coverage assessments using high-resolution airborne multispectral instruments and completed a shade impact study to quantify the direct effects of trees on the greens.

Analysis of the high resolution multispectral imagery confirmed that the area contains a high density of tree cover when compared with the surrounding urban landscape. Tree canopy (>3m in height) occupies 38.4 ha or 36.8% of the Country Club. Initial tree audits conducted by the Country Club estimated that this tall tree cover is made up of about 20,000 individual trees, most of which are remnant native species, included many large tuart and marri trees.

Greater than 250 large native trees occur very close to the 18 playing greens at the Championship Course. Not all greens showed high levels of deterioration. Shade risk and impact assessment studies showed that the hours of direct sunlight received by the greens decreases significantly during winter months. Problematic shade (<4 hours of sunlight) occurred for four months of the year between May and August at eight of 18 holes on the Championship Course, and the deterioration on these eight greens was caused by shade-casting from 74 large tuart (*E. gomphocephala*), jarrah (*E. marginata*) and marri trees (*C. calophylla*), as well as three planted non-endemic Australian species (two *C. citriodora* and one *E. camaldulensis*). Ideal growth of the turf requires greater than six hours of direct sunshine; however, with greatly increased management of greens, condition can be maintained with areas receiving four to six hours of winter sunshine per day. Shade-modelling spatial-analysis has shown that direct sunlight to the greens can be increased to between 4 to 6 hours with the removal of 25 endemic native trees in total (11 tuart, 3 jarrah and 11 marri trees). The Country Club are committed to increase management at these greens to maintain their international standard whilst retaining 49 endemic native trees that have been shown to decrease the direct sunlight in winter to 4 to 6 hours. **In addition the Country Club have committed to:**

- Only clear trees once a suitably qualified and experienced wildlife ecologist has confirmed native fauna are not using the trees proposed for clearing. This survey will occur within 24 hours of clearing. If native fauna are identified using habitat hollows within a tree, then clearing of that tree will be postponed until the tree hollow is vacated.
- Progressively clear trees over 12 months and will have qualified wildlife ecologist who is experienced with handling wildlife is on-site as each tree is cleared.

- Re-plant within the Country Club grounds 90 endemic trees; 40 tuart, 10 jarrah and 40 marri trees.
- Commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of native trees and remnant vegetation within the 104ha grounds.

Request for permit to Clear trees.

Based on the need to maintain the international standard of the facilities at Lake Karrinyup Country Club and informed by these background studies a Vegetation Clearing Area Permit for the removal of 25 endemic native trees (11 tuart, 3 jarrah and 11 marri trees), three non-endemic Australian native trees and 1 dead bull banksia is requested. This Executive Summary and accompanying report assesses the likely impact of this clearing against the ten clearing principals under Part V Division 2 of the *Western Australian Environmental Protection Act 1986* (EP Act). The accompanying report outlines in more detail the location of the individual trees to be cleared. It also briefly outlines how the extent of tree clearing was avoided or reduced through additional studies and commitments being made to mitigate and enhance the condition of native vegetation at the Country Club against the loss of these trees.

10 Clearing Principals

Principle (a) – Native vegetation should not be cleared if it comprises a high level of biological diversity.

Not at Variance with Principal (a).

Clearing is taking place on the Swan Coastal Plain 14 km north north-west of Perth. Clearing is of **25** endemic trees; **11** *E. gomphocephala*, **3** *E. marginata* and **11** *C. calophylla*. In addition, 3 non-endemic natives and one dead banksia will be cleared; **1** *C. citriodora* and **2** *E. camaldulensis* and **1** dead *B. grandis*. The combined number of endemic, non-endemic and dead trees requested to be cleared is **29 trees** with a total area of **0.3764** ha.

The applicant understands the need to protect and enhance tuart forests in particular and have committed to replant 40 tuart, 10 jarrah and 40 marri trees within the grounds of the Country Club in 2018-19.

Principle (b) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.

Risk of being At Variance with Principal (b); *Not At Variance with Principal (b) achieved through avoidance and mitigation of residual risks outlined below.*

Field studies and regular observation by staff and Country Club members have confirmed the presence and use of the Country Club by protected species (under *Wildlife Conservation Act 1950* (*Biodiversity Conservation Act 2016* – regulations pending) and *Environment and Biodiversity Conservation Act 1999*). These are Carnaby's cockatoo (*Calyptorhincus latirostris*) and red-tailed black cockatoo (*C. banksia*). Approval is being sort for the clearing of 25 endemic trees that are vegetation forming part of significant habitat for these species. The degree of avoidance of trees and scale of impact of removal of these endemic habitat trees is:

- 74 endemic trees were found to be causing detrimental impacts to the Championship Course. Modelling and adaption of greens management will mean 25 trees will be cleared, avoiding the loss of 49 trees (66% of shade-impacting trees will be avoided and conserved).
- **0.3577** ha of endemic trees will be cleared. The Country Club grounds contain 38.4 ha of tree cover > 3m. The loss will be 0.93% in area of habitat within the grounds and risk of direct impact to protected fauna is low.
- 25 endemic trees of approximately 20, 000 trees within the 104 ha of the Country Club. The loss will be <0.2% of trees within the Country Club and the risk of direct impact to protected fauna is low.
- 25 trees of which **6 are very large trees (dbh >800mm) that have been confirmed by Dr Mark Garkaklis to contain hollows suitable for native fauna.** Field survey and observations by staff have not identified use of the hollows by endemic native fauna. One tree was occupied by introduced (pest) rainbow lorikeets. The risk of direct impact to protected native fauna is low, **but the consequences of an impact if it occurs is high.**

The residual risk of impact to these protected species by the removal of these trees will be addressed by the following commitments. The applicant will:

- Only clear trees once a suitably qualified and experienced wildlife ecologist has confirmed native fauna are not using the trees proposed for clearing. This survey will occur within 24 hours of clearing of each tree. If native fauna are identified using habitat hollows within a tree, then clearing of that tree will be postponed until the tree hollow is vacated.
- Progressively clear the 25 trees over 12 months from March 2018 to April 2019 and will have an experienced wildlife ecologist and animal handler on-site as each tree is cleared.
- Re-plant within the Country Club grounds 90 endemic trees; 40 tuart, 10 jarrah and 40 marri trees.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds over 10 years.

Principle (c) – Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.

Not at Variance with Principal (c).

Clearing targets 25 individual trees within the 104 ha of the Country Club. No rare flora have been identified within the grounds.

Principle (d) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community.

Not at Variance with Principal (d).

Clearing will be 11 tuart, 3 jarrah and 11 marri trees which do not comprise or maintain a Threatened Ecological Community. However, the applicant is aware of the public and expert comment invited by the commonwealth Threatened Species Scientific Committee (TSSC) who are assessing the conservation threat to tuart forests and woodlands of Western Australia. The applicant is committed to the replacement of the cleared trees through planting of 40 tuart trees in 2018. Twenty-two of these replanted trees will replace the 11 cleared tuart trees, but their position will be 'offset' 20 metres away from the playing greens to reduce the risk of shade impacts that could occur as they grow. The remaining 18 tuart trees will be planted on the perimeter of the Country Club and within remnant native vegetation that is suitable for enhancement. The applicant will:

- Re-plant within the Country Club grounds 90 endemic trees; 40 tuart 10 jarrah and 40 marri trees.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds over 10 years.

Principle (e) – Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

At Variance with Principal (e); Not At Variance with Principal (e) achieved through avoidance and mitigation of residual risks outlined below.

The three endemic tree species to be cleared are species that comprise part of significant remnant native vegetation that has been identified in *Draft Strategic Conservation Plan for the Perth to Peel Region* as a priority for the maintenance of environmental values in the region. The Regional scale of impact of removal of these remnant vegetation trees is:

- 25 endemic trees comprising 0.3577 ha of remnant vegetation that contributes to connectivity of regional protected areas to the west, south and north of the Country Club. The Western Australian government *Draft Strategic Conservation Plan for the Perth to Peel Region* is committed to avoiding loss to over 15,700 hectares of Carnaby's cockatoo Swan Coastal Plain feeding habitat. The clearing of these 25 endemic trees represents <0.0002% of this regional commitment and is a very low risk of impact to Principal (e).

The very low residual risk of impact to significant remnant native vegetation by the removal of these 25 endemic trees will be mitigated by the following commitments. The applicant aims to enhance regional remnant native vegetation by:

- Initially re-planting within the Country Club grounds 90 endemic trees in 2018-19; 40 tuart, 10 jarrah and 40 marri trees as an immediate response to the clearing of 11 tuart, 3 jarrah and 11 marri trees.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds over 10 years.

Principle (f) – Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.

Not At Variance with Principal (f)

Lake Karrinyup and associated drainage lines occur within the Country Club. However, none of the trees to be cleared is growing in or associated with the drainage lines or Lake Karrinyup.

Principle (g) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

Not At Variance with Principal (g)

The removal of these 25 trees is a very low risk of appreciable land degradation. The commitment to replanting 90 endemic native trees will mitigate any very low residual risk.

Principle (h) – Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

Not At Variance with Principal (h)

The removal of 25 trees occurs within a site that provides east-west connectivity between Trigg Bushland Reserve, Star Swamp Reserve, Carine Regional Open Space and Lake Gwelup Reserve. Planning for the clearing of these trees has been undertaken to avoid, reduce and mitigate any potential environmental impacts. The clearing of 25 endemic trees is 0.93% of the 38.4 ha of remnant forest and woodlands that make up this area of connectivity. The risk of direct impact to connectivity between regional protected areas is low.

The applicant understands the need to protect and enhance remnant forests and woodlands to support connectivity between the Country Club and local protected areas. To mitigate against the very low risk of residual impact to connectivity the applicant will:

- Re-plant within the Country Club grounds 90 endemic trees; 40 tuart, 10 jarrah and 40 marri trees to replace the loss of 11 tuart, 3 jarrah and 11 marri trees.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds. Successful implementation of the plan is very likely maintain or lead to improved connectivity between locally significant areas of native vegetation.

Principle (i) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.

Not At Variance with Principal (i)

The risk of impact to the hydrology and hydrogeology of the region is very low. However, the Country Club monitors the quality of groundwater and is committed to enhancing the condition of native vegetation within the Country Club through re-planting 90 endemic native trees and development of a management plan to enhance the condition of native vegetation within the 104ha grounds.

Principle (j) – Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.

Not At Variance with Principal (j)

Twenty-five endemic trees, 3 introduced and 1 dead tree are proposed to be cleared. The total area of clearing of endemic and exotic native trees is 0.98% of the treed areas of the Country Club and is at very low risk of causing or exacerbating the incidence of flooding. Any very low residual risk will be mitigated through re-planting 90 endemic native trees and development of management plans to enhance the condition of native vegetation within the 104ha grounds.

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1 Introduction

Lake Karrinyup Country Club (Country Club) Championship Course is widely acknowledged as Western Australia’s premier golf club, with its outstanding quality greens, fairways and facilities enabling it to be the venue for the Perth International Golf Championship sponsored by the Government of Western Australia (ISPS HANDA World Super 6 Perth, February 2018). The importance of this venue to the Western Australian economy cannot be underestimated. The Professional Golfers Association (PGA) have advised the Government of Western Australia that the predicted international viewing audience for this event in February 2018 will be well in excess of 100 million viewers (D. Lonnie, LKCC Pers. Comm.).

The Country Club grounds cover an area of over 104 ha within the urbanised suburb of Karrinyup approximately 13 km north-northwest of Perth CBD (31.8597° S, 115.7840° E; 385000E; 6474000N. Figure 1). It is bounded by North Beach Road in the north and east and by Clement, Sandover and Summerhayes Drives in the west.



Figure 1: Approximate Location of the 104 ha Lake Karrinyup Country Club (LKCC) on the Swan Coastal Plain (31.8597° S, 115.7840° E).

Key to the County Clubs international reputation is the quality of the playing greens and fairways. Maintenance of these facilities to an international standard is the highest priority for grounds management at the Country Club. The key requirement for healthy turf within the golf course environment is adequate

exposure to solar radiation. Lack of solar radiation has a number of negative impacts on turf quality and vigour. The photosynthetic productivity of turf is directly related to the amount of sunlight received and as such, reduced sun exposure inhibits growth and vigour of the turf. Turf of low vigour is more susceptible to pest and diseases, water stress, wear from traffic, as well as competition from weedy grass species, mosses and algae. This results in increased management costs and inputs (e.g. chemicals) to maintain turf at an acceptable level of quality. Access to morning sunlight is particularly important due to its effect of rapidly increasing soil temperatures and reducing leaf wetness during the cooler months. Prolonged leaf wetness can increase susceptibility to fungal diseases. Reduced soil temperatures due to shading can also cause a build-up of organic matter, due to reduced decomposition rates. Very reduced exposure to solar radiation means that turf quality deteriorates.

In 2016 and 2017 changes to the condition of playing greens at the Championship Course was observed. Any decline in the condition of the greens poses a threat to the status of the Country Club as a premier golfing venue and thus required immediate management responses to ensure the facilities are maintained to a standard to continue to attract International competition to Western Australia. In response the Country Club implemented more intensive greens management and commenced investigations into probable causes, with the shade cast by adjacent large remnant eucalyptus trees considered the likely factor driving a decrease in condition.

In early 2017 the Country Club engaged ArborCarbon to work in partnership with the grounds management to consider the process to remove trees closest to playing greens that are likely causing deterioration in their condition. ArborCarbon are recognised national and international specialists in the management of Green Infrastructure and the ArborCarbon scientific team in this project are internationally recognised specialists in remote sensing for management native vegetation condition, plant and forest pathology, sustainable forest management, biodiversity planning and management, conservation biology and Environmental Impact Assessment. ArborCarbon are a 'Major Industry Partner' in the University of Sydney CubeSat Centre and are Australian supplier for a range of multispectral and hyperspectral instruments for remote-sensing vegetation condition using UAV and fixed-wing aircraft.

Initially three options were considered by the entire project team:

1. Immediately seek regulatory approval to remove all trees that are potentially causing green deterioration.
2. Do nothing and accept the deterioration in condition of the greens.
3. Aim to minimise the tree clearing required yet maintaining the international standard of the greens by undertaking further investigations that:
 - a. Better quantify the extent and cover of remnant forest and woodland within the Country Club grounds.
 - b. Avoid and minimise tree clearing by better determining the effect caused by individual trees that is leading to deterioration of greens.
 - c. Design a "2018-19 re-vegetation works plan" to mitigate any residual environmental impacts of tree clearing through planting programs that aim to establish endemic tree species on the perimeter of the country club, and within some of the native vegetation remnants that will improve their condition through endemic native tree establishment.

Option 1 required removal of a large number of trees and without additional information could not be justified. Option 2 is not viable for maintenance of the international standard of the golfing facilities. Option 3 was considered the preferred approach that would avoid and minimise the extent of tree clearing required to maintain the condition of the greens and through revegetation would mitigate the effects of clearing. In 2017 ArborCarbon undertook remote-sensed canopy coverage assessments using high-resolution airborne multispectral instruments and completed a shade impact study to quantify the direct effects of trees on the greens. On completion of the canopy coverage and shade-studies it was agreed that an application to clear a number of trees under Part V Division 2 of the *Western Australian Environmental Protection Act 1986* (EP Act) was required and the background preparation for submission of the Vegetation Clearing Area Permit was commenced.

2 Methods

2.1 Airborne multi-spectral imagery acquisition

Airborne multispectral imagery was obtained over the Country Club using a fixed wing aircraft on 16th March 2017. Imagery was obtained at a pixel resolution of 0.5m in 4 spectral bands, using narrow band-pass filters in the blue, green, red-edge and near-infrared region of the light spectrum. A Digital Height Model of the golf course was derived from the imagery. This method of image acquisition, spatial modelling and stratified canopy cover measurement is well developed and extensively ground-truthed. This method is currently used by Local Government Authorities throughout Australia and internationally (e.g. Cities of Perth, Joondalup, Subiaco, Onkaparinga, Sydney, North Sydney and Hong Kong to name a few).

2.2 Shade modelling

The height model of the Country Club derived from the multispectral imagery was used to model shade falling on the greens using a propriety shade-cast algorithm. The shade model was run at hourly intervals for the first day of every month throughout the year. The hourly shade maps were summed to produce a daily image showing the number of hours of direct sunlight on all greens and fairways within the Country Club.

The accuracy of the shade-cast model was assessed by comparing the shade mask produced by the model to the actual shade observed in the multispectral imagery, when the model was run for the same date and time (Figure 2).

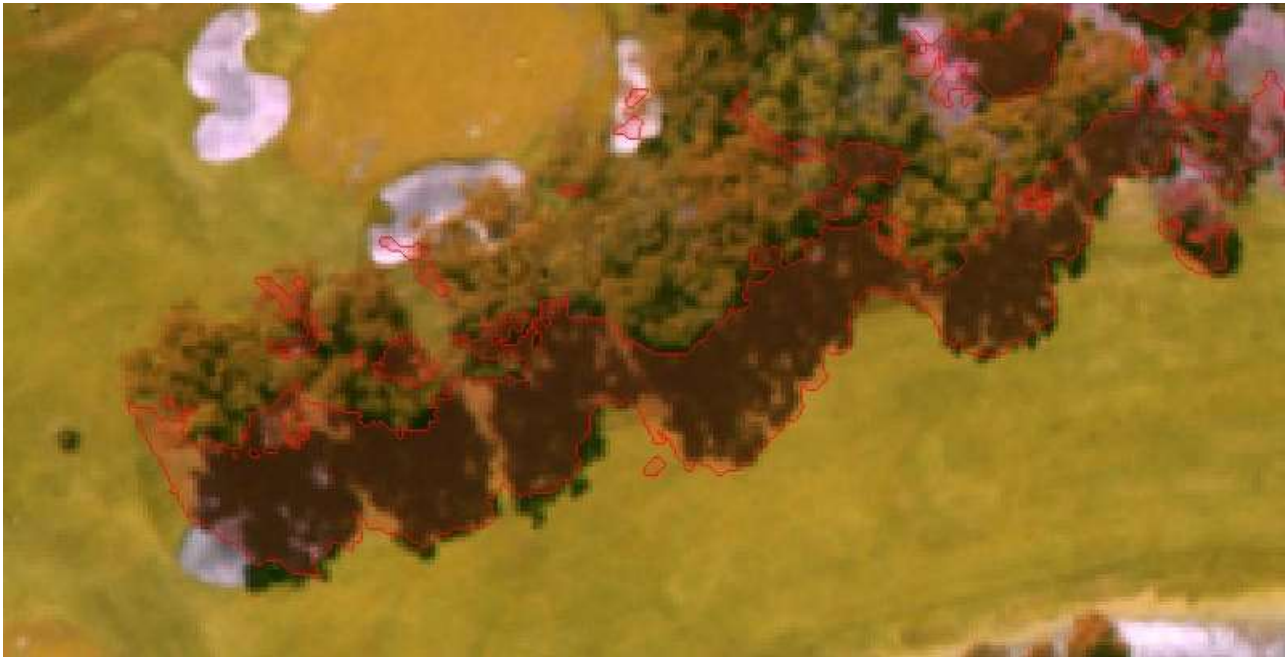


Figure 2: Comparison of actual shade in an aerial photograph of LKCC, and the area of shade predicted by the model (red) for the same date and time.

With the development of the shade-model, sun exposure for each the 18 playing greens on the Championship Course was then modelled as a function of month. The project team categorized each playing green on the basis of sun exposure:

- Greater than 6 hours (>6) exposure to solar radiation = Least Concern.
- Between 4 to 6 hours (4-6) exposure to solar radiation = Concern. Intensive greens management required.
- Less than 4 hours (<4) exposure to solar radiation = High Concern and Risk. Maintenance of greens condition at high risk of failure.

Ground-truthing of trees at each green that received exposure to winter solar radiation of less than 4 hours was carried out to confirm the spatial location (GPS), number, species, diameter at breast height (dbh) and estimated height of the trees causing shading. Data were captured on field table using MAPPT software (www.mappt.com.au). At each green a number of scenarios were assessed with the aim of avoiding and minimising tree clearing, and measures to mitigate the residual impact were planned.

2.3 Application to Clear Native Vegetation (Trees) Area Permit

In support of an Application to Clear Native Vegetation Area Permit a brief review and description of the local conservation assets and the environmental and biodiversity values of the country club were compiled. Combined with the technical studies this allowed better assessment of the impact of tree clearing against the Ten Clearing Principals (Western Australian *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (Clearing Regs.)).

3 Results and Discussion

3.1 The Lake Karrinyup Country Club

The Country Club grounds occur on the Spearwood Dune System inland from the coast on the Swan Coastal Plain (SWA2 Bioregion). It is located between important local conservation reserves; namely Trigg Bushland Reserve, Star Swamp Reserve, Lake Gwelup Reserve and Carine Regional Open Space. Therefore the native vegetation within the Country Club acts as an important stepping stone, providing connectivity between these other local protected areas.

Vegetation is typically open forest and ecotonal, with *Eucalyptus gomphocephala* and *Corymbia calophylla* dominating forest patches interspersed with fewer *E. marginata*. *Banksia grandis* and *B. attenuata* occur in small remnant patches of native vegetation with *Xanthorrhoea preissii*, *Macrozamia riedlei*, *Acacia* spps., *Allocasuarina fraseriana* and a small number of other understorey species. The species richness within remnant patches have been simplified and its likely invasion of these remnants by weed species such as perennial veldt grass *Ehrharta calycina* (Keighery and Keighery 2016) is leading to the decline in understorey diversity and cover. Lake Karrinyup occurs within the Country Club grounds and a few *E. rudis* fringe the eastern shore of the lake.

Remnant open forest of *E. gomphocephala*, *C. calophylla* and *E. marginata* dominate the Country Club and the many thousands of individual trees provide a striking vista within the grounds (Figure 2). A 2016 audit of trees within the course conducted by ground staff counted over 3000 large native trees in the vicinity of the fairways and estimated about 20,000 trees within the Country Club (F. Brown, LKCC, Pers. Comm.). Several thousand large trees within the Country Club are likely to provide suitable foraging and nesting habitat for important native species.



Figure 3: A typical fairway view of tall endemic trees at Lake Karrinyup Country club. Many trees at the country Club are likely >150 years old with 3000 large trees associated with fairways. Some of these trees are > 30m in height and contain hollows that are potential nesting habitat.

The Country Club is habitat or potential habitat for a high diversity of urban native wildlife. Examples of some of the fauna that are known to be supported by the Country Club environment include:

- A very significant urban remnant of nomadic and migratory birds including protected species such as Carnaby's cockatoo (*Calyptorhincus latirostris*), red-tailed black cockatoo (*C. banksia*), rainbow bee-eater (*Merops ornatus*) and common sandpiper (*Actitis hypoleucos*). These species are protected under *Wildlife Conservation Act 1950* (*Biodiversity Conservation Act 2016* – regulations pending) and/or *Environment and Biodiversity Conservation Act 1999* (cwth.).
- A rich community of waterfowl associated with Lake Karrinyup and forest and woodland bird species that are less common in Perth's urban environs that are found in the open tuart and marri forests.
- Iconic bird species such as the great crested grebe (*Podiceps cristatus*), red-necked avocet (*Recurvirostra novaehollandiae*) and little eagle (*Hieraetus morphnoides*).
- An iconic and highly valued remnant urban population of western grey kangaroos (*Macropus fuliginosus*).

3.2 Tree canopy cover

The Country Club grounds cover an area of 104 ha. The area contains a high density of tree cover when compared with the surrounding urban landscape (Figure 4). Tree canopy (>3m in height) occupies 38.4 ha or 36.8% of the area of the Country Club.



Figure 4: Map of LKCC showing photosynthetic vegetation cover stratified by height. Note low tree canopy to the west.

3.3 Shade modelling

High resolution maps of sunlight hours on all greens and fairways for each month were developed. An example of these output maps is presented below for July (Figure 5).

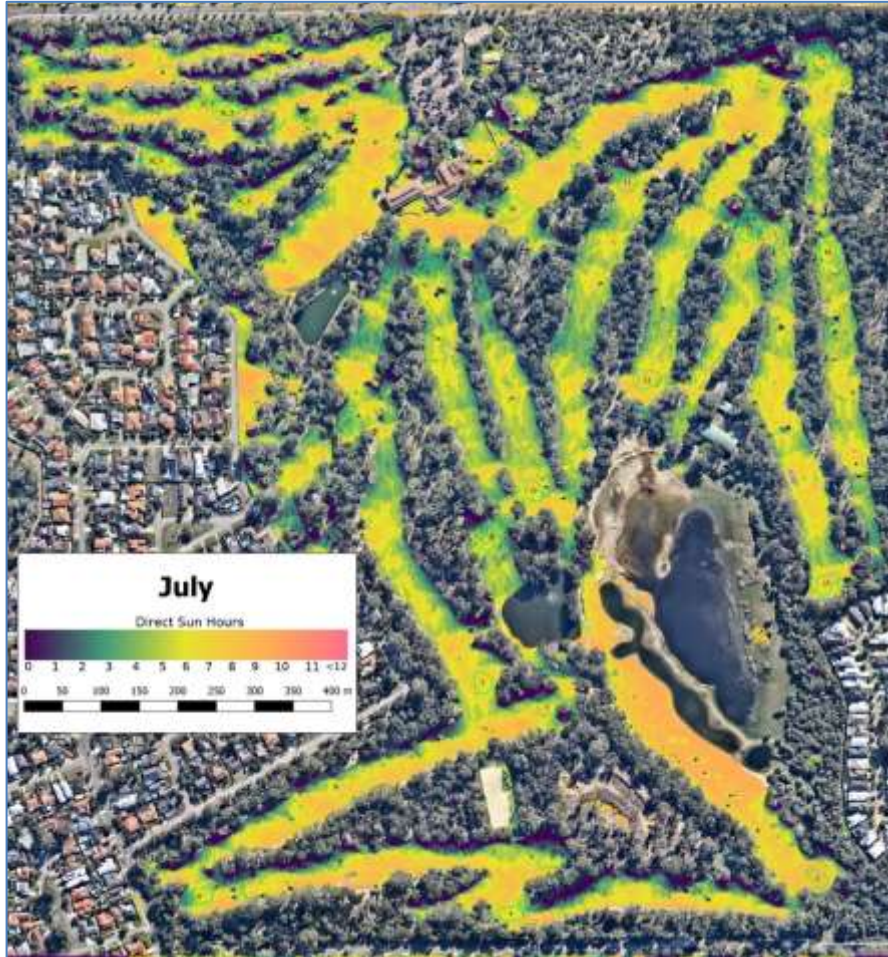


Figure 5: Map of LKCC showing an example of the results of the shade modelling for the month of July. Turfgrass areas are colour scaled according to the number of direct sunlight hours.

Six hours of direct sun exposure was defined as the critical threshold for healthy turf growth. Sun exposure between 4-6 hours per day was considered less than ideal, but could be compensated for over short periods by appropriate management. However, it is known that less than 4 hours of direct sunlight during any month leads to a decline in turf condition.

Sun hours received by the greens declined towards the middle of the year during the winter months as expected. The fewest sun hours was generally received during the month of July. Problematic shade (≤ 4 hours of sunlight) was identified between the months of May and August. The green at Hole 5 received the fewest sun hours of any green in the Championship Course, with approximately 10% of the green receiving only 1 hour of direct sunlight during June and July correlating with severe deterioration of the condition of this playing green.

Greens receiving < 4 hours of sunlight during any month of the year were Holes: 1, 5, 6, 8, 9, 11, 14 and 17.

3.4 Tree removal – avoiding and minimizing need for clearing

Spatial analysis using shade modelling demonstrated that 8 of 18 greens are categorised as <4 hours, High Risk and this outcome is related to the shade-cast of 77 trees in total. This confirmed tree removal was required to increase the required solar radiation in winter months to >4 hours. All 74 endemic native, 3 exotic native and one dead ‘candidate trees’ identified for removal were inspected on-ground. The aim was to identify individual trees that could be removed that would, (as predicated through repeated spatial and shade modelling) increase solar radiation exposure of the greens to between 4 to 6 hours during the winter months. **The result of this iterative modelling approach meant 49 endemic native trees identified as causing impacts to greens have been protected. Twenty-five endemic natives, 3 exotic native trees and one dead banksia** were identified for clearing, resulting in all affected greens receiving 4 to 6 hours of winter sunlight. These trees occur as individuals or as a group of up to five trees. The total area of all endemic, native and dead trees to be cleared is **0.3764 ha**. The area of endemic native trees to be cleared is **0.3577 ha**. Spatial coordinates and measurements of each tree are appended.



Figure 6: Position of trees for removal to at Holes 1, 5, 6, 8, 9, 11, 14 and 17.

3.4.1 Hole 1

Shade modelling indicated that most shade comes from one large *E. gomphocephala* to the north-west of the green. Removing this tree increased sunlight exposure to all areas of the green to a minimum of 5 hours. This tree contains a number of hollows likely to provide suitable habitat for native species.



Figure 7: HOLE 1: One (1) E. gomphocephala to be cleared; DBH = 1740mm, Estimated height 28m. Potential nesting hollows were identified in this tree.

3.4.2 Hole 5

Five *C. calophylla* and three large *E. gomphocephala* have been identified for clearing. Eight trees in total need to be removed at this area to maintain the playing green with 4 to 6 hours of direct solar radiation during winter months.



Figure 8: HOLE 5: Five (5) *C. calophylla* to be cleared; DBH = 400mm, 350mm, 140mm, 410mm, 880mm. Estimated heights = 16m, 14m, 7m, 15m, 20m.



Figure 9: HOLE 5: Three (3) *E. gomphocephala* to be cleared; DBH = 720mm, 730mm, 990mm. Estimated heights = 25m, 25m, 27m. The largest tree to the right of view has a number of suitable nesting hollows.



Figure 10: HOLE 5: One dead *Banksia grandis* in the foreground identified for removal.

3.4.3 Hole 6

One large *E. gomphocephala* to the north-east of the playing green has been identified for removal at Hole 6. This tree contains a number of potential nesting hollows.



Figure 11: HOLE 6: One (1) *E. gomphocephala* to be cleared; DBH = 1060mm. Estimated height = 25m. Potential nesting hollows were identified in this tree.

3.4.4 Hole 8

One *E. gomphocephala* and one non-endemic *C. citriodora* have been identified for removal at Hole 8. The *E. gomphocephala* to the north west of the green is in poor condition. The crown displayed symptoms of decline and a large basal scar was observed indicative of infection by the fungal pathogen *Armillaria luteobubalina* (Australian Honey Fungus). This possibly spread from a dead adjacent tree via root-to-root contact.



Figure 12: HOLE 8: One (1) *E. gomphocephala* to be cleared; 2 stems DBH = 830mm, 680mm. Estimated height = 17m.

3.4.5 Hole 9

Hole 9 was shaded primarily by three *E. gomphocephala* to the north-west and north-east. However, removal of three trees increased solar radiation sufficiently to maintain green condition coupled with intensive greens management.



Figure 13: HOLE 9: Number 1 of 3 *E. gomphocephala* to be cleared; DBH = 1100mm. Estimated height = 20m. Suitable habitat hollows were identified on this tree.



Figure 14: HOLE 9: Number two of 3 *E. gomphocephala* to be cleared; DBH = 1050mm. Estimated height = 19m. This tree had suitable habitat hollows.



Figure 15: HOLE 9: Number three of 3 *E. gomphocephala* to be cleared in centre of group; 2 stems DBH = 800mm, 1150mm. Estimated height = 18m. This tree contained suitable habitat hollows.

3.4.6 Hole 11

Scenario 1 at Hole 11 requires the removal of 2 planted *E. camaldulensis* and one large *E. gomphocephala* to the north of the green. This increased direct sun hours to 7 hours across the playing green.



Figure 16: HOLE 11: One (1) of *E. gomphocephala* to be cleared DBH = 890mm. Estimated height = 18m.



Figure 17: HOLE 11: A *E. camaldulensis* to be cleared DBH = 110mm. Estimated height = 11m.

3.4.7 Hole 14

A group including one large *C. calophylla* (marri) and three *E. marginata*. Removal of the 3 endemic trees improved solar radiation exposure in winter to > 4 hours.



Figure 18: HOLE 14: One *C. calophylla* to be cleared DBH = 750mm. Estimated height = 27m.



Figure 19: HOLE 14: Three *E. marginata* to be cleared DBH = 455mm, 740mm, 570mm. Estimated height = 22m, 24m, 22m.

3.4.8 Hole 17

Shade cast modelling identified that one group of 2 and one group of 3 *C. calophylla* need to be cleared. This increased playing green solar radiation exposure during winter to > 4 hours.



Figure 20: HOLE 11: Two (2) *C. calophylla* to be cleared DBH = 490mm, 770mm. Estimated height = 27m, 27m.



Figure 21: HOLE 11: Three (3) closest *C. calophylla* to be cleared DBH = 280mm, 700mm, 590mm. Estimated height = 19m, 24m, 24m.

3.4.9 Summary of tree clearing

To maintain the condition of greens permission to remove 25 endemic native, 3 exotic native and one dead banksia is being sort. Species requested to be cleared are:

- *E. gomphocephala* (tuart) = 11 trees
- *C. calophyla* (marri) = 11 trees
- *E. marginata* (jarrah) = 3 trees
- *C. citriodora* (lemon scented gum) = 1 tree
- *E. camaldulensis* (rive red-gum) = 2 trees
- *Dead B. grandis* = 1 tree.

Clearing will take place progressively over the period March 2018 to April 2019.

3.5 Commitments

Any residual risk of environmental due to removal of these trees will be addressed by the following commitments. The applicant will:

- Only clear trees once a suitably qualified and experienced wildlife ecologist has confirmed native fauna are not using the trees proposed for clearing. This survey will occur within 24 hours of clearing of each tree. If native fauna are identified, individual tree clearing will be postponed until the tree is vacated.
- Progressively clear the 25 endemic trees, 3 exotic native and one dead tree over 9 months from March 2018 to December 2018 and will have an experienced wildlife ecologist on-site experienced in handling native fauna as each tree is cleared.
- In 2018-19 re-plant within the Country Club grounds **90 endemic trees**; 40 tuart, 10 jarrah and 40 marri trees. Trees will be planted within remnant vegetation that is suitable for enhancement and around the perimeter of the Country Club. All trees will be monitored for survival and health and planted trees not successfully established will be replanted the following autumn.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds over the next 10 years.

4 Assessment Against the Ten Clearing Principals

Based on the need to maintain the international standard of the facilities at Lake Karrinyup Country Club and informed by these background studies a Vegetation Clearing Area Permit for the removal of 25 endemic native trees (11 tuart, 3 jarrah and 11 marri trees), three non-endemic Australian native trees and 1 dead bull banksia is requested. This report assesses the likely impact of this clearing against the ten clearing principals under Part V Division 2 of the *Western Australian Environmental Protection Act 1986* (EP Act). The assessment below briefly outlines how the extent of tree clearing was avoided or reduced through additional studies and commitments being made to mitigate and enhance the condition of native vegetation at the Country Club against the loss of these trees.

10 Clearing Principals

Principle (a) – Native vegetation should not be cleared if it comprises a high level of biological diversity.

Not at Variance with Principal (a).

Clearing is taking place on the Swan Coastal Plain 14 km north north-west of Perth. Clearing is of **25** endemic trees; **11** *E. gomphocephala*, **3** *E. marginata* and **11** *C. calophylla*. In addition, 3 non-endemic natives and one dead banksia will be cleared; **1** *C. citriodora* and **2** *E. camaldulensis* and **1** dead *B. grandis*. The combined number of endemic, non-endemic and dead trees requested to be cleared is 29 trees with a total area of 0.3764 ha.

The applicant understand the need to protect and enhance tuart forests in particular and have committed to replant 40 tuart, 10 jarrah and 40 marri trees within the grounds of the Country Club by December 2018.

Principle (b) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.

At Variance with Principal (b); *Not At Variance with Principal (b) achieved through avoidance and mitigation of residual risks outlined below.*

Field studies and regular observation by staff and members have confirmed the presence and use of the Country Club by protected species (under *Wildlife Conservation Act 1950 (Biodiversity Conservation Act 2016 – regulations pending)* and *Environment and Biodiversity Conservation Act 1999*). These are Carnaby's cockatoo (*Calyptorhynchus latirostris*) and red-tailed black cockatoo (*C. banksia*). Approval is being sort for the clearing of 25 endemic trees that are vegetation forming part of significant habitat for these species. The scale of impact of removal of these endemic habitat trees is:

- 74 endemic trees were found to be causing detrimental impacts to the Championship Course. Modelling and adaption of greens management will mean 25 trees will be cleared, avoiding the loss of 49 trees (66% of impacting trees will be avoided and conserved).
- **0.3577** ha of endemic trees will be cleared. The Country Club grounds contain 38.4 ha of tree cover. The loss will be 0.93% in area of habitat within the grounds and risk of direct impact to protected fauna is low.
- 25 endemic trees of approximately 20, 000 trees within the 104 ha of the Country Club will be cleared. The loss will be <0.2% of trees within the Country Club and the risk of direct impact to protected fauna is low.
- 25 trees of which 6 were very large trees (dbh >800mm) that have been confirmed to contain hollows suitable for native fauna. Field survey and observations by staff have not identified use of the hollows by endemic native fauna. One tree was occupied by introduced (pest) rainbow lorikeets. The risk of direct impact to protected native fauna is low, **but the consequences of an impact if it were to occur is high.**

The residual risk of impact to these protected species by the removal of these trees will be addressed by the following commitments. The applicant will:

- Only clear trees once a suitably qualified and experienced wildlife ecologist has confirmed native fauna are not using the trees proposed for clearing. This survey will occur within 24 hours of clearing of each tree.
- Progressively clear the 25 trees over 12 months from March 2018 to April 2019 and will have an experienced wildlife ecologist on-site as each tree is cleared.
- Re-plant within the Country Club grounds 90 endemic trees; 40 tuart, 10 jarrah and 40 marri trees.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds over 10 years.

Principle (c) – Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.

Not at Variance with Principal (c).

Clearing targets 25 individual endemic trees 3 planted exotic natives and one dead tree within the 104 ha of the Country Club. No rare flora have been identified within the grounds.

Principle (d) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community.

Not at Variance with Principal (d).

Clearing will be 11 tuart, 3 jarrah and 11 marri trees which do not comprise or maintain a Threatened Ecological Community. However, the applicant is aware of the public and expert comment invited by the commonwealth Threatened Species Scientific Committee (TSSC) who are assessing the conservation threat to tuart forests and woodlands of Western Australia. The applicant is committed to the replacement of the lost trees through planting of 40 tuart trees in 2018. Twenty-two of these replanted trees will replace the 11 cleared tuart trees, but their position will be 'offset' 20 metres away from the playing greens to reduce the risk of shade impacts that could occur as they grow. The remaining 18 tuart trees will be planted on the perimeter of the Country Club and within remnant native vegetation that is suitable for enhancement. The applicant will:

- Re-plant within the Country Club grounds 90 endemic trees; 40 tuart 10 jarrah and 40 marri trees.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds over 10 years.

Principle (e) – Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

At Variance with Principal (e); *Not At Variance with Principal (e)* achieved through avoidance and mitigation of residual risks outlined below.

The two tree species to be cleared are species that comprise part of significant remnant native vegetation that has been identified in *Draft Strategic Conservation Plan for the Perth to Peel Region* as a priority for the maintenance of environmental values in the region. The Regional scale of impact of removal of these remnant vegetation trees is:

- 25 endemic trees comprising 0.3577 ha of remnant vegetation that contributes to connectivity of regional protected areas to the west, south and north of the Country Club. The Western Australian government *Draft Strategic Conservation Plan for the Perth to Peel Region* is committed to avoiding loss to over 15,700 hectares of Carnaby's cockatoo Swan Coastal Plain feeding habitat. The clearing of these 25 endemic trees represents <0.0002% of this regional commitment and is a low risk of impact to Principal (e).

The very low residual risk of impact to significant remnant native vegetation by the removal of these 25 endemic trees will be mitigated by the following commitments. The applicant aims to enhance regional remnant native vegetation by:

- Initially re-planting within the Country Club grounds 90 endemic trees in 2018-19; 40 tuart, 10 jarrah and 40 marri trees as an immediate response to the clearing of 11 tuart, 3 jarrah and 11 marri trees.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds over the next 10 years.

Principle (f) – Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.

Not At Variance with Principal (f)

Lake Karrinyup and associated drainage lines occur within the Country Club. However, none of the trees to be cleared is growing in or associated with the drainage lines or Lake Karrinyup.

Principle (g) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

Not At Variance with Principal (g)

The removal of these 25 trees is a very low risk of appreciable land degradation. The commitment to replanting 90 endemic native trees will mitigate any very low residual risk.

Principle (h) – Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

Not At Variance with Principal (h)

The removal of 25 endemic trees occurs within a site that provides east-west connectivity between Trigg Bushland Reserve, Star Swamp Reserve, Carine Regional Open Space and Lake Gwelup Reserve. Planning for the clearing of these trees has been undertaken to avoid, reduce and mitigate any potential environmental impacts. The clearing of 25 trees is 0.93% of the 38.4 ha of remnant forest and woodlands that make up this area of connectivity. The risk of direct impact to connectivity between regional protected areas is low.

The applicant understands the need to protect and enhance remnant forests and woodlands to support connectivity between the Country Club and regional protected areas. To mitigate against the very low risk of residual impact to connectivity the applicant will:

- Re-plant within the Country Club grounds 90 endemic trees; 40 tuart, 10 jarrah and 40 marri trees to immediately replace the loss of 11 tuart, 3 jarrah and 11 marri trees.
- In 2018 commence development of the *Lake Karrinyup Country Club Strategic Native Vegetation Conservation and Management Plan* that will guide the conservation and enhancement of health of native trees, age classes of the tuart, marri, jarrah and flooded gum forests and enhance remnant vegetation within the 104ha grounds. Successful implementation of the plan is very likely to maintain or lead to improved connectivity between regionally significant areas of native vegetation.

Principle (i) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.

Not At Variance with Principal (i)

The risk of impact to the hydrology and hydrogeology of the region is very low. However, the Country Club monitors the quality of groundwater and is committed to enhancing the condition of native vegetation within the Country Club through re-planting 90 endemic native trees and development of management plans to enhance the condition of native vegetation within the 104ha grounds.

Principle (j) – Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.

Not At Variance with Principal (j)

Twenty-five endemic trees, 3 introduced and 1 dead tree are proposed to be cleared. The total area of clearing of endemic and exotic native trees is 0.98% of the treed areas of the Country Club and is at very low risk of causing or exacerbating the incidence of flooding. Any very low residual risk will be mitigated through re-planting 90 endemic native trees and development of management plans to enhance the condition of native vegetation within the 104ha grounds.

5 References

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Appendix A – Spatial locations of trees to be cleared.

Tree number	Playing green (Hole number)	Species	dbh/mm	x coord. centroid	y coord. centroid
1	1	<i>Eucalyptus gomphocephala</i>	1740	384860.7336	6473992.272
2	5	<i>Corymbia calophylla</i>	400	385159.4386	6473427.543
3	5	<i>Corymbia calophylla</i>	350	385159.4386	6473427.543
4	5	<i>Corymbia calophylla</i>	140	385159.4386	6473427.543
5	5	<i>Corymbia calophylla</i>	410	385159.4386	6473427.543
6	5	<i>Corymbia calophylla</i>	880	385159.4386	6473427.543
7	5	<i>Eucalyptus gomphocephala</i>	720	385109.8734	6473442.487
8	5	<i>Eucalyptus gomphocephala</i>	730	385109.8734	6473442.487
9	5	<i>Eucalyptus gomphocephala</i>	990	385109.8734	6473442.487
10	5	DEAD <i>Banksia grandis</i>	190		
11	6	<i>Eucalyptus gomphocephala</i>	1060	384649.6	6473351.856
12	8	<i>Eucalyptus gomphocephala</i>	830	385095.4853	6473845.283
13	8	<i>Eucalyptus gomphocephala</i>	830, 680	385095.4853	6473845.283
14	8	<i>Corymbia citriodora</i>	600	385062.3217	6473849.62
15	9	<i>Eucalyptus gomphocephala</i>	1100	385006.1164	6474188.707
16	9	<i>Eucalyptus gomphocephala</i>	1050	385006.1164	6474188.707
17	9	<i>Eucalyptus gomphocephala</i>	800, 1150	385006.1164	6474188.707
18	11	<i>Eucalyptus camaldulensis</i>	240	385258.4807	6474300.032
19	11	<i>Eucalyptus camaldulensis</i>	110	385258.4807	6474300.032
20	11	<i>Eucalyptus gomphocephala</i>	890	385242.4851	6474292.035
21	14	<i>Eucalyptus marginata</i>	455	385415.9087	6474257.043
22	14	<i>Eucalyptus marginata</i>	740	385415.9087	6474257.043
23	14	<i>Eucalyptus marginata</i>	570	385415.9087	6474257.043
24	14	<i>Corymbia calophylla</i>	750	385431.4938	6474236.734
25	17	<i>Corymbia calophylla</i>	490	385511.8827	6474476.299
26	17	<i>Corymbia calophylla</i>	770	385511.8827	6474476.299
27	17	<i>Corymbia calophylla</i>	280	385511.8827	6474476.299
28	17	<i>Corymbia calophylla</i>	700	385511.8827	6474476.299
29	17	<i>Corymbia calophylla</i>	590	385511.8827	6474476.299