OVERVIEW OF ASSESSMENTS OF THE THREATENED ORCHID

Caladenia huegelii

AT JANDAKOT AIRPORT, s 45

2011 – 2015

Prepared for

Jandakot Airport Holdings Pty Ltd

Prepared by

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1. SUMMARY

Mattiske Consulting Pty Ltd was commissioned by Jandakot Airport Holdings Pty Ltd to monitor existing, and search for new occurrences of the threatened orchid *Caladenia huegelii* (T) within s 45 established s 45 in s 45 at Jandakot Airport and to review the results over the entirety of the monitoring program since s 45 establishment in 2011. *Caladenia huegelii* (T) is endemic to the region between Perth to Busselton. It is known from only 71 populations in mixed *Eucalyptus marginata* and *Banksia attenuata* woodlands in deep grey-white sands. This species is mainly restricted to localized remnant areas of *Eucalyptus marginata* and *Banksia attenuata* woodlands on the Swan Coastal Plain.

Caladenia huegelii (T) is a threatened flora species pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act 1950* and as listed by the Department of Parks and Wildlife. *Caladenia huegelii* (T) is also listed as threatened flora pursuant to sections s178, s181 and s183 of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* and as listed by the Department of the Environment.

Surveys for *Caladenia huegelii* have been at Jandakot Airport over fourteen years (2001 to 2015). These include surveys by Mattiske Consulting in 2001, 2006, 2007, 2008 and 2009 (Mattiske 2001, 2006, 2007, 2010a), the then Department of Conservation and Land Management (CALM) in 2005 and Cardno BSD consultants in 2005 (Cardno BSD 2005). The majority of occurrences were found in s 45 Three s 45 were established in s 45 to undertake more targeted assessments. Despite undertaking thorough targeted searches insufficient plant numbers have been located in s 45 or other areas to enable the establishment of additional s 45

A total population of 85 *Caladenia huegelii* (T) individuals are known to exist within the three established s 45 in s 45 at Jandakot Airport, having been recorded between 2011 and 2015, with a subset of these emerging each year. The latter work was undertaken during spring months when the maximum number of plants were flowering. Fifty-five ndividuals recorded during the 2015 survey, emergence was lower than previous years (64.7% of the population compared to 74.1%, 76.5%, 80.0% and 29%, respectively for 2014, 2013, 2012 and 2011). This decline is possibly due to detrimental impacts from grazing in previous years and/or environmental conditions surrounding the 2015 survey; the months of June and July 2015 received noticeably lower amounts of rainfall than the long term averages for each month. However, it is difficult to form any conclusions about the decline in emergence without longer term monitoring of the population. The orchids that emerged during the 2015 survey were not always consistent with those that emerged in 2014, with individuals recorded that had not emerged in one (JA001, JA026, JA099, JA143, JA146, JA303), two (JA005, JA106) or three (JA015) years. On average orchids emerged 3 times over the 4 years the s 45 were monitored.

Findings from Mattiske Consulting Pty Ltd surveys (2012 – 2015) indicate that 32-41% of individuals in a population may flower between August and September (with 46-56% of emerged individuals flowering in any given year). In 2011 only 16.4% of the 85 plants flowered, but at that stage only 29% of the population had been located and tagged. However these percentages are reduced when grazing is considered. Flowering is dependent on a range of environmental factors such as rainfall, temperature, competition, and grazing. Overall, little research has been conducted on flower emergence rates. Therefore, long-term monitoring of the s 45 orchid s 45 would provide valuable quantitative biological information for future recovery actions.

Herbivory was identified as a potential future management issue, with over 40% of the plants experiencing herbivory. In recent years observations indicate that native fauna species are grazing on this species. s 45 . A lower proportion of herbivory was recorded after the s 45 with majority of orchids experiencing no form of herbivory. These results provide good evidence that s 45 may aid the survival and health of orchids. One issue highlighted across this monitoring program is the question as to what species is/are predominantly grazing on the population. If grazing is predominantly by rabbits, management of this species is considered to be relatively straight forward as Jandakot Airport currently manages these in their Feral Management Plan. However if the primary grazers are protected native fauna (under the *Environment Protection and Biodiversity Conservation Act 1999* conditions), such as Quendas and Wallabies, the issue becomes a conflicting dilemma that would require impacting one protected species for the benefit of another. s 45

After analysing the results of the Spring surveys of *Caladenia huegelii* (T) in three s 45 within s 45 from 2011 to 2015, the following actions are recommended:

- restrict access to the conservation precincts to enable protection of the Banksia woodlands near the established populations;
- as part of a wider research program on *Caladenia* species, review the potential impact of controlled burning on *Caladenia huegelii* prior to undertaking any fuel reduction burning in the *Banksia* woodlands;
- integrate native species into rehabilitation activities that support the pollinating wasp, following consideration of Dixon (2015) research findings;
- facilitate research and monitoring of the known locations with other researchers of orchids to better understand emergence, local mortality, recruitment, flower development, pollination, and seed production patterns; and
- investigate grazing and if warranted implement appropriate management strategies to reduce potential impacts.

It is unlikely that the population of *Caladenia huegelii* (T) within s 45 at Jandakot Airport, or any other location in the bushlands of urban Perth, will be able to survive into the future without management and human intervention (i.e. hand pollination) as the natural pollinator (thynnid wasp *Macrothynnus insignis*) is no longer present in bushland remnants in urban Perth (as expressed by Kings Park Botanic Garden and Parks Authority). Incidental pollination by species other than the thynnid wasp is possible, however it would not be at a significant rate. Therefore there is a need to negotiate options for either ceasing monitoring and assume that the decline will continue, at least until such time as the responsible authorities are able to re-introduce the responsible pollinator – which is potentially achievable given the longevity of *Caladenia huegelii* (T), or negotiate options for a modified monitoring programme with appropriate regulators. If the population is to be naturally sustainable, research in to the pollinator and re-introduction of the pollinator into the local area will be required. The population may prove more effective as a source of seed for propagation and translocation of the species, and if required, this would be by relevant authorities/researches, not Jandakot Airport Holdings.

2. INTRODUCTION

Mattiske Consulting Pty Ltd was commissioned in August 2015 by Jandakot Airport Holdings Pty Ltd to re-monitor s 45 pre-established s 45 within vegetation supporting *Caladenia huegelii* (T) plants within s 45 at Jandakot Airport and to review and re-assess all results since s 45 were established in 2011.

Caladenia huegelii (T) is a threatened flora species pursuant to subsection (2) of section 23F of the *Wildlife Conservation Act 1950* and as listed by the Department of Parks and Wildlife (2016b). *Caladenia huegelii* (T) is also listed as an endangered species pursuant to section 179 of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* and as listed by the Department of the Environment (2016). No other threatened or priority flora species have been located within the s 45 surveyed s 45 at s 45 between 2011 and 2015.

In 2005, a formal survey by the Department of Parks and Wildlife (formerly the Department of Environment and Conservation) recorded a population of 169 individuals of *Caladenia huegelii* (T) (Department of Environment and Conservation 2009). Since 2005, the Department of Parks and Wildlife, Mattiske Consulting Pty Ltd, and the Kings Park Botanic Garden and Parks Authority have been involved in surveys to monitor factors relating to the population, including plant numbers, area of occupancy, flower emergence, recruitment, seed production, and herbivory (Mattiske Consulting Pty Ltd 2010).

Under the *Environment Protection and Biodiversity Conservation Act 1999* referral 2009/4796 (Jandakot Airport Expansion, Commercial Development and Clearance of Native Vegetation, Western Australia) approval was given with conditions by the then Minister for Environment, Water, Heritage and Arts in March 2010. This approval allows for the clearing of native vegetation within Jandakot Airport Precincts to enable aviation and commercial development as detailed in Master Plan 2009 (and the subsequent Master Plan 2014). The impacts considered during the *Environment Protection and Biodiversity Conservation Act 1999* referral process included *Caladenia huegelii* (T) habitat and the need to translocate approximately 40 plants that were believed to be present within the development area. The conditions of the approval include the requirement to develop and implement various management plans that require the approval of the Minister, including a Conservation Management Plan. The Conservation Management Plan was required to include orchid management, including translocation procedures, funding arrangements for the Kings Park Botanic Garden and Parks Authority Rare Orchid Integrated Research Program, and monitoring and survey methods. The Conservation Management Plan therefore committed to undertaking an annual s 45 monitoring program until such time as the Kings Park Botanic Garden and Parks Authority research concluded.

In 2011, the Kings Park Botanic Garden and Parks Authority established s 45 at Jandakot Airport within vegetation supporting *Caladenia huegelii* (T). A total of 35 orchids were recorded by the Kings Park Botanic Garden and Parks Authority at this time. Mattiske Consulting Pty Ltd was appointed to re-monitor the orchids and search for new *Caladenia huegelii* (T) individuals within these s 45 during spring from 2012 to 2015. s 45

Following results of the 2012 s 45 monitoring, which saw low rates of pollination, Kingsley Dixon from the Botanic Gardens and Parks Authority advised that their research confirmed the absence of the pollinator wasp across Perth's urban bushland, and as a result, pollination (with the exception of very occasional and non-targeted pollination by non-species specific pollinators) was unlikely to be observed in the s 45 monitoring, and recommended that Jandakot Airport Holdings ceased recording pollination success in future monitoring events and assume natural pollination (at least by the pollinator wasp) to be absent (J. Wann pers. comm. 2016).

A selection of orchids within s 45 were hand pollinated in spring 2014 using an already proven Botanic Gardens and Parks Authority method in order to obtain seed for the Botanic Gardens and Parks Authority to store within their seed bank for future research and/or translocation trials. However this was not a component of the s 45 monitoring program.

2.1 Location and Scope of Proposal

Jandakot Airport is located approximately 16 km south of Perth, off Karel Avenue from Roe Highway. The s 45 established to monitor the *Caladenia huegelii* (T) population at Jandakot Airport are located within s 45 Attempts were made in 2011 by the Kings Park Botanic Garden and Parks Authority and subsequently by Mattiske Consulting Pty Ltd in 2012 to establish a s 45 however *Caladenia huegelii* (T) was not found in suitable numbers/densities to enable this to occur. The current report provides a consolidated re-assessment and summary of results from s 45 monitoring over the last five years since s 45 establishment in 2011.

2.2 *Caladenia huegelii* (T)

Caladenia huegelii (T) is a tuberous, perennial herb growing up to 60 cm high (Plate 1). It is dependent on a single species of mycorrhizal fungi to provide fixed carbon and mineral nutrients for germination and annual growth (Cameron *et al*. 2006; Swarts *et al.* 2010). It flowers from September to October and prefers grey or brown sand, or clay loam soils (Department of Parks and Wildlife 2016d). There are 41 specimens of *Caladenia huegelii* (T) held at the Western Australian Herbarium and 130 records of the species listed by the Department of Parks and Wildlife databases (Department of Parks and Wildlife 2007- ; 2016d).

Plate 1: *Caladenia huegelii* (T) at Jandakot Airport s 45 A: Q2-20 JA136 (Photo B. Ellery 2012)

2.3 Conservation Status of *Caladenia huegelii* (T)

Flora within Western Australia (under State legislation) that is considered to be under threat may be classified as either threatened or priority flora. Threatened flora (declared rare flora – extant) are described as taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such under Schedule 1 of the *Wildlife Conservation Act 1950* (Appendix A1).

Threatened flora are further ranked by the Department of Parks and Wildlife according to their level of threat using the World Conservation Union (IUCN) Red List Criteria as one of three categories:

- Critically Endangered (CR) – considered to be facing an extremely high risk of extinction in the wild;
- Endangered (EN) – considered to be facing a very high risk of extinction in the wild; and
- Vulnerable (VU) – considered to be facing a high risk of extinction in the wild.

Currently under this State Act, *Caladenia huegelii* (T) is listed as a threatened flora species, and is further listed as Endangered by the Department of Parks and Wildlife (2016b). The Department of Parks and dlife, in conjunction with community groups and the public, develop and implement recovery plans and interim recovery plans for species that are listed as threatened.

Furthermore, threatened flora may be listed by the Commonwealth Minister for the Environment under Section 178 of the *Environment Protection and Biodiversity Conservation Act 1999* in any one of the following categories:

- extinct;
- extinct in the wild;
- critically endangered;
- endangered;
- vulnerable; and
- conservation dependent.

Currently under this Commonwealth Act, *Caladenia huegelii* (T) is listed as an Endangered species, which is described as taxa which is not critically endangered and is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with prescribed criteria Appendix A2).

Jandakot Airport Holdings is situated on Commonwealth land as opposed to State land, and as such, previous developments have been assessed under Commonwealth legislation, however significance at the State level is taken into account by the Commonwealth in such cases.

2.4 Records of *Caladenia huegelii* (T)

Caladenia huegelii (T) has previously been recorded by the Department of Environment and Conservation (2009), Mattiske Consulting Pty Ltd (2010; 2012; 2013; and 2014), and the Kings Park Botanic Garden and Parks Authority as occurring at a number of different locations within Jandakot Airport (Table 1). The Department of Environment and Conservation (2009) has also recorded *Caladenia huegelii* (T) as occurring s 45 in some areas of Jandakot (Department of Environment and Conservation 2009).

Caladenia huegelii (T) was first discovered at Jandakot Airport in 2003 and subsequent surveys have located up to 169 individuals (Department of Environment and Conservation 2009). The population at Jandakot Airport is listed as population number 56 and is comprised of 8 subpopulations (Department of Environment and Conservation 2009). Jandakot Airport Holdings is currently responsible for managing this population. As required under the Jandakot Airport Conservation Management Plan, Jandakot Airport maintains a *Caladenia huegelii* (T) database. In 2012 and 2013 attempts to locate the plants identified in previous surveys (of which only a proportion had been previously identified with stakes or pin tags) were made using known GPS coordinates. In addition, searches were undertaken for new individuals that had not been recorded in previous surveys. Following the completion of spring flowering in 2013, all data gathered during the previous two years, including plants located s 45 , was used to update the database and compile new *Caladenia huegelii* (T) location mapping at Jandakot Airport. There were 351 confirmed and suspected (i.e. yet to be confirmed via photographic record of the flowers of *Caladenia huegelii* (T) individuals located within s 45). A single suspected plant within s 45 flowered in 2013 and has been confirmed as *Caladenia paludosa*. Kings Park Botanic Garden and Parks Authority assisted Jandakot Airport staff in confirming species identification from the photographic record.

Table 1: Number of *Caladenia huegelii* (T) individuals recorded in previous surveys at Jandakot Airport between 2011 and 2015

Surveyors	Year	Survey Site	Individuals Recorded
Kings Park Botanic Gardens and Parks Authority	2011	s 45	35
Mattiske Consulting Pty Ltd	2012	s 45	68
Mattiske Consulting Pty Ltd	2013	s 45	66
Mattiske Consulting Pty Ltd	2014	s 45	63

2.5 Regional Perspective

Caladenia huegelii (T) is an endemic orchid species restricted to the Southwest Australian Floristic Region (Hopper and Gioia 2004). The species is known from 71 populations from just north of Perth to Busselton in the south. *Caladenia huegelii* (T) has been recorded growing in areas of mixed woodland of *Eucalyptus marginata*, *Banksia attenuata*, *Banksia ilicifolia*, and *Banksia menziesii* with scattered *Allocasuarina fraseriana* and *Corymbia calophylla* over dense shrubs of *Stirlingia latifolia*, *Hypocalymma robustum*, *Hibbertia hypericoides*, *Hibbertia vaginata*, *Xanthorrhoea preissii*, *Adenanthos cuneatus* and *Conostylis* species (Department of Environment and Conservation 2009). The species tends to primarily grow in deep grey-white sand associated with the Bassendean sand-dune system (Department of Environment and Conservation 2009; Swarts *et al*. 2009). The number of *Caladenia huegelii* (T) populations has declined steadily over the last two decades. This decline has been attributed to habitat loss and destruction through urban expansion, encroachment of weeds, and changes in fire frequency (Swarts *et al.* 2009).

2.6 Climate

Beard (1990) described the climate of the survey area to be Mediterranean, with hot dry summers and cool, wet winters. A summary of rainfall received in the two months (July and August) prior to each monitoring survey, along with the long term average for those months and the annual rainfall for each assessment year is presented in Table 2. For more detailed climate data for Jandakot Aero (Station 009172) for the period January 2011 to December 2015, please refer to Appendix B.

Monthly rainfall across the five years of monitoring was highly variable, with the highest rainfall received for July and August occurring in 2014 and 2013 respectively (Table 2). The year in which the study commenced received the highest annual rainfall of 915.6 mm, whilst 2015 received the lowest of 651.2 mm (excluding 2014 due to lack of data) (Table 2).

Table 2: Summary of rainfall (mm) recorded for Jandakot Aero (station 009172) over the duration of the monitoring program
LTA = Long Term Average
^Total excludes amount for May, as this was unavailable on the Bureau of Meteorology (2016) website

Year	July LTA Rainfall (mm)	July Rainfall (mm)	August LTA Rainfall (mm)	August Rainfall (mm)	Annual Rainfall (mm)
2011	173.7	181.0	126.1	136.2	915.6
2012		34.6		100.6	684.4
2013		165.2		194.6	889.0
2014		186.2		109.4	564.8^
2015		137.6		131.6	651.2

S 45

3. OBJECTIVES

The aim of the current survey was to reassess the threatened orchid, *Caladenia huegelii* (T), within the s 45 at Jandakot Airport, as established by the Kings Park Botanic Garden and Parks Authority in 2011, and summarise all findings to date. Specifically, the objectives of the survey were to:

- locate tagged plants within the established s 45 of s 45 Jandakot Airport, and re-tag where necessary;
- search for and tag new individuals of *Caladenia huegelii* (T) within the s 45 established s 45 in s 45 Jandakot Airport;
- record the condition of *Caladenia huegelii* (T) within the s 45 established s 45 in s 45 Jandakot Airport;
- generate an updated database including the GPS location and condition of each orchid located within each s 45 at s 45 Jandakot Airport;
- review s 45 assessments to date;
- provide recommendations on the future monitoring and management of the orchids; and
- prepare a report summarising the findings.

4. METHODS

4.1 Field Survey

The current assessment of *Caladenia huegelii* (T) within s 45 at Jandakot Airport was undertaken by one experienced botanist from Mattiske Consulting Pty Ltd on the 15th September 2015.

On the 15th September, the s 45 were searched for previously recorded *Caladenia huegelii* (T) individuals (Table 3). The locations of previously recorded orchids were recognisable by the s 45. Each s 45 was intensively searched for new individuals that were then s 45 The identity, GPS position, leaf length, flower presence, flower/stalk length, and leaf and flower herbivory were noted for each orchid. Each orchid was also assigned one of three health ratings based on leaf colour, flower condition and herbivory. Orchids were recorded as "healthy" if the plant had green leaves, an intact flower (if present), and little to no evidence of herbivory. "Slightly stressed" orchids had occasional brown spots on the leaves and a medium incidence of leaf or flower herbivory. "Stressed" orchids had brown leaves and/or a very high incidence of herbivory.

Across all surveys between 2011 and 2015 wherever possible the orchid species were identified in the field. Photographs of unknown species were compared with pressed specimens housed at the Western Australian Herbarium and where appropriate, plant taxonomists with specialist skills were consulted. Additionally, in 2013 Ryan Phillips (BGPA) was consulted and confirmed the identification of a number of unidentified individuals using photographs from the Jandakot Airport Photographic Record. Nomenclature of the species recorded is in accordance with the Department of Parks and Wildlife (2016d).

Table 3: Geographic locations of orchid s 45 within s 45 at Jandakot Airport

s 45

4.2 Survey Limitations and Constraints

An assessment of each survey (2012 – 2015) conducted by Mattiske Consulting Pty Ltd was assessed against a range of factors which may have had an impact on the outcomes of each of the four annual surveys (excluding the initial survey by the Kings Park and Botanic Garden and Parks Authority) (Table 4). Based on each assessment, the current and previous surveys have not been subject to constraints which would affect the thoroughness of each survey, and the conclusions which have been formed.

Table 4: Potential flora and vegetation survey limitations for the survey area, 2012 – 2015

Potential Survey Limitation	Impact on Survey	Reason
Sources of information and availability of contextual information (i.e. pre-existing background versus new material).	Not a constraint	Adequate information was able to be accessed from available databases and previous surveys conducted in areas adjacent to and within the survey area.
Scope (i.e. what life forms, etc., were sampled).	Not a constraint	The vascular plant species *Caladenia huegelii* (T) was the focus of the survey. This orchid species was thoroughly surveyed within the project area.
Proportion of flora collected and identified (based on sampling, timing and intensity).	Not a constraint	The three survey areas were thoroughly surveyed by a botanist and a representative of Jandakot Airport Holdings during peak flowering time in September.
Completeness and further work which might be needed (i.e. was the relevant survey area fully surveyed).	Not a constraint	The survey area was thoroughly searched.
Mapping reliability.	Not a constraint	Not applicable in the context of the current survey type.
Timing, weather, season, cycle.	Not a constraint	The survey was conducted during the species' flowering and seeding period (September to October).
Disturbances (fire flood, accidental human intervention, etc.).	Not a constraint	No disturbances were encountered in the survey area.
Intensity (in retrospect, was the intensity adequate).	Not a constraint	The survey intensity is considered to have been thorough.
Resources (i.e. were there adequate resources to complete the survey to the required standard).	Not a constraint	Resources, in terms of time, equipment, support and personnel were adequate to undertake and complete the survey.
Access problems (i.e. ability to access survey area).	Not a constraint	The survey area was easily accessible from pre-existing access tracks. There were no obstacles to surveying the designated area.
Experience levels (e.g. degree of expertise in plant identification to taxon level).	Not a constraint	Appropriate levels of ecological, botanical and taxonomic expertise were available during the project.

4.3 Data Analysis

Data from the 2015 s 45 monitoring was analysed in conjunction with data collected by Kings Park Botanic Garden and Parks Authority from 2011 and from Mattiske Consulting Pty Ltd from 2012, 2013 and 2014 (Mattiske Consulting Pty Ltd 2012; 2013; 2014). Data collected in the initial survey in 2011 and in 2012 vary slightly to that recorded for the following three years. It is important to note that it is possible across each monitoring year that not all individuals that have emerged may be located. Due to inherent factors such as predation by grazing, growth in thick understorey making them difficult to identify (particularly if not in flower) and the fact that not all individuals emerge each year, will have an impact on numbers recorded. Hence when viewing results and comparisons and the differences between monitoring years, these factors should be kept in mind.

5. RESULTS

5.1 Monitoring of *Caladenia huegelii* (T) 2011 – 2015

Across the five monitoring years no other threatened or priority flora species were located within the s 45 s 45 surveyed at s 45 A total of 55 *Caladenia huegelii* (T) individuals were recorded across the s 45 within s 45 at Jandakot Airport during the 2015 assessment on the basis of leaf presence (Appendix D). This is the lowest recorded since the initial assessment which recorded 25 individuals, however the number of orchids recorded as emerged in 2015 is still comparable with the results of the previous three years (Appendix D). Of the 25 plants monitored each year for five years including 2011: 8 (32%) emerged each year; 10 (40%) emerged for four of the past five years; 3 (12%) emerged for three of the past five years; 2 (8%) emerged for two of the past five years; and 2 (8%) emerged for one of the past five years and hasn't been observed since it was located in 2011 (Appendix D).

During 2015 s 45 contained 29 orchids, s 45 contained 13 orchids, and s 45 contained 13 orchids (Table 5). The number of orchids emerged has been highly variable over the course of the monitoring program, however there appears to be a slow decline in the number of emerged orchids each year (Table 5). Of the 55 orchids recorded in the 2015 assessment, one plant in s 45 represented a new individual that had not been recorded since s 45 establishment in 2011. Thirty tagged orchids from a total of 85 recorded historically within the s 45 s 45 could not be located during the 2015 survey: 14 records from s 45, 10 records from s 45 and 6 records from s 45. Emergence was lower than previous years (64.7% compared to 74.1%, 76.5% and 80.0%, respectively for 2014, 2013 and 2012), however the orchids that emerged during the 2015 survey were not always consistent with those that emerged in 2014, with individuals recorded that had not emerged in one (JA001, JA026, JA099, JA143, JA146, JA303), two (JA005, JA106) or three (JA015) years (Appendix F). On average orchids emerged 3 times over the 4 years the s 45 were monitored (Appendix F).

The presence of a flower on individuals was highly variable across the monitoring program, ranging from 14 recorded during the initial assessment, up to 35 during the 2014 assessment, with a slight reduction during the 2015 assessment to 27 (Table 5; Appendix E). Flowers were present on 58.62% of individuals in s 45 15.38% in s 45 and 23.1% in s 45 that emerged during the 2015 survey (Table 5). The flowering rates in 2015 in both s 45 and s 45 were the lowest since the establishment of the s 45 however s 45 exhibited a higher flowering rate (Table 5). Flowering presence was highly variable, with 2015, 2012 and 2011 seeing the highest flower presence for s 45 s 45 (Table 5). Throughout the duration of the study, between 2012 and 2015, 32-41% of individuals in the population flowered, with 46-56% of emerged flowering in any given year. However, these percentages were reduced when grazing is taken into account (Appendix F). Comparatively, during the initial survey in 2011, only 16.4% of the 85 plants flowered. On average orchids flowered once over the 4 years the s 45 were monitored, or closer to 1.5 times over the 4 years if flowers that were grazed are included (Appendix F). Considerable variation was observed with respect to emergence and flowering within the population, with some individuals not recorded as flowering throughout the duration of the study, despite a leaf being present each year, and some orchids flowering every year (Appendix F).

Of the 55 orchids recorded within the three s 45 in s 45 Jandakot Airport, 80.0% of orchids were recorded in a healthy condition (H), 10.9% were in a slightly stressed condition (SS), and 9.1% were in a stressed condition (S) (Table 5). The health of the orchids appears to be stable over the duration of the study, with majority of orchids consistently recorded as healthy (Table 5). Of all the orchids within the s 45, 58.2% had not been grazed, with 89.7% of individuals s 45 s 45 remaining ungrazed, 7.7% in s 45 and 38.5% in s 45 (Table 5). Grazing pressure appears to be stable over the years, with the exception of s 45 s 45 the 2012 and 2013 monitoring periods (Table 5).

Table 5: Count of flower presence, leaf condition and herbivory of the orchids within each s 45 within s 45 at Jandakot Airport, 2011-2015

Note: The number of individuals with flowers present excludes those in which the flower had been completely grazed and where the flowering stalk still remained, with the number of plants where the flower was completely grazed shown in brackets. Not all data was recorded during 2011.

A summary of the percentage of emerged plants that produced flowers and those that produced flowers s 45 is presented in Table 6. The current survey recorded a combined total of 49.09% of emerged plants producing flowers, this was the third highest since the initial assessment, which recorded 56.00%.

Table 6: Percentage (%) of emerged plants producing flowers and those that flowered and s 45, 2011 – 2015

	2011	2012	2013	2014	2015
Percentage (%) of emerged plants that produced flowers					
s 45	50.00	40.00	47.06	66.67	58.62
s 45	42.86	57.89	35.71	36.84	38.46
s 45	75.00	46.67	47.06	57.14	38.46
s 45	56.00	46.38	44.62	55.56	49.09
s 45					
s 45	20.00	34.29	44.12	53.33	58.62
s 45	42.86	42.11	14.29	21.05	15.38
s 45	62.50	40.00	35.29	28.57	23.08
s 45	40.00	37.68	35.38	38.10	40.00

The average length of the flowering stalk was 35.0 cm and the average length of the leaf was 11.7 cm during the 2015 monitoring period, with s 45 having the highest average length of both leaf and flower stalk length (Table 7). There does not appear to be any noticeable trends in leaf and flower length over time (Table 7).

Table 7: Average leaf and stalk length (± standard error) of orchids within each s 45 within s 45 at Jandakot Airport, 2012 – 2015

s 45		s 45	Total
Leaf length (cm)	2015		11.7 ± 0.8
	2014		13.6 ± 0.7
	2013		12.8 ± 0.8
	2012		10.4 ± 0.5
Stalk length (cm)	2015		35.0 ± 1.9
	2014		32.5 ± 2.5
	2013		32.7 ± 3.2
	2012		32.2 ± 1.6

The total number of plants located over the duration of the monitoring program along with the cumulative percentage of total plants located is presented in Table 8. From this it can be seen that over the five year period, each successive survey recorded an increasing number of plants, reaching a maximum during the fifth survey in 2015 with 85 total plants across the s 45 surveyed. The initial survey during 2011 recorded 25 total plants, which was followed by a noticeable increase the following year during 2012, at a total of 74 plants.

Table 8: Summary of plants located within s 45 over the duration of the monitoring program
^ Total after five years

Total Number of Plants Located over the Monitoring Program						
	2011	2012	2013	2014	2015	TOTAL ^
s 45						

6. DISCUSSION

The targeted *Caladenia huegelii* (T) search within three s 45 within s 45 at Jandakot Airport over the duration of the five year monitoring period highlights many important factors relating to the population including plant numbers, flower emergence and herbivory. Over the years of the study, since the s 45 were established, between 65% and 81% of all individuals within the s 45 emerged, excluding 2011. During 2011 only 29% of plants were seen to emerge, however factors such as it being the initial survey and increased herbivory impacts due to the survey being conducted later in the season than the other surveys (October as opposed to September) may influence the results. Fifty-five of the orchids emerged within the s 45 in s 45 in 2015. Compared to all previous survey years, this represented the lowest rate of emergence recorded to date. This is possibly due to detrimental impacts from grazing in previous years or environmental conditions surrounding the 2015 survey. The months of June and July 2015 received noticeably lower amounts of rainfall then the long term averages for each month. These drier conditions leading up to the 2015 survey may have influenced the number of plants that emerged. However, only limited conclusions can be drawn from the data obtained during the s 45 monitoring program.

A high incidence of herbivory was recorded during the survey in s 45. Grazing has been observed as a threatening process for other *Caladenia huegelii* (T) populations. For example, kangaroos and caterpillars have been observed predating on various parts of the plant including leaves, buds, flowers, and developing seed capsules in "Population 6", which is a *Caladenia huegelii* (T) population adjacent to the survey area (Department of Environment and Conservation 2009). Wallabies, kangaroos, Quendas and rabbits have been observed at s 45 and may be contributing to the grazing damage. Grazing of leaves and flowers can negatively affect long-term survival by reducing growth and subsequently hindering the reproductive and photosynthetic capacity of the orchids (Department of Environment and Conservation 2009). However Batty *et al.* (2009, in Department of Environment and Conservation 2009) states that recruitment of *Caladenia huegelii* (T) is naturally low at <0.05%, which is balanced by generally long-lived individuals. Additionally, in most instances of herbivory observed on plants within the s 45 plants appear to only be impacted on their above-ground structures, not the roots and underground tubers. Hence grazing impacts may be more likely to be a gradual long-term effect, and the orchids may be evolved to cope with herbivory (J. Wann pers. comm. 2016). In order to better understand the impacts of grazing, s 45 prior to leaf emergence in 2013. s 45 s 45 These results provide good evidence that s 45 may aid the survival and health of orchids. Future development in surrounding areas of Jandakot Airport may result in increased grazing pressure on remaining bushland remnants such as s 45 It is therefore recommended that further research towards grazing and management techniques for protection of the orchids be considered for the future as there is the current knowledge gap and issue as to what species is/are grazing on the population. This knowledge will help to guide future management actions. For example, if grazing is predominantly by rabbits (which are currently managed under the Jandakot Airport Conservation Management Plan's Appendix F Feral Animal Management Plan), then management of this species is considered to be rather straight forward. However if grazing is done by fauna such as the Quenda and Western Brush Wallaby (which are considered significant species and must be protected under Jandakot Airport's Conservation Management Plan as required by the *Environment Protection and Biodiversity Conservation Act 1999* conditions), then this is considered to be a conflicting dilemma that would require impacting one protected species for the benefit of another. Jandakot Airport's Conservation Management Plan is currently being amended to include an action to monitor orchids with motion-sensitive cameras in an attempt to determine which herbivores are responsible for the grazing impacts on *Caladenia huegelii* (T).

Little is known about flower emergence rates in natural *Caladenia huegelii* (T) populations. The Department of Environment and Conservation (2009) indicates that "some (but not all) plants" flower between late September and early November, and begin to dry out by mid-November. Findings from Mattiske Consulting Pty Ltd surveys (2012 – 2015) indicates that 32-41% of individuals in a population may flower between August and September (with 46-56% of emerged individuals flowering in any given year). In 2011 only 16.4% of the 85 plants flowered, but at that stage only 29% of the population had been located and tagged. However, these percentages are reduced when grazing is considered. Flowering of the orchid is dependent on a range of environmental factors such as rainfall, temperature, competition, and grazing (Mattiske Consulting Pty Ltd 2012; 2013; 2014). Overall, little research has been conducted on flower emergence rates. Therefore, long-term monitoring of the s 45 orchid s 45 would provide valuable quantitative biological information to support future recovery actions.

Very little evidence of natural pollination was observed over the course of the surveys of the s 45 s 45 within s 45 (Mattiske Consulting Pty Ltd 2012; 2013; 2014). In *Caladenia huegelii* (T) Population 6, the major limiting factor preventing pollination was believed to be the absence of appropriate thynnid wasp pollinators (Department of Environment and Conservation 2009). Similarly, it is likely that the lack of a suitable pollinator may be resulting in low pollination rates in s 45 with research by Kings Park Botanic Garden and Parks Authority determining that the natural pollinator (thynnid wasp *Macrothynnus insignis*) of *Caladenia huegelii* (T) is not present in bushland remnants in urban Perth (Kingsley Dixon pers. comm.). The results of this study and evidence that the natural pollinator is not present in the area indicate that hand pollination may be the only means of pollinating the *Caladenia huegelii* (T) population at Jandakot, and it is unlikely that the population at s 45 will survive in to the future without continued management. Incidental pollination by species other than the thynnid wasp is possible, although this would not be at a significant rate and is likely to have accounted for the pollination of a single plant observed with a swollen ovary during the 2012 survey (J. Wann pers. comm. 2016).

If *Caladenia huegelii* (T) is present in an area, there is some certainty that at least a proportion of the population will be identified upon searching for a single day during the flowering season, as demonstrated in 2011. A high proportion of plants present within an orchid population (averaging 87% over the three s 45 can be identified after searches in two flowering season (i.e. by the end of the 2012 season in this monitoring program). These results justify the approach taken to date that full surveys of the population should be conducted over two years/flowering seasons. Subsequent searches of the same area for more than two years only identifies a small additional percentage (i.e. and additional 7% in the third year, 5% in the fourth year and 1% in the fifth year).

7. CONCLUSIONS AND RECOMMENDATIONS

As little is known about the life history characters and long term stability of *Caladenia huegelii* (T) populations (Swarts *et al.* 2009), the findings from this study provide important information about the health and size of the populations within s 45 at Jandakot Airport and provide insight towards the protection of the species for the future. Overall, the orchids within the s 45 in s 45 were in good condition, but the extent of grazing may lead to a decline in population numbers based on the current observed impacts. s 45 Hand pollination appears to be an effective way of pollinating *Caladenia huegelii* (T), and with the lack of the natural pollinator in the area this may be needed in order to sustain the population in the long term. The population of orchids within the s 45 at s 45 represent a large subset of the recorded orchids in the Jandakot area and is therefore of conservation significance.

After analysing the results of the spring surveys of *Caladenia huegelii* (T) from 2011 to 2015, the following actions are recommended:

- restrict access to the conservation precincts to enable protection of the Banksia woodlands near the established populations;
- as part of a wider research program on *Caladenia* species, review the potential impact of controlled burning on *Caladenia huegelii* prior to undertaking any fuel reduction burning in the *Banksia* woodlands;
- integrate native species into rehabilitation activities that support the pollinating wasp, following consideration of Dixon (2015) research findings;
- facilitate research and monitoring of the known locations with other researchers of orchids to better understand emergence, local mortality, recruitment, flower development, pollination, and seed production patterns; and
- investigate grazing and if warranted implement appropriate management strategies to reduce potential impacts.

It is unlikely that the population of *Caladenia huegelii* (T) within s 45 at Jandakot Airport or any other location in the bushlands of urban Perth will be able to survive into the future without management and human intervention as the natural pollinator does not exist in the area. Therefore there is a need to negotiate options for either ceasing monitoring and assume that the decline will continue, at least until

such time as the responsible authorities are able to re-introduce the responsible pollinator – which is potentially achievable given the longevity of *Caladenia huegelii* (T) or negotiate options for a modified monitoring programme with appropriate regulators. If the population is to be naturally sustainable, research into the pollinator and re-introduction of the pollinator in to the local area will be required. The population may prove more effective as a source of seed for propagation and translocation of the species, and if required, this would be by relevant authorities/researched and not by Jandakot Airport Holdings Pty Ltd.

8. ACKNOWLEDGEMENTS

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9. LIST OF PERSONNEL

The following Mattiske Consulting Pty Ltd personnel were involved in this project:

Name	Position	Project Involvement	Flora Collection Permit
Dr s47F	Managing Director & Principal Ecologist	Planning, Management & Reporting	N/A
Mr s47F	Experienced Botanist	Fieldwork	SL010386
Ms s47F	Experienced Ecologist	Data interpretation and report preparation	N/A
Ms s47F	Experienced Botanist	Data interpretation and report preparation	N/A

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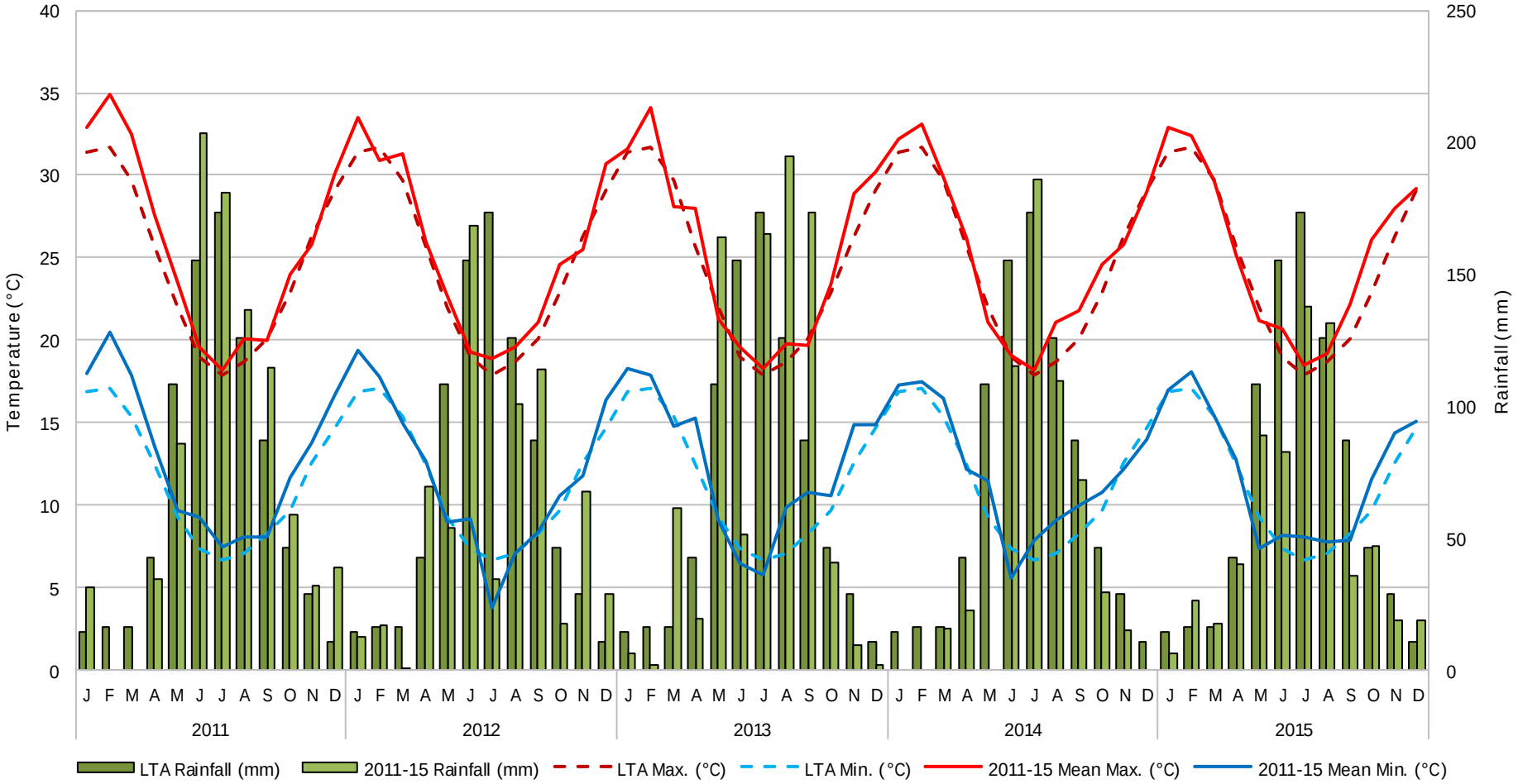
APPENDIX A1: DEFINITION OF THREATENED AND PRIORITY FLORA SPECIES (Department of Parks and Wildlife 2016c)

Conservation Code	Category
T	**Threatened Flora (Declared Rare Flora – Extant)** "Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the *Wildlife Conservation Act 1950*). Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria: • **CR:** Critically Endangered – considered to be facing an extremely high risk of extinction in the wild • **EN:** Endangered – considered to be facing a very high risk of extinction in the wild • **VU:** Vulnerable – considered to be facing a high risk of extinction in the wild."
P1	**Priority One – Poorly Known Species** "Species that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes."
P2	**Priority Two – Poorly Known Species** "Species that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes."
P3	**Priority Three – Poorly Known Species** "Species that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them."
P4	**Priority Four – Rare Threatened and other species in need of monitoring** "a. Rare - Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. b. Near Threatened - Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. c. Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy."
P5	**Priority Five – Conservation Dependent Species** "Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years."

APPENDIX A2: DEFINITION OF THREATENED FLORA SPECIES (*Environment Protection and Biodiversity Conservation Act 1999*)

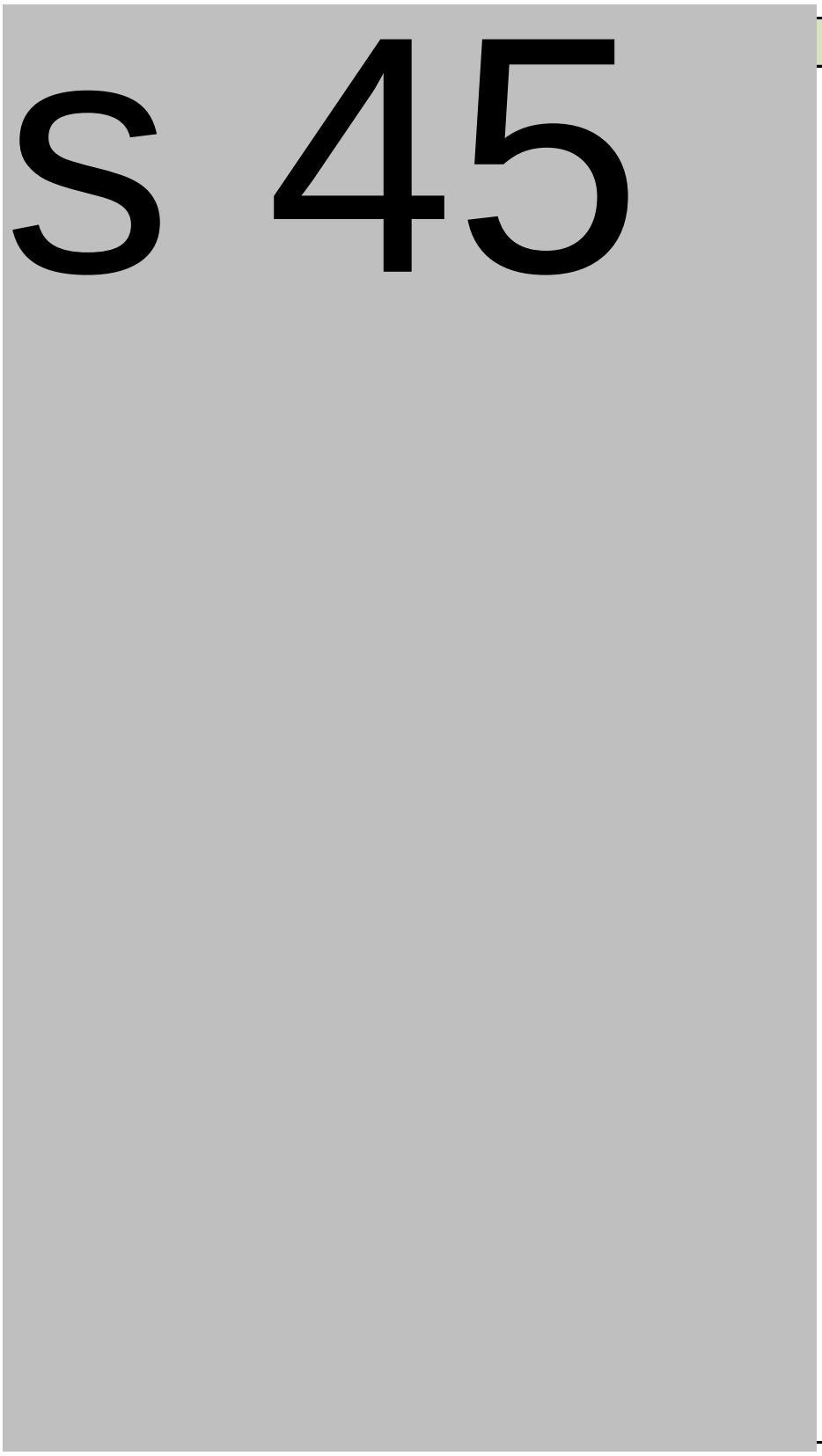
Category Code	Category
Ex	**Extinct** Taxa which at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
ExW	**Extinct in the Wild** Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	**Critically Endangered** Taxa which at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	**Endangered** Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
V	**Vulnerable** Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which at a particular time if, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

APPENDIX B: RAINFALL AND TEMPERATURE DATA FOR JANDAKOT AERO (STATION 009172) (BUREAU OF METEOROLOGY 2016)



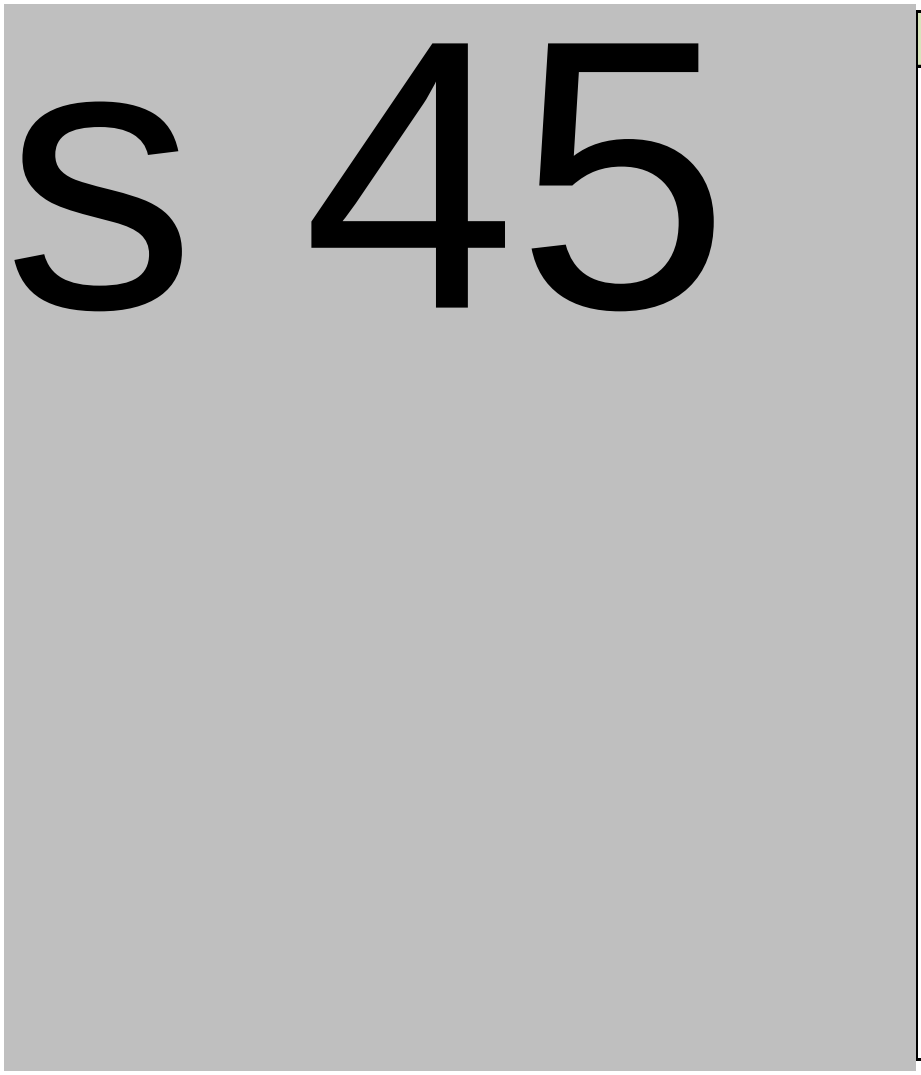
Long term average rainfall and temperature data, together with monthly rainfall and average maximum and minimum temperature data for the period January 2011 to December 2015 (Bureau of Meteorology 2016)

APPENDIX C: LOCATION OF *CALADENIA HUEGELII* (T) WITHIN s 45 s 45
AT JANDAKOT AIRPORT (GDA94_Z50H)



Leaf Presence 2015
Y
N
N
N
N
N
N
Y
N
N
Y
Y
Y
Y
N
Y
Y
Y
N
Y
N
Y
Y
Y
N
Y
N
Y
Y
Y
N
Y
Y
Y
N
Y
Y
Y
N
N
Y
N
Y
Y
Y
Y
Y
Y
Y
Y
Y

APPENDIX C: LOCATION OF *CALADENIA HUEGELII* (T) WITHIN s 45 s 45
AT JANDAKOT AIRPORT (GDA94_Z50H)



Leaf Presence 2015
Y
N
N
Y
N
Y
N
N
Y
Y
Y
N
Y
N
Y
Y
Y
N
Y
Y
Y
N
Y
Y
Y
Y
N
N
Y
Y
Y
N
Y

APPENDIX D: LEAF EMERGENCE/PRESENCE OF *CALADENIA HUEGELII* (T) WITHIN s 45 s 45 AT JANDAKOT AIRPORT FROM 2011 TO 2015

Note: N/A refers to plants not yet discovered; green cells indicate orchid presence and red indicates absence

s 45

2011	2012	2013	2014	2015	TOTAL
1	1	1		1	4
1	1	1			3
1	1	1	1		4
1	1	1	1		4
1			1		2
1	1	1	1		4
1	1	1			3
1	1	1	1	1	5
1					1
1	1	1			3
N/A	1	1		1	3
N/A	1	1			2
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1	1			2
N/A	1	1	1	1	4
N/A	1			1	2
N/A	1	1	1	1	4
N/A	1		1	1	3
N/A	1	1	1	1	4
N/A	1	1			2
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1	1	1		3
N/A	1	1			2
N/A	1	1	1	1	4
N/A	1	1			2
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1		1	1	3
N/A	1	1	1	1	4
N/A	N/A	1	1	1	3
N/A	N/A	1	1	1	3
N/A	N/A	N/A	1	1	2
N/A	N/A	N/A	1	1	2
N/A	N/A	N/A	1	1	2
N/A	N/A	N/A	N/A	1	1
10	35	34	30	29	

APPENDIX D: LEAF EMERGENCE/PRESENCE OF *CALADENIA HUEGELII* (T) WITHIN s 45 s 45 AT JANDAKOT AIRPORT FROM 2011 TO 2015

Note: N/A refers to plants not yet discovered; green cells indicate orchid presence and red indicates absence

S 45

2011	2012	2013	2014	2015	TOTAL
1	1	1	1	1	5
1	1	1	1	1	5
1				1	2
1	1		1	1	4
1					1
1	1	1	1	1	5
1	1	1	1	1	5
N/A	1	1	1	1	4
N/A	1		1		2
N/A	1	1			2
N/A	1	1	1	1	4
N/A	1	1	1		3
N/A	1		1	1	3
N/A	1				1
N/A	1		1		2
N/A	1	1	1	1	4
N/A	1	1	1	1	4
N/A	1		1	1	3
N/A	1		1		2
N/A	1	1	1	1	4
N/A	1	1	1		3
N/A	N/A	1	1		2
N/A	N/A	1	1		2
7	19	14	19	13	
1	1	1	1	1	5
1	1	1	1		4
1	1	1		1	4
1	1	1	1		4
1		1	1	1	4
1	1	1	1	1	5
1	1	1	1	1	5
1	1	1	1		4
N/A	1	1	1	1	4
N/A	1		1	1	3
N/A	1	1		1	3
N/A	1	1	1		3
N/A	1	1		1	4
N/A	1	1		1	3
N/A	1	1	1	1	4
N/A	1	1			2
N/A	N/A	1	1	1	3
N/A	N/A	1		1	2
N/A	N/A	N/A	1		1
8	15	17	14	13	
25	69	65	63	55	

APPENDIX E: FLOWER PRESENCE OF *CALADENIA HUEGELII* (T) INDIVIDUALS WITHIN s 45 s 45 AT JANDAKOT AIRPORT FROM 2011 TO 2015

Note: N/A refers to plants not yet discovered; green cells indicate orchid presence; orange indicate flower initially present but predated; red indicates absence

ND indicates plants were not emergent in that year

s 45	2011	2012	2013	2014	2015
		1		ND	
			1	ND	ND
	1				ND
	1	1	1	1	ND
	1	ND	ND		ND
		1			ND
				ND	ND
	1	1	1	1	1
		ND	ND	ND	ND
	1	1		ND	ND
	N/A			ND	
	N/A		1	ND	ND
	N/A	1			
	N/A	1		1	
	N/A			1	1
	N/A		ND	ND	ND
	N/A		1	1	1
	N/A		ND	ND	
	N/A	1			
	N/A			1	1
	N/A				1
	N/A	1		ND	ND
	N/A	1		1	
	N/A	1	1	1	1
	N/A				ND
	N/A		1	ND	ND
	N/A				1
	N/A	1	1	ND	ND
	N/A			1	1
	N/A		1	1	1
	N/A		1	1	
	N/A			1	1
	N/A		1	1	1
	N/A		1	1	
	N/A		1		
	N/A	1	ND	1	
	N/A	1	1	1	
	N/A	N/A	1	1	1
	N/A	N/A	1		1
	N/A	N/A	N/A	1	1
	N/A	N/A	N/A	1	1
	N/A	N/A	N/A	1	1
	N/A	N/A	N/A	N/A	1
	5	14	16	20	17

APPENDIX E: FLOWER PRESENCE OF *CALADENIA HUEGELII* (T) INDIVIDUALS WITHIN s 45 s 45 AT JANDAKOT AIRPORT FROM 2011 TO 2015

Note: N/A refers to plants not yet discovered; green cells indicate orchid presence; orange indicate flower initially present but predated; red indicates absence

ND indicates plants were not emergent in that year

S 45

2011	2012	2013	2014	2015
1	1			1
	ND	ND	ND	
		ND		
	ND	ND	ND	ND
1	1	1	1	
1	1	1	1	
N/A	1	1	1	1
N/A	1	ND		ND
N/A			ND	ND
N/A				
N/A				ND
N/A	1	ND		1
N/A		ND	ND	ND
N/A	1	ND		ND
N/A				
N/A			1	
N/A	1	ND		1
N/A	1	ND		ND
N/A	1	1	1	1
N/A	1	1	1	ND
N/A	N/A			ND
N/A	N/A		1	ND
3	11	5	7	5
	1		1	1
1	1	1	1	ND
1			ND	
1	1	1		ND
1	1	1	1	1
	ND		1	
1	1			
1		1		ND
N/A	1	1	1	
N/A		ND		
N/A		1	ND	
N/A			1	ND
N/A	1		1	1
N/A			ND	
N/A				
N/A		1	ND	ND
N/A	N/A	1	1	1
N/A	N/A		ND	1
N/A	N/A	N/A		ND
6	7	8	8	5
14	32	29	35	27

APPENDIX F: LEAF AND FLOWER PRESENCE OF *CALADENIA HUEGELII* (T) INDIVIDUALS WITHIN s 45 s 45 AT JANDAKOT AIRPORT FROM 2012 TO 2015

Note: s 45 represent plants that were frist recorded/tagged in 2011; s 45 were tagged in 2011 but have not emerged since; Presence is indicated by green colouration when present and red when not present: Orchids with flowers completely predated are shown in orange.

s 45

LEAF PRESENCE					FLOWER PRESENCE				
2012	2013	2014	2015	Total	2012	2013	2014	2015	Total
1	1		1	3	1				1
1	1			2		1			1
1	1	1		3					0
1	1	1		3	(1)	1	1		2
		1		1					0
1	1	1		3	1				1
1	1			2					0
1	1	1	1	4	1	1	1	1	4
1	1			2	(1)				0
1	1		1	3					0
1	1			2		1			1
1	1	1	1	4	1				1
1	1	1	1	4	1		1		2
1	1	1	1	4			(1)	1	1
1				1					0
1	1	1	1	4		1	1	1	3
1			1	2					0
1	1	1	1	4	1				1
1	1	1	1	4			1	1	2
1	1	1	1	4				1	1
1	1			2	1				1
1	1	1	1	4	1		1		2
1	1	1	1	4	1	(1)	1	1	3
1	1	1		3					0
1	1			2		1			1
1	1	1	1	4				1	1
1	1			2	1	1			2
1	1	1	1	4			1	1	2
1	1	1	1	4			1	1	3
1	1	1	1	4		1	1		2
1	1	1	1	4			1	1	2
1	1	1	1	4		1	1	1	3
1	1	1	1	4		1	1		2
1	1	1	1	4		1			1
1		1	1	3	1		1		2
1	1	1	1	4	1	1	1		3
	1	1	1	3		1	(1)	1	2
	1	1	1	3		1		1	2
		1	1	2			1	1	2
		1	1	2			(1)	1	1
		1	1	2			(1)	1	1
			1	1				1	1
35	34	30	29	3.05	12	15	16	17	1.43

APPENDIX F: LEAF AND FLOWER PRESENCE OF *CALADENIA HUEGELII* (T) INDIVIDUALS WITHIN s 45 s 45 AT JANDAKOT AIRPORT FROM 2012 TO 2015

Note: s 45 represent plants that were frist recorded/tagged in 2011; s 45 were tagged in 2011 but have not emerged since; Presence is indicated by green colouration when present and red when not present: Orchids with flowers completely predated are shown in orange.

s 45

LEAF PRESENCE					FLOWER PRESENCE				
2012	2013	2014	2015	Total	2012	2013	2014	2015	Total
1	1	1	1	4	(1)			(1)	0
1	1	1	1	4					0
			1	1					0
1		1	1	3					0
1	1	1	1	4	1	(1)	(1)		1
1	1	1	1	4	(1)	(1)	(1)		0
1	1	1	1	4	(1)	1	(1)	(1)	1
1		1		2	1				1
	1			1					0
1	1	1	1	4					0
1	1	1		3					0
1		1	1	3	1			1	2
1				1					0
1		1		2	1	(1)			1
1	1	1	1	4					0
1	1	1	1	4			1		1
1		1	1	3	1			(1)	1
1		1		2	1				1
1	1	1	1	4	1	(1)	1	1	3
1	1	1		3	1	1	1		3
	1	1		2					0
	1	1		2			1		1
18	14	19	13	2.91	8	2	4	2	0.73
1	1	1	1	4	1		1	1	3
1	1	1		3	1	1	1		3
1	1		1	3					0
1	1	1		3	(1)	1			1
1	1	1	1	4	1	(1)	(1)	1	2
	1	1	1	3			(1)		0
1	1	1	1	4	1				1
1	1	1		3		1			1
1	1	1	1	4	1	1	(1)		2
1		1	1	3					0
1	1		1	3		(1)			0
1	1	1		3			(1)		0
1	1	1	1	4	1		1	1	3
1	1		1	3					0
1	1	1	1	4					0
1	1			2		1			1
	1	1	1	3		1	1	(1)	2
	1		1	2				(1)	0
		1		1					0
15	17	14	13	3.11	6	6	4	3	1
68	65	63	55	3.02	26	23	24	22	1.14

SPRING SURVEY RESULTS FOR THE THREATENED ORCHID

Caladenia huegelii

AT JANDAKOT AIRPORT, s 45

Prepared for

Jandakot Airport Holdings Pty Ltd

Prepared by

Mattiske Consulting Pty Ltd

October 2012

JAC1201/60/2012

Mattiske Consulting Pty Ltd

Disclaimer and Limitation

This report has been prepared on behalf of and for the exclusive use of Jandakot Airport Holdings Pty Ltd, and is subject to and issued in accordance with the agreement between Jandakot Airport Holdings Pty Ltd and Mattiske Consulting Pty Ltd. Mattiske Consulting Pty Ltd accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

This report is based on the scope of services defined by Jandakot Airport Holdings Pty Ltd, budgetary and time constraints imposed by Jandakot Airport Holdings Pty Ltd, the information supplied by Jandakot Airport Holdings Pty Ltd (and its agents), and the method consistent with the preceding.

DOCUMENT HISTORY

Report	Version	Prepared By	Reviewed By	Submitted to Client	
				Date	Copies
Internal Review	V1	MH	EMM	-	-
Draft Report released for Client Review	V2	MH	EMM	16/11/2012	Email and Hard Copies
Final Report	V3	MH	EMM	27/02/2013	Email and Hard Copies

APPENDICES

A1: Definition of Threatened and Priority Flora species (Department of Environment and Conservation 2012c)

A2: Definitions of Threatened Flora species (*EPBC Act 1999*)

B: Location of *Caladenia huegelii* individuals within s 45 orchid s 45 at Jandakot Airport

C: Photographic record of the orchid species recorded within the s 45 orchid s 45 at Jandakot Airport

D: Photographic record of the orchid s 45 within s 45 at Jandakot Airport

1. SUMMARY

Mattiske Consulting Pty. Ltd. was commissioned by Jandakot Airport Holdings to monitor and search for new occurrences of the orchid *Caladenia huegelii* within s 45 at Jandakot Airport (Figure 1). Up to 169 *Caladenia huegelii* individuals have previously been recorded at various locations at Jandakot Airport. The s 45 represent a subset of this population. *Caladenia huegelii* is endemic to the region between Perth to Busselton. It is known from only 71 populations in mixed *Eucalyptus marginata* and *Banksia attenuata* woodlands in deep grey-white sands and as such this species is primarily restricted in the main to localized remnant areas on the Swan Coastal Plain.

Caladenia huegelii is a Threatened Flora species pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* and as listed by the Department of Environment and Conservation. *Caladenia huegelii* is also listed as Threatened Flora under the *Environment Protection and Biodiversity Conservation Act 1999* and as listed by the Department of Sustainability, Environment, Water, Population and Communities.

A total of 69 alive *Caladenia huegelii* individuals were recorded in the current survey. No additional Threatened or Priority Flora species were located within the s 45. Flowering orchids thought to be *Caladenia huegelii* in Precinct 1B were confirmed as *Caladenia longicauda* subsp. ?*longicauda*.

The majority of orchids were recorded as being in a healthy condition and flower emergence was apparent for about a third of the orchids. Grazing was identified as a potential future management issue, with over half of the plants experiencing slight to medium forms of herbivory. In recent years observations indicate that native fauna species are grazing on this species.

In response to the 2012 spring survey of *Caladenia huegelii*, it is recommended to:

- Continue monitoring the known locations of orchids to understand local mortality, recruitment, flower development, pollination, and seed production patterns;
- Monitor rates of grazing and implement appropriate management strategies; and
- Continue monitoring the orchid population at s 45 over sequential years to confirm the identity of the sterile orchids in 2012.

As little is known about the life history characters and long term stability of *Caladenia huegelii* populations, surveys such as the one documented in this report are providing important insight towards protecting Threatened species *Caladenia huegelii* in s 45 for the future.

S 45

2. INTRODUCTION

Mattiske Consulting Pty Ltd was commissioned in August 2012 by Jandakot Airport Holdings Pty Ltd to monitor s 45 that are known to support *Caladenia huegelii* plants within s 45 at Jandakot Airport.

2.1 Location and Scope of Proposal

Jandakot Airport is located approximately 20 km south of Perth, accessible off Karel Avenue from Roe Highway. In 2005, a formal survey by the Department of Environment and Conservation recorded a population of 169 individuals of the Threatened orchid *Caladenia huegelii* (Department of Environment and Conservation 2009). Since 2005, the Department of Environment and Conservation, Mattiske Consulting Pty Ltd, and the Botanic Gardens and Parks Authority have been involved in surveys to monitor factors relating to the population including plant numbers, area of occupancy, flower emergence, recruitment, seed production, and herbivory (Mattiske Consulting Pty Ltd 2010). In 2011, the Botanic Gardens and Parks Authority recorded 33 orchids occurring inside s 45 . Previous records of *Caladenia huegelii* have also been recorded within s 45 by Mattiske Consulting (2007) and Jandakot Airport Holdings in 2012. Mattiske Consulting Pty Ltd was appointed to monitor and search for new occurrences of the orchid within s 45 as well as a section of s 45 where new individuals of *Caladenia huegelii* were thought to occur.

2.2 Western Australia's Flora – A Legislative Perspective

Western Australia has a unique and diverse flora, and is recognised as one of the world's 34 biodiversity hotspots (Myers *et al.* 2000). In this context, Western Australia possesses a high degree of species richness and endemism. This is particularly pronounced in the south-west region of the state. There are currently over 12,000 plant species known to occur within Western Australia (Department of Environment and Conservation 2012a), and scientific knowledge of many of these species is limited.

The legislative protection of flora within Western Australia is principally governed by three Acts. These are:

- The *Wildlife Conservation Act 1950*;
- The *Environmental Protection Act 1986*; and
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The unique flora of Western Australia is potentially under threat due to historical clearing practices associated with agricultural, mining and human habitation activities. As a consequence of these historical clearing practices a number of flora species have become threatened or have the potential to become threatened as their habitat is impacted by human activity. In addition, some areas of the State have been affected by past clearing practices such that entire ecological communities are under threat. The following sections describe these threatened and priority flora and ecological communities, and outline the legislative protection afforded to them.

At the State level, the *Wildlife Conservation Act 1950* provides for taxa of native flora (and fauna) to be specially protected because they are subject to identifiable threats. Protection of these taxa has been identified as being warranted because they may become extinct, are threatened, or are otherwise in need of special protection. Ecological communities that are deemed to be threatened are afforded protection under the *Environmental Protection Act 1986*. Listings of threatened species and communities are reviewed annually by the Western Australian Threatened Species Scientific Committee (TSSC), which is a body appointed by the Minister for the Environment and supported by the Department of Environment and Conservation. The TSSC reviews threatened and specially protected flora (and fauna) listings on an annual basis. Recommendation for additions or deletions to the listings of specially protected flora (and fauna) is made to the Minister for the Environment by the TSSC, via the Director General of the Department of Environment and Conservation, and the WA Conservation Commission. Under Schedule 1 of the *Wildlife Conservation Act 1950*, the Minister for the Environment

may declare that a class or description of flora to be threatened flora throughout the State, by notice published in the *Government Gazette* (Department of Environment and Conservation 2012b).

At the Commonwealth level, under the *Environment Protection and Biodiversity Conservation Act 1999*, a nomination process exists, to list a threatened species or ecological community. Additions or deletions to the lists of Threatened species and communities are made by the Minister for Sustainability, Environment, Water, Populations and Communities, on advice from the Federal Threatened Species Scientific Committee. *Environment Protection and Biodiversity Conservation Act 1999* lists of Threatened flora and ecological communities are published on the Department of Sustainability, Environment, Water, Populations and Communities website (2012a, 2012b).

2.2.1 Threatened and Priority Flora

Flora within Western Australia that is considered to be under threat may be classed as either threatened flora or priority flora. Where flora has been gazetted as threatened flora under the *Wildlife Conservation Act 1950*, it is an offence "to take" such flora without the written consent of the Minister. The *Wildlife Conservation Act 1950* states that "to take" flora includes to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means.

Priority flora constitute species which are considered to be under threat, but for which there is insufficient information available concerning their distribution and/or populations to make a proper evaluation of their conservation status. Such species are considered to potentially be under threat, but do not have legislative protection afforded under the *Wildlife Conservation Act 1950*. The Department of Environment and Conservation categorises priority flora according to their conservation priority, using five categories, P1 to P5, to denote the conservation priority status of such species, with P1 listed may have their priority status changed when more information on the species becomes available. Appendix A1 sets out definitions of both threatened and priority flora (Department of Environment and Conservation 2012c).

At the Commonwealth level, under the *Environment Protection and Biodiversity Conservation Act 1999*, threatened species can be listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable, or conservation dependent, by the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities. Refer to Appendix A2 for a description of each of these categories of threatened species. Under the *Environment Protection and Biodiversity Conservation Act 1999*, a person must not take an action that has or will have a significant impact on a listed threatened species without approval from the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities, unless those actions are not prohibited under the Act.

The current *Environment Protection and Biodiversity Conservation Act 1999* list of Threatened flora may be found on the Department of Sustainability, Environment, Water, Population and Communities (2012) website.

2.2.2 Local and Regional Significance

Flora or vegetation may be locally or regionally significant in addition to statutory listings by the State or Federal Government.

In regards to flora; species, subspecies, varieties, hybrids and ecotypes may be significant other than as threatened flora or priority flora, for a variety of reasons, including:

- a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;
- relic status
- anomalous features that indicate a potential new discovery;
- being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- the presence of restricted subspecies, varieties, or naturally occurring hybrids;
- local endemism/a restricted distribution; and
- being poorly reserved (Environmental Protection Authority 2004).

3. OBJECTIVES

The aim of this survey was to monitor existing and identify new individuals of *Caladenia huegelii* within s 45 at Jandakot Airport. Specifically, the objectives of the survey were to:

- Monitor the condition of and re-tag the orchids within the three established s 45 , Jandakot Airport;
- Search for and tag new individuals of *Caladenia huegelii* and other Threatened and Priority orchids within the established s 45 , Jandakot Airport;
- Map the location of Threatened and Priority orchids within each s 45 , Jandakot Airport;
- Generate an updated database including the GPS location and condition of each orchid located within each s 45 , Jandakot Airport;
- Confirm the identity of marked orchids in s 45 and establish a s 45 if those orchids are identified as *Caladenia huegelii*;
- Provide recommendations on the future monitoring and management of the orchids; and
- Prepare a report summarising the findings.

4. METHODS

4.1 Desktop Survey

A desktop assessment was conducted using the Department of Environment and Conservation (2007) and Department of Sustainability, Environment, Water, Population and Communities (2012) databases to review the location and conservation status of Threatened and Priority orchid species in a 6 km buffer of the survey area. The climate of the survey area and the regional perspective of *Caladenia huegelii* were also investigated. .

4.2 Field Survey

The assessment of the Threatened and Priority orchids of s 45 at Jandakot Airport was undertaken by two experienced botanists from Mattiske Consulting Pty. Ltd. on the 17th September and 18th October, 2012.

On the 17th September, the s 45 pre-established s 45 were searched for previously recorded *Caladenia huegelii* individuals (Table 1). The locations of previously recorded orchids were recognisable by the placement of s 45 Potentially new orchids were recognisable by the placement of s 45 s 45 ; Each s45 was also intensively searched for new individuals s 45 The identity, GPS position, leaf length, flower presence, flower/stalk length, and leaf and flower herbivory were noted for each orchid. Each orchid was also assigned one of three health ratings based on leaf colour, flower condition and herbivory. Orchids were recorded as "healthy" if the plant had green leaves, an intact flower (if present), and little to no evidence of herbivory. "Slightly stressed" orchids had occasional brown spots on the leaves and a medium incidence of leaf or flower herbivory. "Stressed" orchids had brown leaves and/or a very high incidence of herbivory. Photographs were taken of each orchid where possible to develop a photographic record of the sites and orchids.

Wherever possible the orchid species were identified in the field. Photographs of unknown species were compared with pressed specimens housed at the Western Australian Herbarium. Where appropriate, plant taxonomists with specialist skills were consulted. Nomenclature of the species recorded is in accordance with the Department of Environment and Conservation (2012d).

On the 18th October, the s 45 were revisited to assess potential pollination and seed production of the orchids. Pollination was recorded when obvious swelling of the plant's ovary was apparent.

Table 1: Geographic locations of orchid s 45 within s 45 at Jandakot Airport

s 45

4.3 Survey Limitations and Constraints

An assessment of the survey against a range of factors which may have had an impact on the outcomes of the present survey was made (Table 2). Based on this assessment, the present survey has not been subject to constraints which would affect the thoroughness of the survey, and the conclusions which have been formed.

Table 2: Potential flora and vegetation survey limitations for the survey area

Potential Survey Limitation	Impact on Survey	Reason
Sources of information and availability of contextual information (i.e. pre-existing background versus new material).	Not a constraint	Adequate information was able to be accessed from available databases and previous surveys conducted in areas adjacent to and within the survey area.
Scope (i.e. what life forms, etc., were sampled).	Not a constraint	The vascular plant species *Caladenia huegelii* was the focus of the survey. This orchid species was thoroughly surveyed within the project area.
Proportion of flora collected and identified (based on sampling, timing and intensity).	Not a constraint	The three survey areas were thoroughly surveyed by two botanists and JAH over consecutive field trips during the appropriate season.
Completeness and further work which might be needed (i.e. was the relevant survey area fully surveyed).	Not a constraint	The relevant survey area was covered.
Mapping reliability.	Not a constraint	Aerial photography quality was adequate for the scale of mapping.
Timing, weather, season, cycle.	Not a constraint	The survey was conducted during the species' flowering and seeding period (September to October).
Disturbances (fire flood, accidental human intervention, etc.).	Not a constraint	No disturbances were encountered in the survey area.

Table 2: Potential flora and vegetation survey limitations for the survey area

Potential Survey Limitation	Impact on Survey	Reason
Intensity (in retrospect, was the intensity adequate).	Not a constraint	The survey intensity is considered to have been thorough.
Resources (i.e. were there adequate resources to complete the survey to the required standard).	Not a constraint	Resources, in terms of time, equipment, support and personnel were adequate to undertake and complete the survey.
Access problems (i.e. ability to access survey area).	Not a constraint	The survey area was easily accessible from pre-existing access tracks. There were no obstacles to surveying the designated area.
Experience levels (e.g. degree of expertise in plant identification to taxon level).	Not a constraint	Appropriate levels of ecological, botanical and taxonomic expertise were available during the project.

5. RESULTS

5.1 Desktop Survey

The following information outlines the findings of the desktop survey including the Threatened orchid species previously recorded near the survey area, climatic data for Jandakot, and the significance of the target species in a regional perspective.

5.1.1 Flora

A total of four Threatened orchid species and one Priority species were recorded as potentially occurring s 45 (Department of Environment and Conservation 2007). These species included the target species *Caladenia huegelii* (T), as well as *Diuris purdiei* (T), *Drakaea elastica* (T), *Drakaea micrantha* (T), and *Microtis quadrata* (P4). Of these species, *Caladenia huegelii* has been recorded by the Department of Environment and Conservation (2009), Mattiske Consulting Pty. Ltd. (2010), and the Botanic Garden and Parks Authority as occurring at a number of different locations within Jandakot Airport (Table 3). The Department of Environment and Conservation (2009) has also recorded *Caladenia huegelii* as occurring near populations of s 45 some areas of Jandakot (Department of Environment and Conservation 2009).

Caladenia huegelii was first discovered at Jandakot Airport in 2003 and subsequent surveys have located up to 169 individuals (Department of Environment and Conservation 2009). The population at Jandakot Airport is listed as population number 56 and is comprised of 8 subpopulations (Department of Environment and Conservation 2009). Jandakot Airport Holdings is currently responsible for managing this population.

Caladenia huegelli is a tuberous, perennial herb from 0.25 to 0.6 m high. It flowers from September to October and prefers grey or brown sand, or clay loam soils (Department of Environment and Conservation 2012d). There are 41 specimens of *Caladenia huegelli* held at the Western Australian Herbarium and 126 records of the species listed by the Department of Environment and Conservation database (Department of Environment and Conservation 2007). A full inventory of all *Caladenia huegelii* plants at Jandakot Airport, including plants identified in previous surveys and newly discovered individuals, will be completed in 2013.

Table 3: **Number of *Caladenia huegelii* individuals recorded by past surveys at Jandakot Airport**

Surveyors	Year	Survey Site	Population
Department of Environment and Conservation	2005	s 45	169
Mattiske Consulting Pty Ltd	2009	s 45	42
Botanic Gardens and Parks Authority	2011	s 45	33(1)

Numbers in brackets indicate dead individuals

5.1.2 Climate

Beard (1990) described the climate of the survey area to be Mediterranean, with hot dry summers and cool, wet winters. Rainfall was below average in the months leading up to the survey, especially in July which was 80% below average (Figure 2). Both average maximum and minimum temperatures were slightly higher than average in most months of 2011 and 2012. Lower than average rainfall and slightly higher temperatures may be expected to affect orchid health and flower development in comparison to previous years.

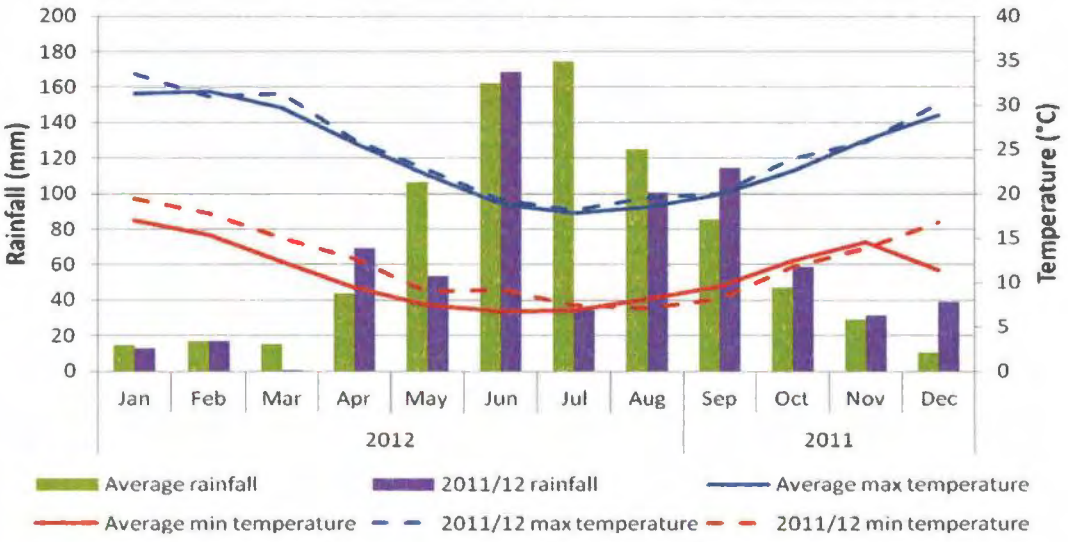


Figure 2: **Rainfall and temperature data for Jandakot Airport**
Long term average rainfall and temperature data, together with monthly rainfall and average maximum and minimum temperature data for the period September 2011 to August 2012 are shown (Bureau of Meteorology 2012)

5.1.3 Regional Perspective

Caladenia huegelii is an endemic orchid species restricted to the Southwest Australian Floristic Region (Hopper and Gioia 2004). The species is known from 71 populations from just North of Perth to Busselton in areas of mixed woodland of *Eucalyptus marginata*, *Banksia attenuata*, *Banksia ilicifolia*, and *Banksia menziesii* with scattered *Allocasuarina fraseriana* and *Corymbia calophylla* over dense shrubs of *Stirlingia latifolia*, *Hypocalymma robustum*, *Hibbertia hypericoides*, *Hibbertia vaginata*, *Xanthorrhoea preissii*, *Adenanthos cuneatus* and *Conostylis* species (Department of Environment and Conservation 2009). The species tends to mainly grow in deep grey-white sand associated with the Bassendean sand-dune system (Department of Environment and Conservation 2009; Swarts *et al.* 2009). The number of *Caladenia huegelii* populations has declined steadily over the last two decades. This decline has been attributed to habitat loss and destruction through urban expansion, encroachment of weeds, and changes in fire frequency (Swarts *et al.* 2009).

5.2 Field Survey

5.2.1 Threatened and Priority Flora

A total of 69 alive *Caladenia huegelii* individuals were recorded in the s 45 within s 45 at Jandakot Airport (Appendix B, Figure 3). s 45 contained 35 orchids, s 45 contained 19 orchids, and s 45 contained 15 orchids (Table 4). Six s 45 orchids from a total of 33 recorded in 2011 could not be found during this survey: 2 records from s 45 3 records from s 45 and 1 record from s 45 See Appendices C and D for a photographic record of each of the s 45 s 45 and recorded orchids.

Caladenia huegelii is a Threatened Flora species pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* and as listed by the Department of Environment and Conservation (2012b) (Appendix B). *Caladenia huegelii* is also listed as Threatened Flora under the *Environment Protection and Biodiversity Conservation Act 1999* and as listed by the Department of Sustainability, Environment, Water, Population and Communities (2012). No other Threatened or Priority Flora species were located within the s 45 surveyed s 45 at s 45 The flowering orchids thought to be *Caladenia huegelii* in s 45 were confirmed as *Caladenia longicauda* by a Senior Botanist at Mattiske Consulting Pty Ltd. The subspecies is believed to be *longicauda*, however, identification at a subspecies level is difficult for this particular species.

Of the 69 orchids recorded within the s 45 within s 45 Jandakot Airport, 89% of orchids were recorded in a healthy condition (H), 7% were in a slightly stressed condition (SS), and 4% were in a stressed condition (S) (Table 4). Of all the orchids within the s 45 only 33% had not been grazed. The remaining 67% of orchids were either slightly grazed (6%) or moderately grazed (61%) (Table 5). Leaf length for grazed leaves was shorter than non-grazed leaves (Table 5).

Flower emergence was similar for all s 45 with 34% of individuals having flowers in s 45 37% in s 45 and 33% in s 45 The overall length of the flowering stalk was 36 ± 1.7 cm (Table 5). By mid-October, the majority of flowers had gone brown or fallen off.

Only one orchid in s 45 was observed to be pollinated. The ovary was observed to be swollen to approximately 0.9 mm wide and 15 mm long. Another orchid in s 45 was potentially pollinated, however, the ovary was not swollen to the same extent as the orchid in s 45 (Appendix C). Hence, pollination success rate was low at 1.4% (Appendix C). No orchids were observed to be producing seed.

Table 4: Count of flower presence, leaf condition and herbivory of the alive orchids within each s 45

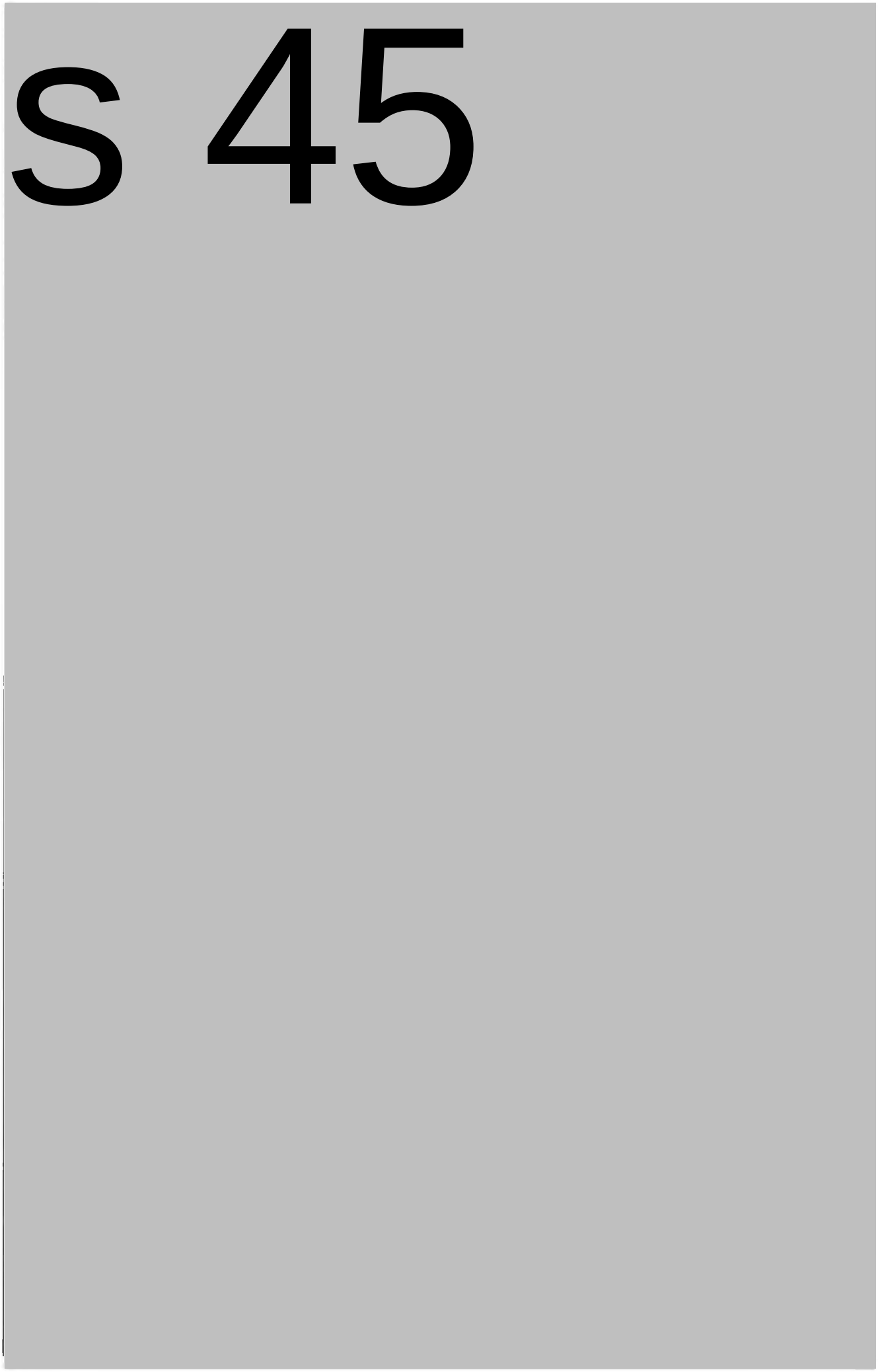
s 45	No. alive	Flower presence	Leaf condition			Herbivory		
			H	SS	S	Not grazed	Slightly grazed	Grazed
	35	12	32	1	2	7	0	28
	19	7	17	2	0	8	3	8
	15	5	12	2	1	8	1	6

Table 5: Average leaf and stalk length (± standard error) of alive orchids within each s 45

s 45	Leaf length (cm)			Stalk length (cm)
	Not grazed	Slightly grazed	Grazed	
	14.2 ± 1.8	0	7.5 ± 0.6	34.4 ± 2.5
	14 ± 1.7	9.3 ± 1.9	12.6 ± 1.3	40.8 ± 2.4
	13.2 ± 0.8	9.5	9.4 ± 0.8	33.5 ± 3.1
	13.7 ± 0.8	9.4 ± 1.3	8.7 ± 0.6	36 ± 1.7

s 45

S 45


S 45

6. DISCUSSION

The targeted *Caladenia huegelii* search within s 45 Jandakot Airport highlighted many important factors relating to the population including plant numbers, flower emergence, herbivory, and pollination activity. The number of orchids in the population seems to be stable and increasing, with 36 additional orchids being recorded this year compared to 2011. An additional 19 orchids were recorded in s 45 an additional 10 in s 45 and an additional 8 in s 45 The increase in orchid numbers found this year may be associated with more intense and consecutive survey efforts from August to October by Jandakot Airport Holdings Pty Ltd and Mattiske Consulting Pty Ltd. Rainfall is also known to influence orchid emergence as *Caladenia huegelii* dies back to an underground storage tuber during summer and resprout following the onset of rainfall in autumn and winter (Department of Environment 2009). However, rainfall in 2012 was 40% lower than in 2011 (Bureau of Meteorology 2012). As a result it is unlikely that rainfall contributed to additional orchid recordings as lower rainfall would be expected to hinder orchid emergence.

A high incidence of herbivory was detected during the survey, with 67% of orchids suffering slight to moderate forms of leaf grazing and 8% of orchids subjected to flower grazing. Grazing has also been observed as a threatening process for other *Caladenia huegelii* populations. For example, kangaroos and caterpillars have been observed predating on various parts of the plant including leaves, buds, flowers, and developing seed capsules in Population 6 (Department of Environment 2009). Wallabies, kangaroos, and rabbits have been observed at s 45 and may be contributing to the grazing damage recorded for 67% of the plants during the current survey. Grazing of leaves and flowers can negatively affect long-term survival by reducing growth and subsequently hindering the reproductive and photosynthetic capacity of the orchids (Department of Environment 2009). Future development in surrounding areas of Jandakot may result in increased grazing pressure on remaining bushland remnants such as s 45 . It is therefore recommended that research towards grazing and management techniques for protection of the orchids (e.g. localized areas restricting grazing activities by native fauna) are considered for the future.

Little is known about flower emergence rates in natural *Caladenia huegelii* populations, although research by the Botanic Gardens and Parks Authority has suggested that flowering can be achieved for seedlings within their third growing season (Department of Environment 2009). The Department of Environment and Conservation (2009) indicates that "some (but not all) plants" flower between late September and early November, and begin to dry out by mid November. Findings from this survey suggest that 30-40% of flowers in a population may flower between August and September although this would be dependent on a range of environmental factors such as rainfall, temperature, competition, and grazing. Overall, little research has been conducted on flower emergence rates. Therefore, long-term monitoring of the s 45 orchid s 45 would provide valuable quantitative biological information for future recovery actions.

Pollination for the orchids in the surveyed s 45 was low (1.4%), with evidence of pollination detected for only one individual in s 45 . Pollination may have occurred for one individual in s 45 however, the ovary had not swollen to the same extent as the orchid in s 45 Low rates of pollination success have also been observed in Caladenia *huegelii* Population 6, with only 4% of flowering plants producing seed in 2005 and 2006 (Department of Environment 2009). The major limiting factor preventing pollination in Population 6 was believed to be the absence of an appropriate pollinator (Department of Environment 2009). Similarly, it is thought that the lack of a suitable pollinator may be resulting in low pollination rates in s 45 .

As little is known about the life history characters and long term stability of *Caladenia huegelii* populations (Swarts et al. 2009), surveys such as the one documented in this report are providing important insight towards protecting this Threatened species in s 45 for the future.

7. CONCLUSIONS AND RECOMMENDATIONS

The findings from this study have helped gain important information about the health and size of the *Caladenia huegelii* populations within s 45 at Jandakot Airport. Overall, the orchids within the s 45 in s 45 were in good condition, but the extent of grazing may lead to a decline in population numbers based on the current observed impacts. At this stage, *Caladenia huegelii* has not been found in sufficient numbers to warrant establishing a s 45 . The population of orchids within the s 45 at s 45 represent a large subset of the recorded orchids in the Jandakot area and is therefore of conservation significance.

After analysing the results of the spring survey of *Caladenia huegelii*, the following actions are recommended:

- Continue monitoring the known locations of orchids to better understand local mortality, recruitment, flower development, pollination, and seed production patterns;
- Monitor rates of grazing and implement appropriate management strategies, such as enclosing some localized areas to protect some *Caladenia huegelii* plants;
- Continue monitoring the orchid population at Precinct 1A over sequential years to confirm the identity of the sterile orchids found in 2012.

8. ACKNOWLEDGEMENTS

The authors would like to thank s 47F from Jandakot Airport Holdings Pty. Ltd. for her assistance with this project.

9. LIST OF PERSONNEL

The following Mattiske Consulting Pty Ltd personnel were involved in this project:

Name	Position	Project Involvement	Flora Collection Permit
s 47F	Managing Director & Principal Ecologist	Planning, Management & Reporting	N/A
s 47F	Senior Botanist	Plant identification	N/A
s 47F	Botanist	Planning, fieldwork, plant identification, data interpretation and report preparation	SL009844
s 47F	Botanist	Fieldwork and plant identification	SL009882
s 47F	Botanist	Fieldwork	SL009860

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APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C3: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C4: s 45 ; *Caladenia huegelii* – leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

s 45

PHOTOGRAPH C6: s 45 ; *Caladenia huegelii* - flower

PHOTOGRAPH C7: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C8: s 45 ; *Caladenia huegelii* – a) flower & C) old flower showing swollen ovary

PHOTOGRAPH C10: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C11: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C12: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

s 45

PHOTOGRAPH C13: s 45 1; *Caladenia huegelii* - flower

PHOTOGRAPH C14: s 45 2; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C15: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C16: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C17: s 45 *Caladenia huegelii* - leaf

PHOTOGRAPH C18: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C19: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C20: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C21: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C22: s 45); *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C23: s 45 1; *Caladenia huegelii* - flower

PHOTOGRAPH C24: s 45 *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C25: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C26: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 T S AT JANDAKOT AIRPORT

PHOTOGRAPH C27: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C28: s 45 ; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C29: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C30: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C31: s 45 *Caladenia huegelii* - leaf

PHOTOGRAPH C32: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C33: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C34: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C35: s 45 ; *Caladenia huegelii* - flower

PHOTOGRAPH C36: s 45 *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C37: s 45 ; *Caladenia huegelii* - flower

PHOTOGRAPH C38: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C39: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C40: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C41: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C42: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C43: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C44: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C46: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C47: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C48: s 45 ; *Caladenia huegelii* - flower

PHOTOGRAPH C49: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C50: s 45 ; *Caladenia huegelii* – leaf & undeveloped flower

PHOTOGRAPH C51: s 45 ; *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C52: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C53: s 45 ; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

s 45

PHOTOGRAPH C54: s 45 ; *Caladenia huegelii* – a) flower & C) old flower showing swollen ovary

PHOTOGRAPH C55: s 45 ; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C56: s 45 ; *Caladenia huegelii* - flower

PHOTOGRAPH C57: s 45 ; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C58: s 45 ; *Caladenia huegelii* - flower

PHOTOGRAPH C59: s 45 ; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C60: s 45 *Caladenia huegelii* - leaf

PHOTOGRAPH C61: s 45 *Caladenia huegelii* – undeveloped flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C62: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C63: s 45 ; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C64: s 45 *Caladenia huegelii* - leaf

PHOTOGRAPH C65: s 45 ; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 **S AT JANDAKOT AIRPORT**

PHOTOGRAPH C66: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C67: s 45 *Caladenia huegelii* - leaf

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C68: s 45 *Caladenia huegelii* - leaf

s 45

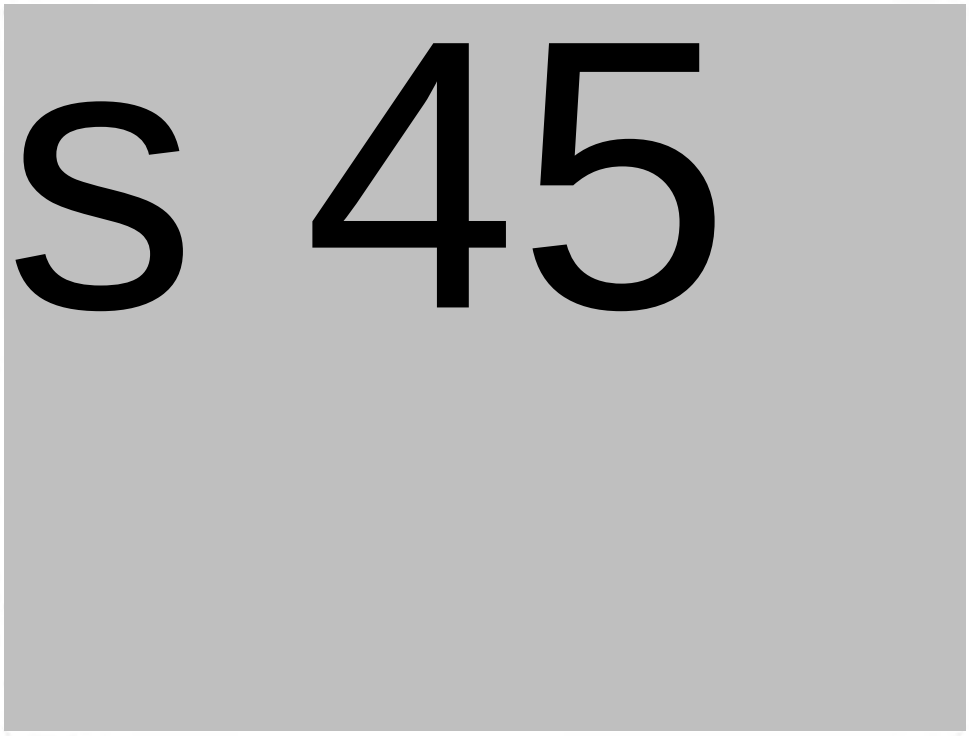
PHOTOGRAPH C69: s 45 ; *Caladenia huegelii* - flower

APPENDIX C: PHOTOGRAPHIC RECORD OF THE ORCHID SPECIES RECORDED WITHIN THE s 45 S AT JANDAKOT AIRPORT

PHOTOGRAPH C70: s 45 ; *Caladenia huegelii* - leaf

PHOTOGRAPH C71: s 45 *Caladenia huegelii* - leaf

APPENDIX D: **PHOTOGRAPHIC RECORD OF THE ORCHID s 45 S WITHIN s 45 S D1. AT JANDAKOT AIRPORT**

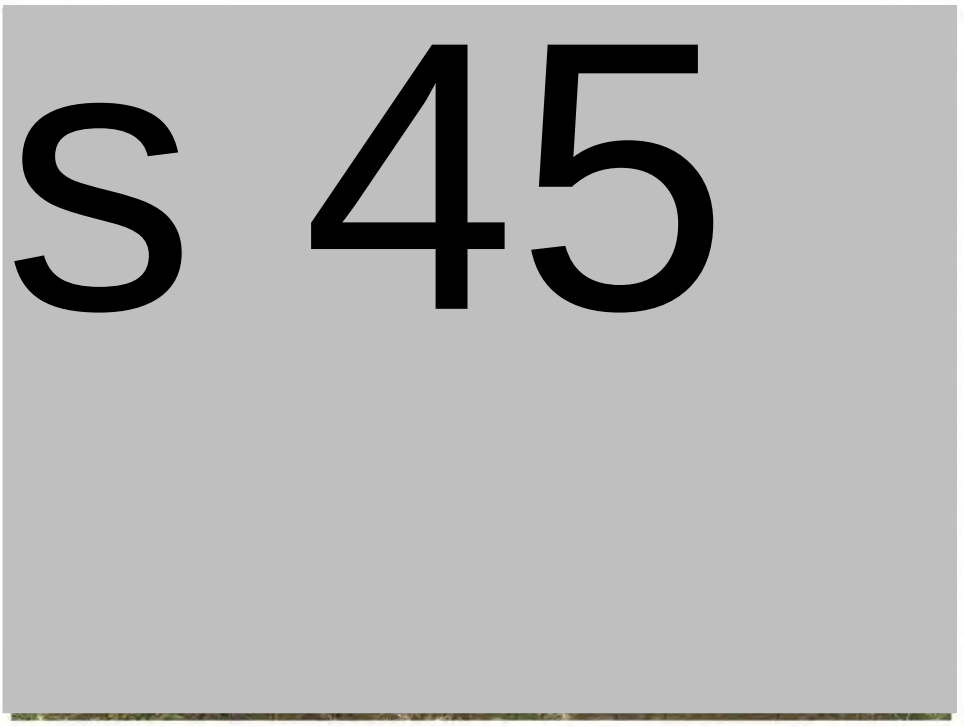


PHOTOGRAPH D1: s 45

PHOTOGRAPH D1: s 45

D2.

APPENDIX D: **PHOTOGRAPHIC RECORD OF THE ORCHID s 45 S WITHIN s 45 'S AT JANDAKOT AIRPORT**



PHOTOGRAPH D1: s 45