



2019 GOLDEN SUN MOTH MONITORING REPORT

Yarralumla Equestrian Park

FINAL

March 2020

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Prepared by
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on behalf of
Suburban Land Agency

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1.0 Introduction

Umwelt Environmental Pty Ltd has monitored the condition of golden sun moth habitat and natural temperate grassland at Yarralumla Equestrian Park (**Figure 1.1**) on behalf of the ACT Government Suburban Land Agency to meet the 2019 annual reporting requirements of the Yarralumla Equestrian Park Offset Management Plan (RJPL 2014a, the OMP). The OMP was prepared to meet specific offset requirements of the Commonwealth Department of Environment and Energy (DoEE) Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) approval decision (EPBC 2012/2692) for mixed-use development proposed for Campbell Section 5, Constitution Avenue, ACT.

The OMP details the requirement for ongoing monitoring of EPBC Act listed endangered Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory, and the EPBC Act listed critically endangered golden sun moth (*Synemon plana*, GSM) populations at the Yarralumla Equestrian Park (YEP) offset area (RJPL 2014a). Subsequent to the approval, the listing of endangered Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory has been revised under the EPBC Act, and areas within the ACT formerly within this community are now classified as the EPBC Act listed critically endangered Natural Temperate Grassland of the South- Eastern Highlands (Australian Government 2016). In this report, the former endangered ecological community and the revised critically endangered ecological community are collectively referred to as natural temperate grassland (NTG) except where a specific reference to the listed ecological community is required. The 2018 monitoring triggered a review of the OMP (RJPL 2014a), which is currently in process. Monitoring has been conducted in accordance with the existing approved OMP (RJPL 2014a).

This report presents the results of monitoring surveys undertaken in November and December 2019 in the YEP offset area. The results are briefly examined in relation to existing site information and the baseline year (i.e. year 0), year 1, year 2, year 3, year 4 and year 5 monitoring data collected during spring and summer from 2013 to 2018 (RJPL 2014b; RJPL 2015; SMEC 2016; SMEC 2017; SMEC 2018; Umwelt 2019). The implications of results are considered in relation to the impact thresholds identified in the OMP.

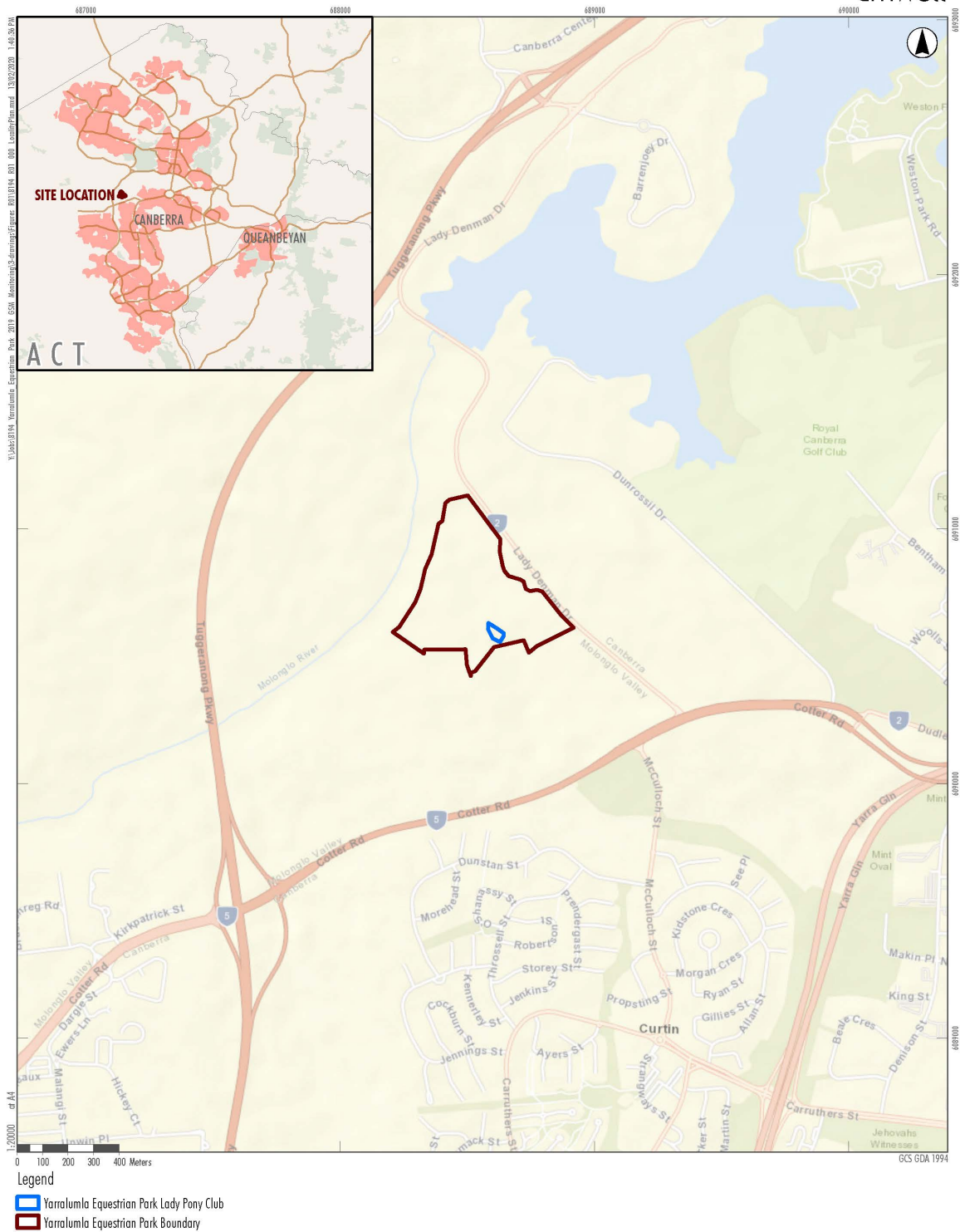


FIGURE 1.1
Locality Plan

Image Sources: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community Data source: Suburban Land Agency (2019)

Figure 1.1 Locality Plan

2.0 Methods

2.1 Regional GSM Information

The start of the GSM flying season was confirmed using known reference sites in the ACT and based on information from other consultants in the ACT, and Conservation Planning and Research, ACT Government (CPR). ACT researchers and consultants shared information regarding the timing and location of GSM sightings, particularly the start of the flying season, via email on a weekly basis during the GSM flying season.

2.2 Survey Area

The survey area comprised the YEP offset area defined in the OMP (RJPL 2014a) (**Figure 2.1**). Traverse routes were located, as defined in the OMP (RJPL 2014a) (**Figure 2.1**). Corrected locations for vegetation quadrats and point-count assessment reported in the year 0 baseline assessment report (RJPL 2014b) were used.

2.3 Revised Vegetation and GSM Habitat Mapping

Mapping of vegetation and potential GSM habitat areas presented in the OMP (RJPL 2014a) and the year 0 (i.e. 2013), year 1 (i.e. 2014), year 2 (i.e. 2015), year 3 (i.e. 2016), year 4 (i.e. 2017) and year 5 (i.e. 2018) monitoring reports (RJPL 2014b; SMEC 2016; SMEC 2017; SMEC 2018; Umwelt 2019) was reviewed by conducting a meandering traverse throughout the site, with close inspection of native pasture and NTG areas. The distribution of native grassland and GSM habitat, the distribution of exotic perennial tussock grasses was updated in accordance with the OMP (RJPL 2014a).

2.4 Native Pasture and Natural Temperate Grassland Monitoring

The following methods were used to assess the condition of natural temperate grassland:

- 4 x 4 metre floristic quadrats analysed with Rehwinkel (2007) for comparison with previous results (RJPL 2014a) (**Figure 2.1**)
- Additional 20 x 20 metre floristic quadrats analysed with Rehwinkel (2015) for comparison against revised NTG community listing (Australian Government 2016) and consistency with ACT Government practises (**Figure 2.1**)
- Qualitative assessment using the NTG scale of Nash and Hogg (2013) for comparison with previous results (RJPL 2014a)
- Additional 25 m transects to assess the dominant component of groundcover (**Figure 2.1**).

As specified in the OMP (RJPL 2014a), a modified version of Rehwinkel (2007) was used to quantitatively determine relative floristic value scores for native pasture and NTG within each quadrat (Appendices C and D of the OMP (RJPL 2014a)), consistent with ACT Government guidelines for assessing NTG (ACT Government 2010a). To ensure consistency and allow comparison with previous years, quadrats were assessed using the floristic value scores based on both Rehwinkel (2007) and Rehwinkel (2015).

NTG condition was reviewed against the criteria for the revised NTG community listing (Australian Government 2016). Threshold values for determining the classification of NTG were determined from the listing criteria (Australian Government 2016). Floristic value scores referenced in these thresholds relate

to the updated method of Rehwinkel (2015) measured at 20 x 20 metre plots and are not comparable to those for long-term monitoring of the 4 x 4 metre plots (Rehwinkel 2007).

To meet criteria for classification as NTG, the patch must be >0.1 hectares (e.g. 20 m x 50 m), within the defined region and altitude, and apparently naturally treeless or sparsely treed, and it must meet criterion A or B:

- Criterion A: contains a foliage cover of more than 50% *Themeda triandra* (Kangaroo Grass) or *Poa labillardierei* (River Tussock) – or *Carex bichenoviana* (Plains Sedge) if the patch is an ephemeral wetland
- Criterion B: contains a greater percentage cover of native plants (including annual and perennial species but not cryptogams) than of perennial exotic species (including weeds), AND in favourable sampling times (generally spring and early summer, and in non-drought affected seasons) it has:
 - at least 8 non-grass native species, or
 - at least 2 indicator species, or
 - a floristic value score of at least 5
 or at other sampling times it has:
 - at least 4 non-grass native species, or
 - at least 1 indicator species, or
 - a floristic value score of at least 3.

Thresholds for favourable sampling times were applied.

Due to the absence of a minimum size criteria for the former EPBC Act listed endangered Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory, the minimum size restriction was not considered as part of the thresholds when monitoring the extent of NTG at this site. The application of this threshold would result in artificial changes in the extent of NTG present.

Qualitative assessment of natural temperate grassland and native pasture using the NTG scale of Nash and Hogg (2013) was undertaken at each quadrat. This qualitative assessment comprises a grassland ranking system which considers the cover of native grasses, native forbs, exotic annual grasses and exotic perennial grasses and varies from 1 (only marginally native with high exotic perennial component and a high proportion of exotic annual species) to 10 (predominantly native groundcover with high forb diversity, including many significant species).

Ten transects were sampled to assess the dominant component of groundcover at such locations. The transects were placed within the 4 m x 4 m quadrats or adjacent to the quadrats. Groundcover was sampled at 50 points along each transect which measured 25 metres in length. At each point the presence of the 13 attributes was recorded at each of the 50 sampling points, namely cryptogams, bare earth, rock, litter, Chilean needle grass, serrated tussock, annual exotic grass, perennial exotic grass, exotic broadleaf, wallaby grass, *Austrostipa* sp., perennial native grass and other to determine the relative extent of each component along each transect.

2.5 GSM Flying Surveys

Flying GSM surveys were conducted according to the protocol outlined in the OMP (RJPL 2014a Appendix F), with additions to improve consistency with the ACT Government protocols for monitoring GSM in offset sites (2010b) GSM (**Figure 2.1**). Three sampling methods were undertaken to survey GSM during 2019, being:

- Rotational point counts for comparison with surveys conducted from 2013-2018 (RJPL 2014a)
- 1 hour traverse for comparison with surveys conducted from 2013-2018 (RJPL 2014a)
- 100m transect survey for consistency with ACT Government Offset monitoring protocols for GSM.

As specified in the OMP (RJPL 2014a), rotational point counts were conducted at the monitoring quadrats located throughout the YEP offset area according to the following protocol:

- Locate each of the quadrats used for the vegetation and habitat assessments using GPS
- While standing in the middle of each quadrat, count all GSM observed in and beyond the quadrat to approximately 20 m while rotating through 360°
- Record GSM numbers on the Flying GSM survey data sheet (RJPL 2014a Appendix G)
- Wait 30 seconds
- Repeat Steps 2-4, nine more times
- Average the GSM count at each site and enter the result on the flying GSM survey data sheet (RJPL 2014a Appendix G).

A timed traverse survey was undertaken, as specified in the OMP (RJPL 2014a Appendix F). During the 2013 baseline survey, the transect route indicated in Figure 5 of the OMP (RJPL 2014a) was confirmed as an appropriate route for the timed traverse survey. As specified in the OMP (RJPL 2014a), the following protocol was followed:

- Follow the mapped traverse identified in the OMP as closely as practicable
- Note the time when starting to walk the traverse
- Count all GSM observed while walking slowly and steadily along the traverse
- Note the time once the traverse is completed
- Record GSM numbers and times on the Flying GSM survey data sheet (RJPL 2014a Appendix G)
- Calculate the number of GSM observed per minute.

Fifteen 100 metre fixed transect surveys were conducted covering the main areas of habitat at YEP. The timed transect surveys were added to the survey program at YEP in 2018 to improve consistency with standard ACT Government GSM survey programs to allow standardised between-site analysis in flying moth numbers. The following protocol was followed:

- Follow the pre-defined 100-metre transects
- Note the time and weather conditions when starting to walk each transect

- Count all GSM observed while walking slowly and steadily along transects
- Note the end time of each transect survey
- Record data as per the ACT Government GSM Survey Protocol
- Calculate the number of GSM observed per minute.

On-site weather data was recorded during all flying GSM field surveys. Incidental GSM observations were also recorded during other site visits and between surveys.

Female golden sun moths and pupa cases were recorded separately from the timed surveys. The records were identified as incidental observations.

2.6 GSM Habitat Monitoring

As specified in the OMP (RJPL 2014a), a qualitative GSM habitat assessment was undertaken in each of the twelve monitoring quadrats using the GSM habitat quality scoring system of Hogg (2012, Appendix H of the OMP), which takes into consideration both grassland condition and GSM activity.

2.7 Meteorological Data

Meteorological data for Canberra Airport from 1 January 2013 to 31 December 2019 was obtained from the Bureau of Meteorology.

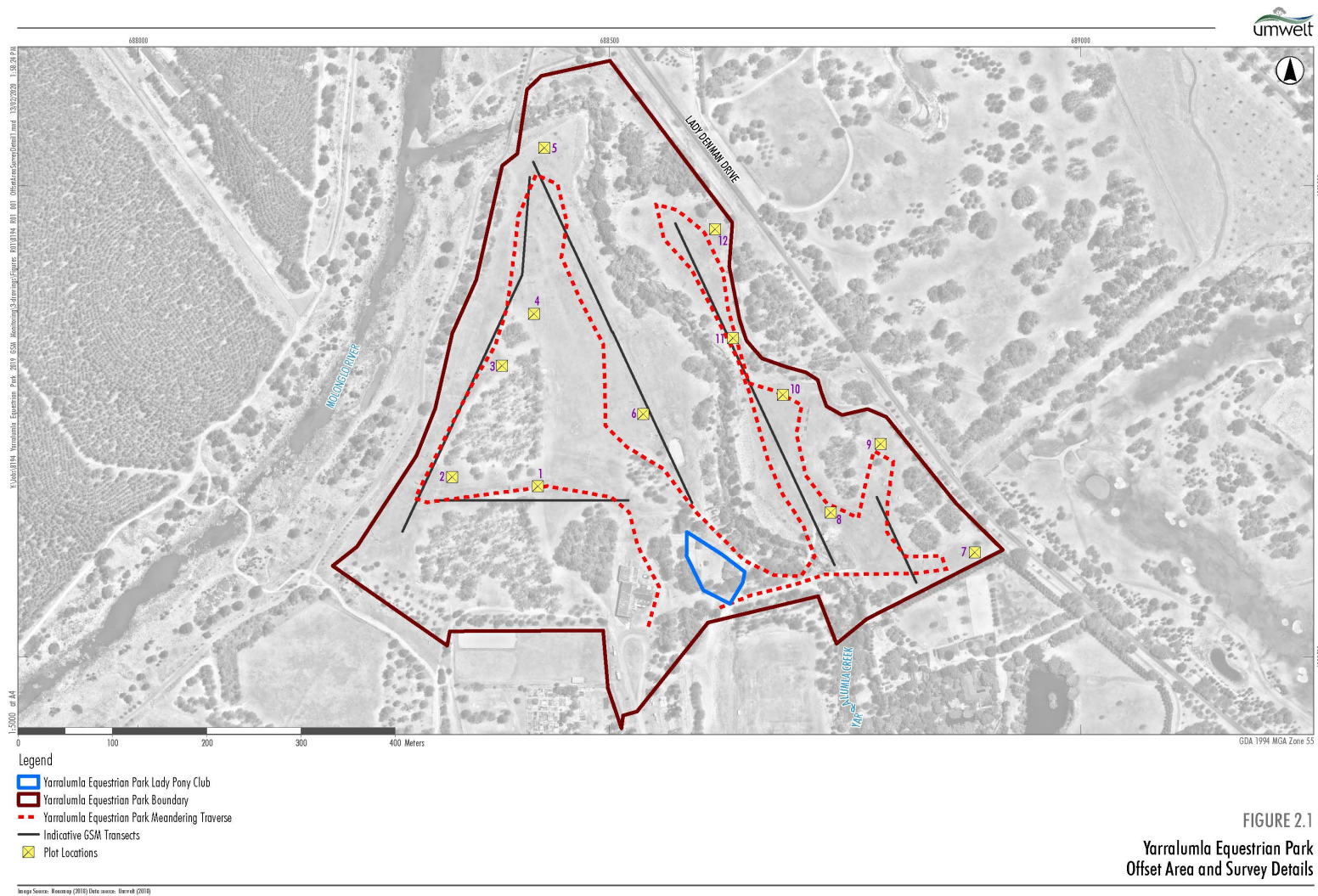


FIGURE 2.1
Yarralumla Equestrian Park
Offset Area and Survey Details

Figure 2.1 Yarralumla Equestrian Park Offset Area and Survey Details

3.0 Results

3.1 Regional GSM Information

Golden sun moth surveys commenced during the known local flight season, based on informal consultation with local specialists (including ACT and New South Wales Government ecologists and consultants). The start of the 2019 flying season was confirmed at numerous sites in late October following observation of 10 individuals at Ainslie on 24 October 2019. This early start to the local season is likely a result of the hot and dry spring conditions. The local season appeared to be largely over by early-mid December 2019.

3.2 Vegetation and GSM Habitat Mapping

Vegetation mapping, step-point transects, and GSM habitat mapping were conducted on 29, 30 October 2019 and 1 November 2019 (**Figure 3.1**) shows the distribution of vegetation communities mapped at YEP in 2019. Summaries of the areas of each vegetation community are shown in **Table 3.1**. The distribution of significant weeds at YEP is shown in **Figure 3.2**. Chilean needle grass (*Nassella neesiana*) and African lovegrass (*Eragrostis curvula*) occur in small to large patches throughout YEP. Patches of serrated tussock (*Nassella trichotoma*) also occur at several locations across YEP. GSM habitat extent within YEP is summarised in **Table 3.2** and shown in **Figure 3.3**. Low to moderate quality GSM habitat persists across the majority of the grassland present at YEP.

Table 3.1 2019 summary of vegetation and land use mapping

Vegetation type / land use	2019 (ha)
Natural temperate grassland	0.5
Native pasture	0.9
Mixed native and exotic pasture	4.7
Exotic pasture	7.6
(Construction area)	0.0
(Non-grassland areas (e.g. buildings, riparian margins, woodland))	8.0
Total Project Area	21.6¹
Chilean needle grass	3.2
African lovegrass	3.0

Note: A recalculation of the total project area was undertaken and has resulted in an increase in the total size, however, this would not have a substantial effect on the results.

Table 3.2 2019 summary of GSM habitat areas

GSM habitat area	2019 (ha)
Low quality	5.8
Low-quality habitat dominated by Chilean needle grass	2.9
Moderate quality	1.1
High quality	0.0
Total	9.9

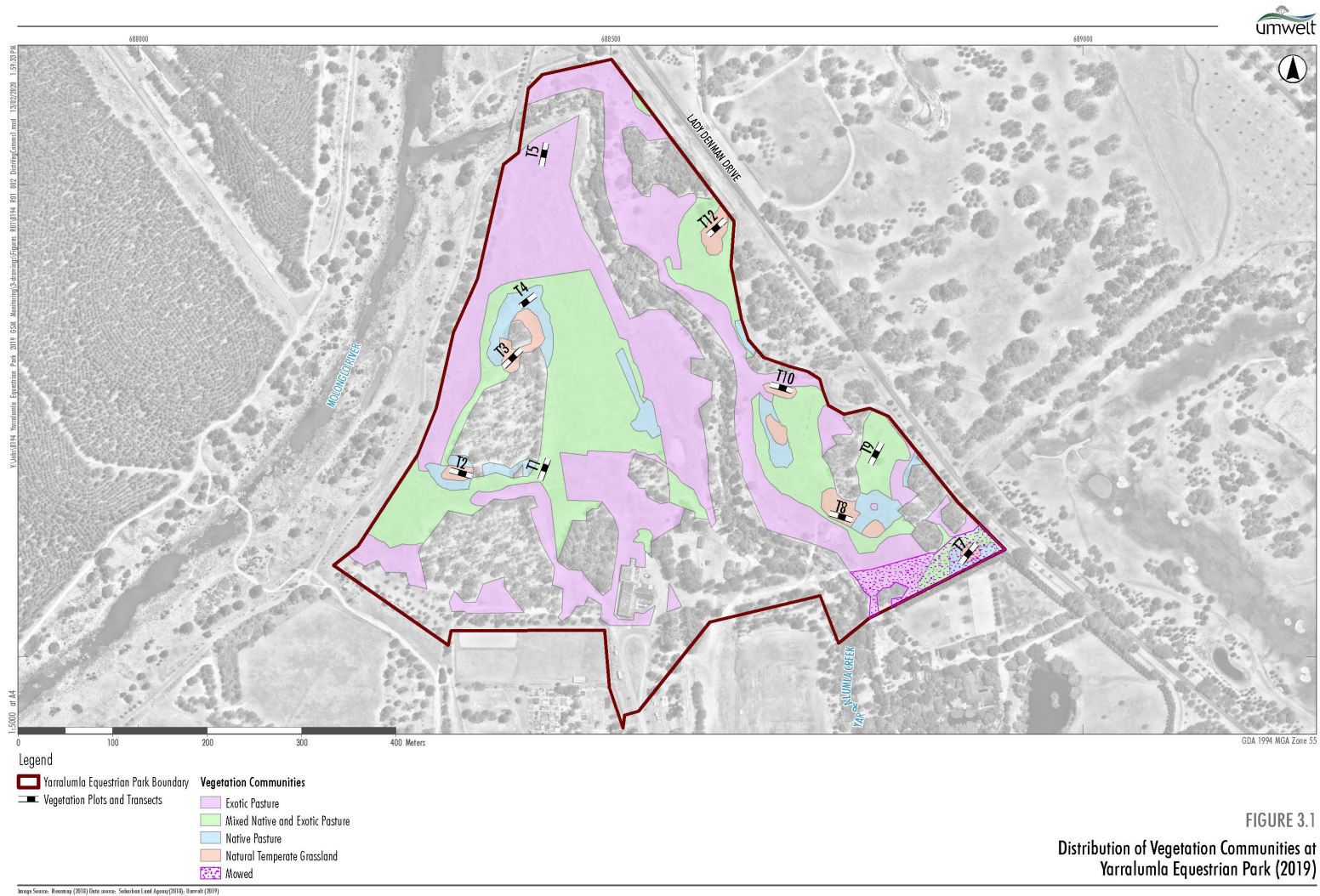


Figure 3.1 Distribution of Vegetation Communities at Yarralumla Equestrian Park (2019)

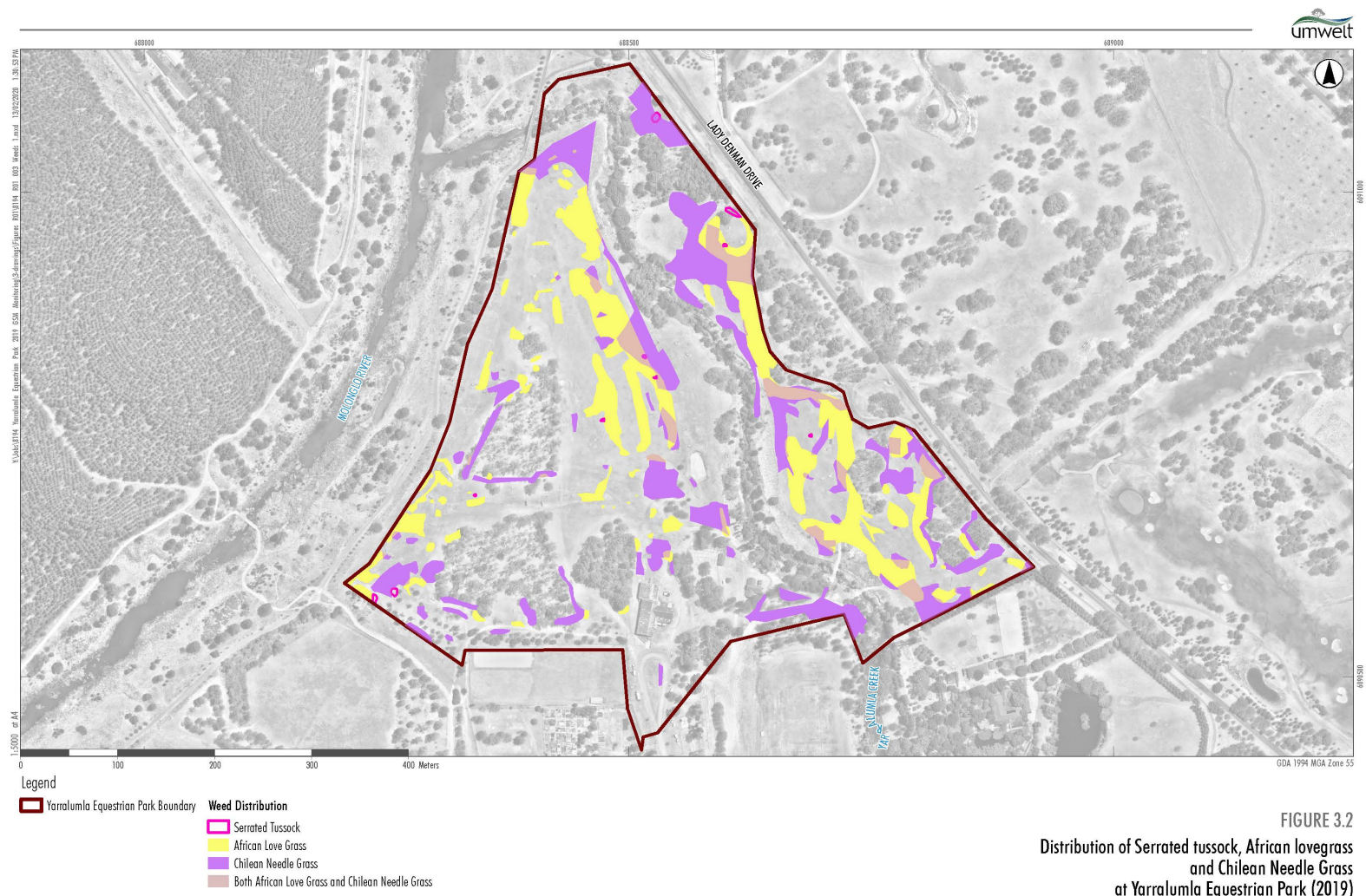


FIGURE 3.2
Distribution of Serrated tussock, African lovegrass and Chilean Needle Grass at Yarralumla Equestrian Park (2019)

Figure 3.2 Distribution of serrated tussock, African lovegrass and Chilean needle grass at Yarralumla Equestrian Park (2019)

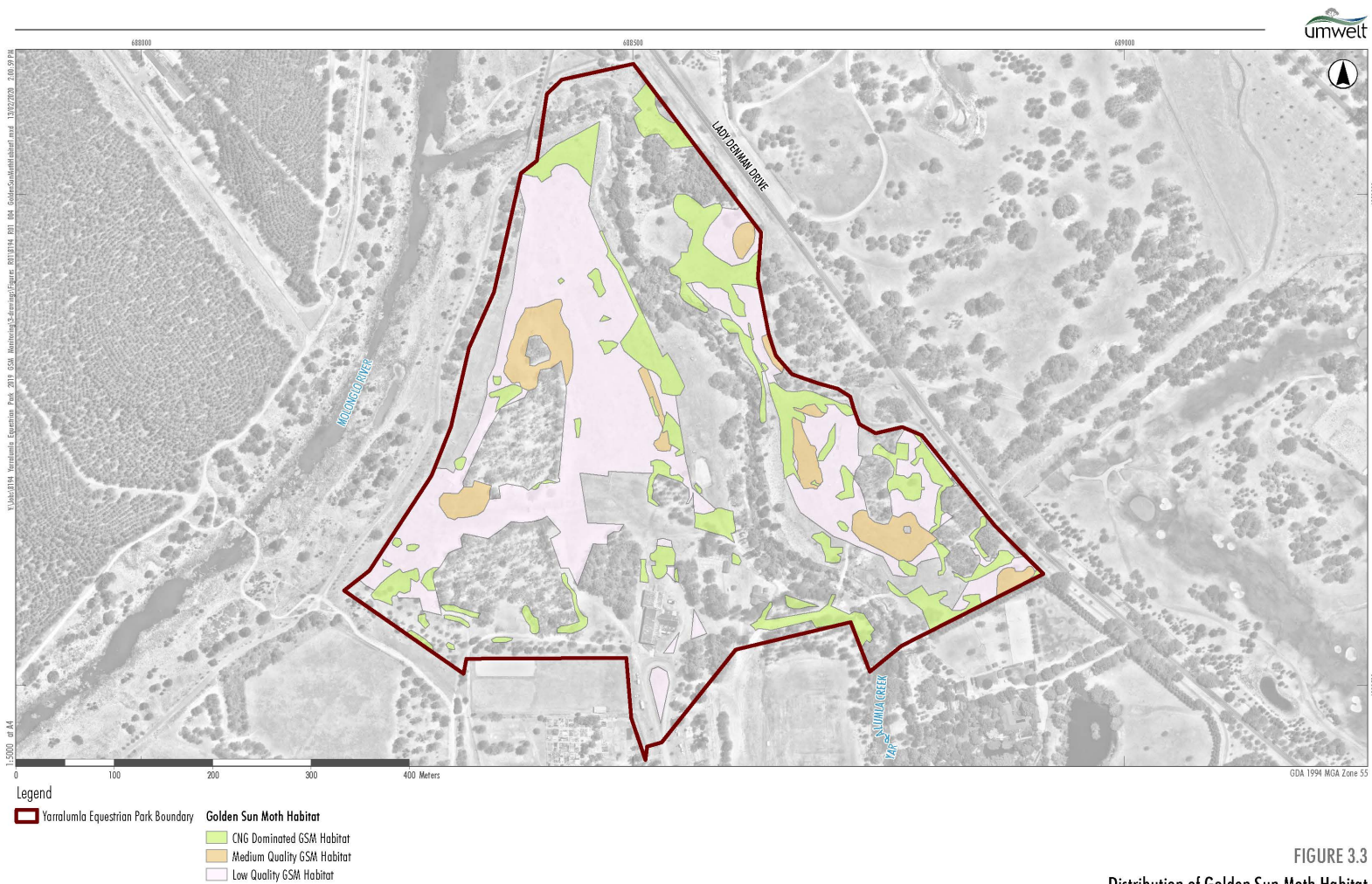


FIGURE 3.3
Distribution of Golden Sun Moth Habitat
at Yarralumla Equestrian Park (2019)

Image Source: Bingmap (2019) Data source: Salween Land Agency (2013), Herold (2019)

Figure 3.3 Distribution of Golden Sun Moth habitat in Yarralumla Equestrian Park (2019)

3.3 Native Pasture and Natural Temperate Grassland Monitoring

Grassland monitoring was conducted on 29, 30 October and 1 November 2019, following an extended dry period. Plant species, Braun-Blanquet abundance scores and a qualitative assessment of grassland quality based on the scale prepared by Nash and Hogg (2013) were recorded for each quadrat (**Table 3.4**). **Table 3.5** presents a summary of the key vegetation quality indicators, including the quantitative site value score calculation based on Rehwinkel (2007) and qualitative grassland quality and GSM habitat quality scores. In 2017, 2018 and 2019 floristic value scores were also calculated according to Rehwinkel 2015, to facilitate consideration against criteria for inclusion in the revised NTG listing (**Table 3.4**). Data is presented in **Appendix A**.

To assess sites against criteria for inclusion in the revised EPBC Act-listed critically endangered natural temperate grassland community (Australian Government 2016), the updated floristic value score calculation described in Rehwinkel (2015) was applied, all quadrats except for quadrats 1,5 and 9 were identified as NTG (**Figure 3.1**). Assessment of the site against the updated criteria for the critically endangered community listings for the 20 m² quadrats are shown in **Table 3.5**.

Appendix A and **Table 3.3** present the results of the 25-metre transects. Chilean needle grass was observed on four transects and African lovegrass was observed in seven transects. No serrated tussock was observed on the transects. Chilean needle grass was most prevalent at transects five and nine whilst African lovegrass was most prevalent at transects four and 11 (**Table 3.3**). Transect data was collected in 2018 but not reported in the monitoring report (Umwelt 2019).

Table 3.3 Proportion of Chilean needle grass, African lovegrass, perennial exotic grass and perennial native grass at transects.

Transect	Chilean needle grass	African lovegrass	Perennial exotic grass	Perennial native grass
1	0.00	0.00	0.05	0.10
2	0.00	0.06	0.47	0.18
3	0.00	0.00	0.64	0.36
4	0.00	0.42	0.03	0.52
5	0.28	0.00	0.00	0.35
6	0.03	0.11	0.44	0.36
7	0.00	0.00	0.62	0.11
8	0.00	0.03	0.53	0.13
9	0.38	0.06	0.13	0.69
10	0.03	0.00	0.69	0.11
11	0.00	0.38	0.03	0.92
12	0.00	0.03	0.72	0.08

Table 3.4 2019 vegetation survey results

Quadrat	Number of native species 4x4m plot (20x20m plot)	Number of exotic species 4x4m plot (20x20m plot)	Number of significant weeds 4x4m plot (20x20m plot)	Floristic value score (Rehwinkel 2007)	Floristic value score (Rehwinkel 2015) (4x4m plot)	Floristic value score (Rehwinkel 2015) (20x20m plot)	Grassland quality score (4x4m plot)	GSM habitat quality score (4x4m plot)
1	2 (3)	8 (11)	1 (1)	0	0.40	0.54	N/A	N/A
2	4 (6)	10 (12)	0 (0)	1	4.15	6.34	4A	5
3	3 (9)	4 (16)	2 (3)	1	1.51	10.92	4A	4
4	0 (5)	8 (18)	0 (2)	0	0	5.17	N/A	2
5	4 (4)	13 (19)	2 (2)	1	3.65	3.83	N/A	1
6	7 (14)	8 (14)	2 (2)	1	4.77	8.67	4A	4
7	6 (14)	14 (19)	0 (1)	2	3.46	9.31	5A	4
8	6 (15)	10 (15)	2 (2)	4	5.44	12.62	4A	5
9	2 (5)	11 (13)	3 (3)	0	0.22	1.30	N/A	N/A
10	9 (9)	15 (18)	1 (3)	8	7.29	10.29	5A	5
11	2 (7)	9 (17)	1 (2)	1	2.44	15.29	1	N/A
12	10 (11)	8 (13)	2 (2)	5	9.54	12.31	5A	4

Table 3.5 Summarised assessment against Commonwealth criteria for the EPBC Act-listed natural temperate grassland critically endangered ecological community based on floristic data and site characteristics for the 20 m² quadrats

Quadrat (Threshold)	Mapped Condition	Number of non-grass native species (8)	Number of indicator species (2)	Floristic value score (5)	Meets natural temperate grassland criteria (Australian Government 2016)
1	Mixed native and exotic	1	0	0.54	No
2	Native grassland	3	2	6.34	Yes
3	Native grassland	5	4	10.92	Yes
4	Native pasture	4	2	5.17	Yes
5	Exotic pasture	3	1	3.83	No
6	Native pasture	2	6	8.67	Yes
7	Native grassland	9	4	9.31	Yes
8	Native grassland	8	4	12.62	Yes
9	Mixed native and exotic	1	0	1.30	No
10	Native grassland	4	3	10.29	Yes
11	Mixed native and exotic	4	2	15.29	Yes
12	Native grassland	6	3	12.31	Yes

3.4 GSM Flying Surveys

All surveys were conducted between 11:00 and 13:30 on warm, sunny days with light winds (**Table 3.6**). Point count survey data is presented in **Appendix B** and a complete list of GSM records is presented in **Appendix C**.

Table 3.6 Weather conditions during GSM flying moth surveys

Date	Temperature (°C)	Last rainfall (mm)	Wind speed (km/h)	Cloud cover
30/10/19	22	7.6 (26 Oct)	Still	Scattered (<30%)
15/11/19	23-25	12.4 (4 Nov)	Fresh (29-38)	Scattered (<30%)
20/11/19	24-28	12.4 (4 Nov)	Light (<11)	Fine

Flying moth surveys were undertaken during the peak period of GSM activity in the ACT and are consequently valid representations of GSM activity levels at the YEP offset site.

The locations of GSM records collected during the traverse surveys are shown in **Figure 3.4** and **Figure 3.5**. A total of 34 GSM were recorded during the traverse survey on 30 October, 70 on 15 November and 80 on 20 November 2019 (**Table 3.7**).

Table 3.7 Summary of traverse survey results

Date	Survey	Start	Finish	Total Time (min)	Number of observations	Total GSM	Max GSM	GSM/min
30/10/19	1	11:19	12:10	49	13	34	10	0.69
15/11/19	2	10:58	12:02	64	35	70	5	1.09
20/11/19	3	13:41	15:04	70	Not recorded	80	Not recorded	1.14

GSM was recorded at 14 of the 15 transects with the highest numbers occurring at transects 4B, 4C and 4D (**Table 3.8**) (**Figure 3.6**). GSM numbers averaged across the three surveys corresponded with low activity levels (<6 per minute) at transects 1A, 2A, 2B, 2C, 2D, 3A, 3B, 3C, 3D and 5A, and low-moderate activity levels at the remaining sites.

GSM was recorded at all rotational survey points except point five with the highest numbers being recorded on 20 November 2019 at point ten (**Table 3.9**) (**Figure 3.4**). GSM activity levels varied between rotational points from low to moderate based on the semi-quantitative GSM site assessment method abundance categories developed by David Hogg Pty Ltd (2010). The highest numbers of GSM were recorded at points 8 and 10 whilst the lowest numbers were observed at points 3, 5, 6, 7, 9 and 12.

Table 3.8 Summary of transect survey results

Transect	S1 Total GSM	S2 Total GSM	S3 Total GSM	Total GSM	Average GSM
1A	0	2	14	16	5.3
1B	1	0	25	26	8.7
2A	0	3	4	7	2.3
2B	0	1	16	17	5.7
2C	0	1	9	10	3.3
2D	0	2	12	14	4.7
3A	0	0	0	0	0.0
3B	0	3	5	8	2.7
3C	0	0	1	1	0.3
3D	0	1	14	15	5.0
4A	0	4	18	22	7.3
4B	0	7	40	47	15.7
4C	0	6	25	31	10.3
4D	0	2	28	30	10.0
5A	0	3	1	4	1.3

Table 3.9 Summary of rotational survey results

Point	Survey 1 Average	Survey 1 Max	Survey 2 Average	Survey 2 Max	Survey 3 Average	Survey 3 Max	Combined Average	Combined Max
1	0.1	1	0	0	3	6	1	6
2	0	0	0	0	3.1	5	1	5
3	0	0	0	0	0.8	2	0.3	2
4	0.1	1	1	10	0.9	3	0.7	10
5	0	0	0	0	0	0	0	0
6	0.1	1	0	0	0.3	1	0.1	1
7	0.3	2	0	0	0.2	1	0.2	2
8	0	0	3.8	8	6.2	15	3.3	15
9	0	0	0.1	1	1.4	3	0.5	3
10	0	0	2.1	6	15.9	25	6	25
11	0	0	0.4	3	3.8	10	1.4	10
12	0	0	0	0	1.5	3	0.5	3

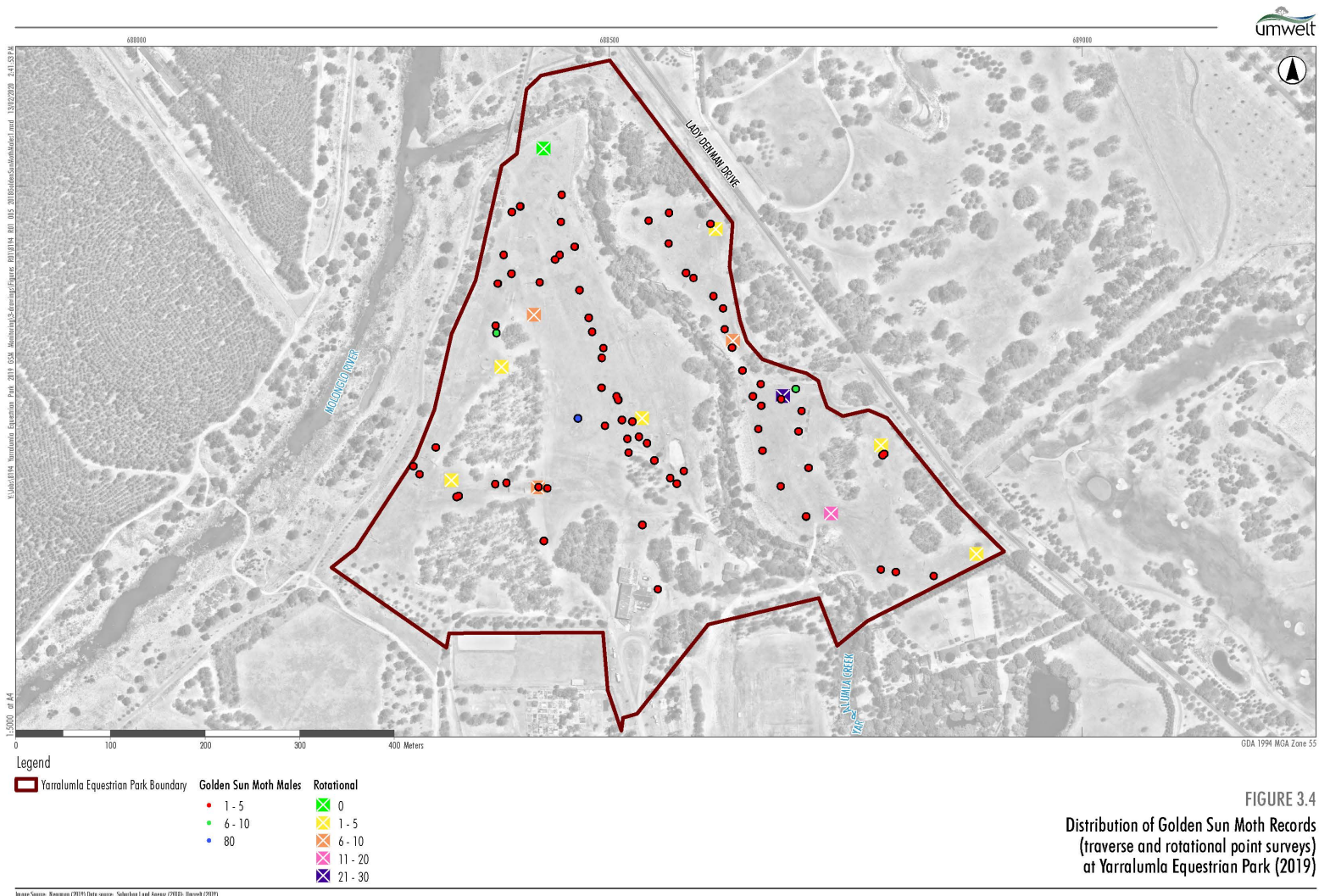
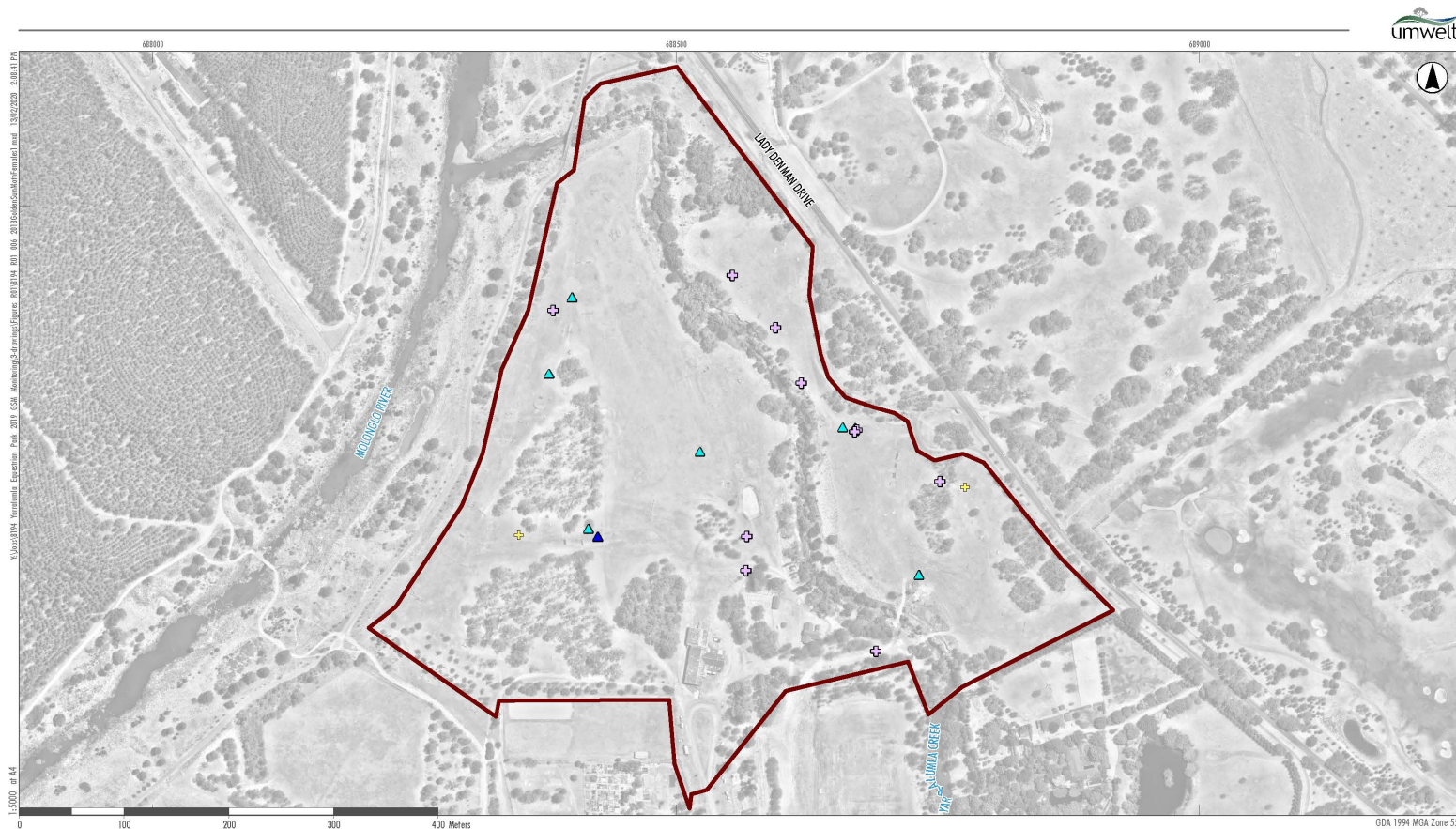


FIGURE 3.4
Distribution of Golden Sun Moth Records
(traverse and rotational point surveys)
at Yarralumla Equestrian Park (2019)

Figure 3.4 Distribution of Golden Sun Moth records (traverse and rotational point surveys) at Yarralumla Equestrian Park (2019)



Legend

Yarralumla Equestrian Park Boundary	Golden Sun Moth Females	Pupa Cases
	1	1 - 5
	2	6 - 10

FIGURE 3.5
Distribution of Golden Sun Moth Records
(female moths and pupae cases) at
Yarralumla Equestrian Park (2019)

Image Source: Resmap (2017) Data source: Sebastian Lind Agency (2014), Umwelt (2019)

Figure 3.5 Distribution of Golden Sun Moth records (female moths and pupae cases) at Yarralumla Equestrian Park (2019)

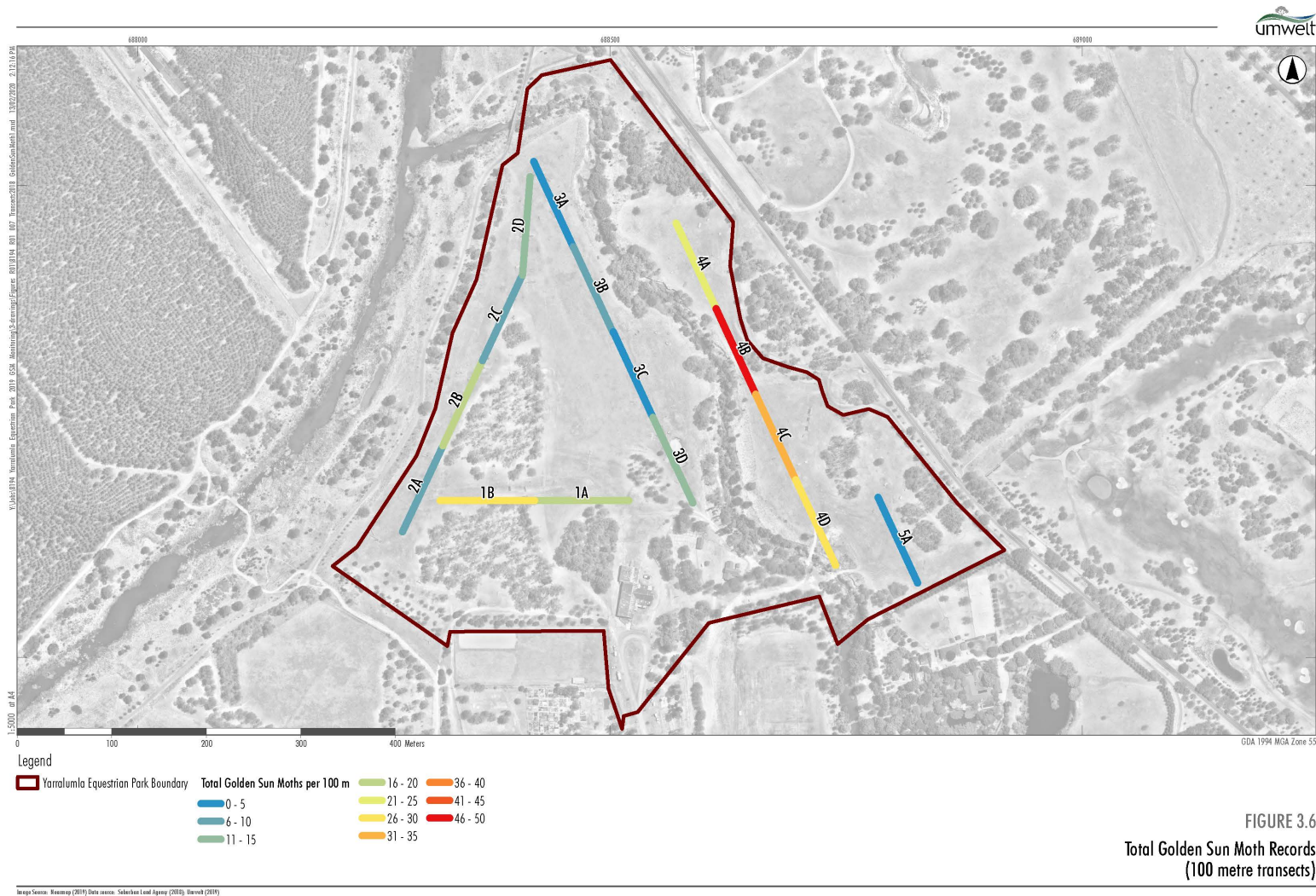


FIGURE 3.6
Total Golden Sun Moth Records
(100 metre transects)

Figure 3.6 Total Golden Sun Moth records (100 metre transects)

3.5 Incidental Observations

Female GSM and pupa cases were recorded as incidental observations which are shown in **Figure 3.5**. One female was recorded during the vegetation assessment on 1 November 2019, five on 15 November during the traverse survey and nine on 20 November during the traverse survey. A total of 10 pupa cases were recorded on 15 November 2019 and 15 on 20 November 2019 (cf. 39 in 2018 and zero in 2017). Sixty-one male GSM were recorded during the vegetation assessment on 1 November 2019.

3.6 GSM Habitat Monitoring

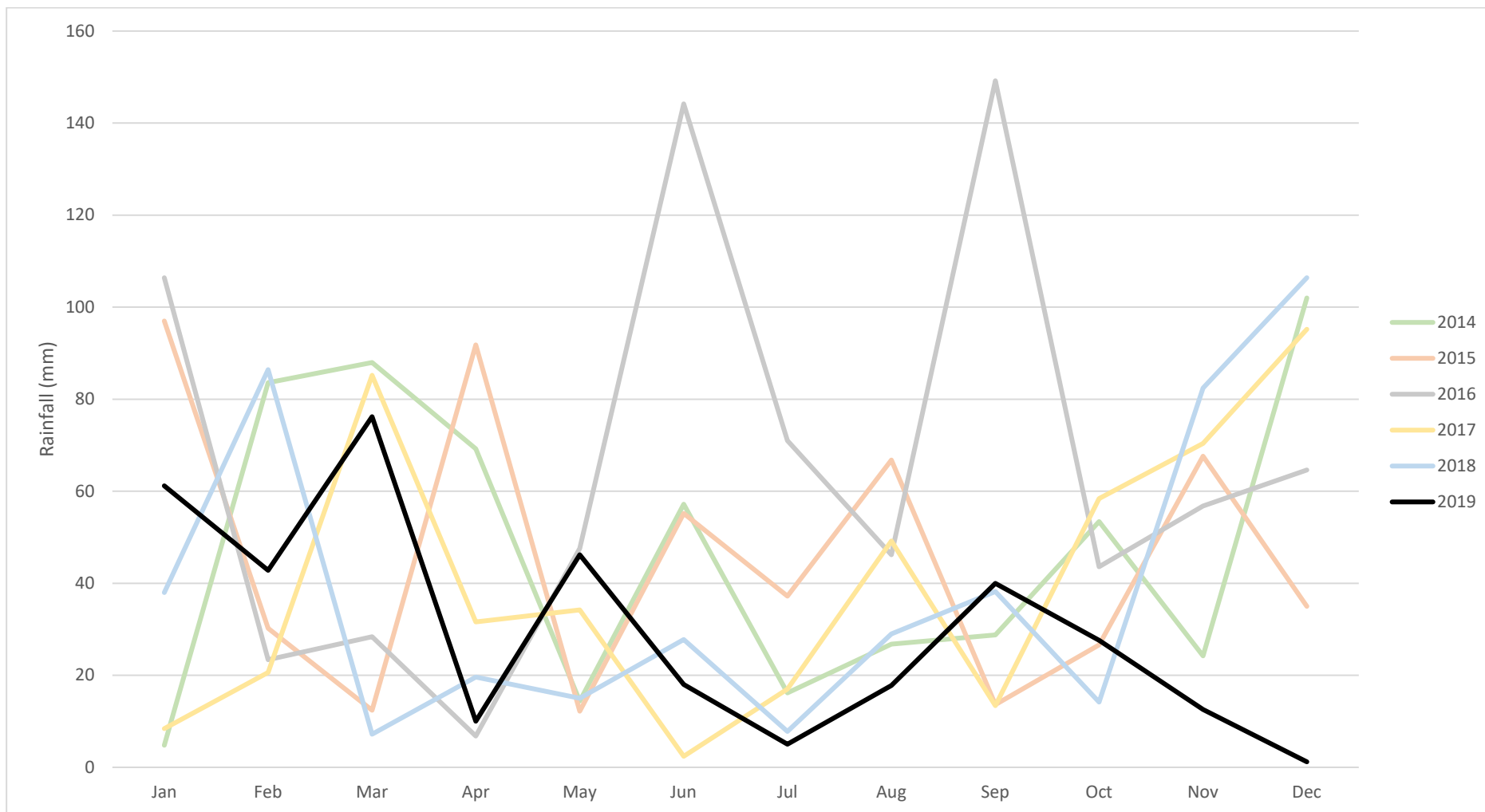
GSM habitat ranking scores (Nash and Hogg 2013) for each quadrat are presented in **Table 3.10**. Quadrats 1, 9 and 11 did not meet thresholds for classification as GSM habitat.

Table 3.10 GSM habitat ranking score (2018)

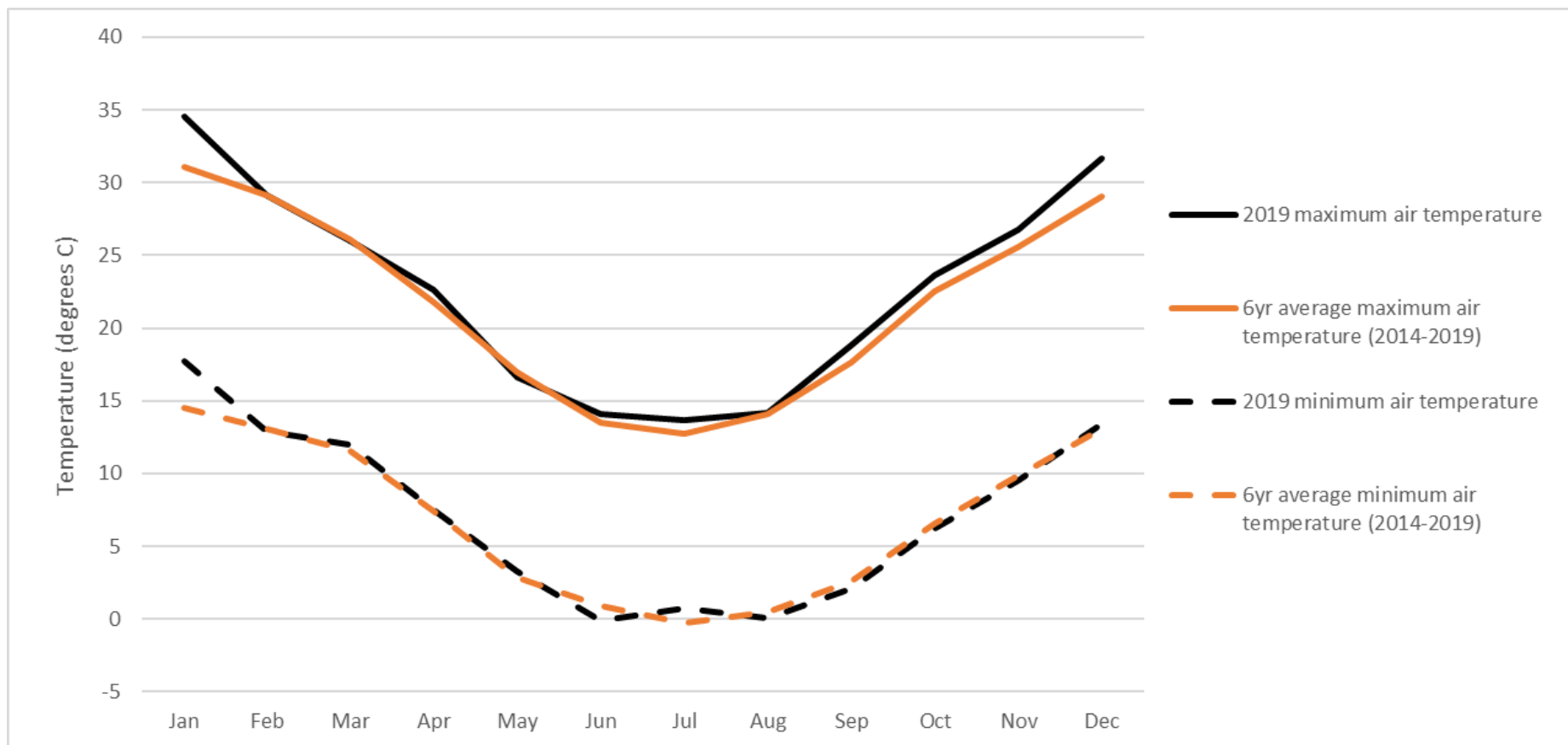
Quadrat	GSM Habitat Ranking Score
1	N/A
2	5
3	4
4	2
5	1
6	4
7	4
8	5
9	N/A
10	5
11	N/A
12	4

3.7 Meteorological Data

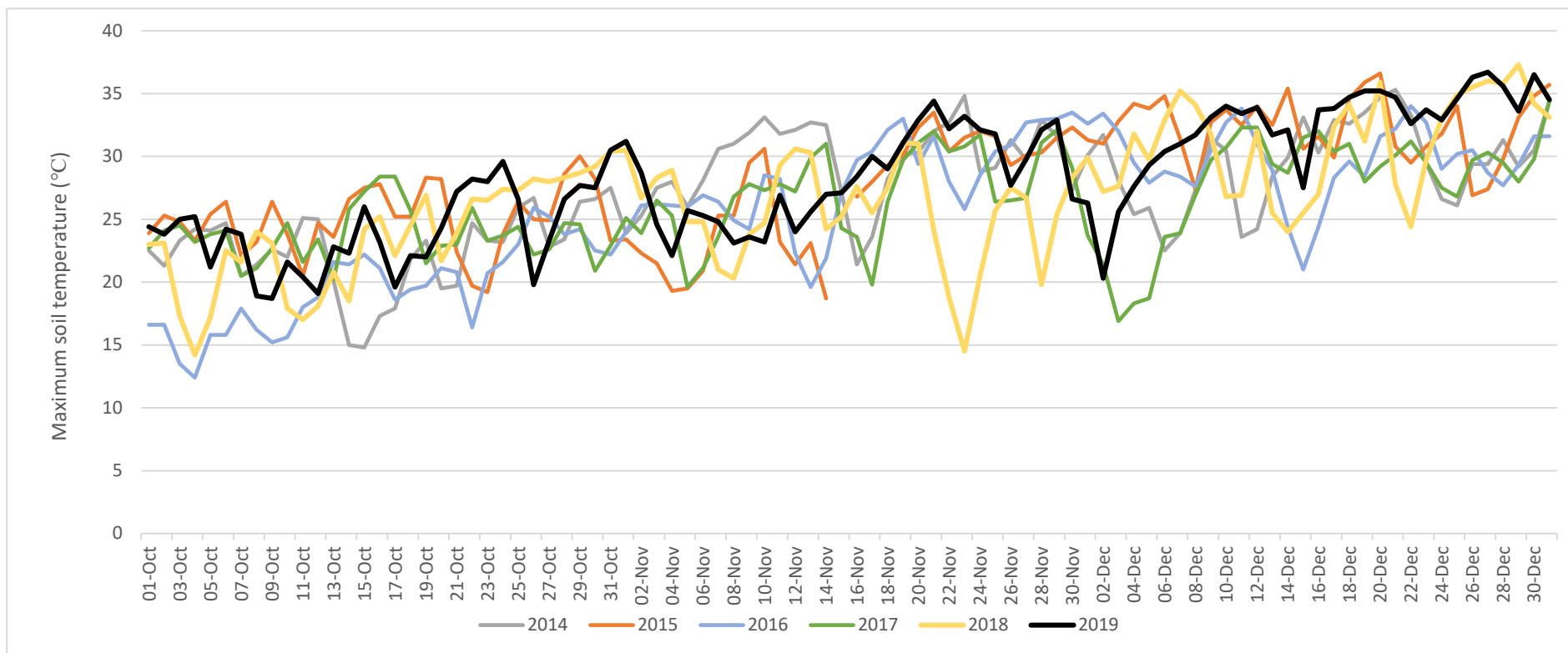
Where applicable survey data is interpreted with reference to summarised meteorological data for the season. Monthly rainfall and average daily maximum and minimum air temperatures (2014-2019) are presented in **Graph 3.1** and **Graph 3.2** respectively. Total rainfall during the months leading up to the GSM 2019 flying season (i.e. June to October: 108.4 mm) was far lower than the 10-year average (i.e. 229.6 mm) and slightly lower than during the same period in 2017 and 2018 (i.e. 140.4 and 117.0 mm respectively). Rainfall during the 2019 flying season (i.e. November / December: 13.8 mm) was extremely low being far lower than the 10-year average (i.e. 149.6 mm) and considerably lower than during the same period in 2017 and 2018 (i.e. 165.5 and 188.8 mm respectively). Monthly average daily maximum and minimum soil temperatures recorded at 10 cm depth for 2014- 2019 is presented in **Graph 3.3**. **Graph 3.4** shows daily maximum soil temperature and **Graph 3.5** shows daily precipitation leading up to and during the past six GSM flying seasons (i.e. October to December). All relevant meteorological data from 2014 to 2019 are presented in **Appendix D** and **Appendix E**. All meteorological data presented in this report were recorded at the Canberra Airport (i.e. site 070351).



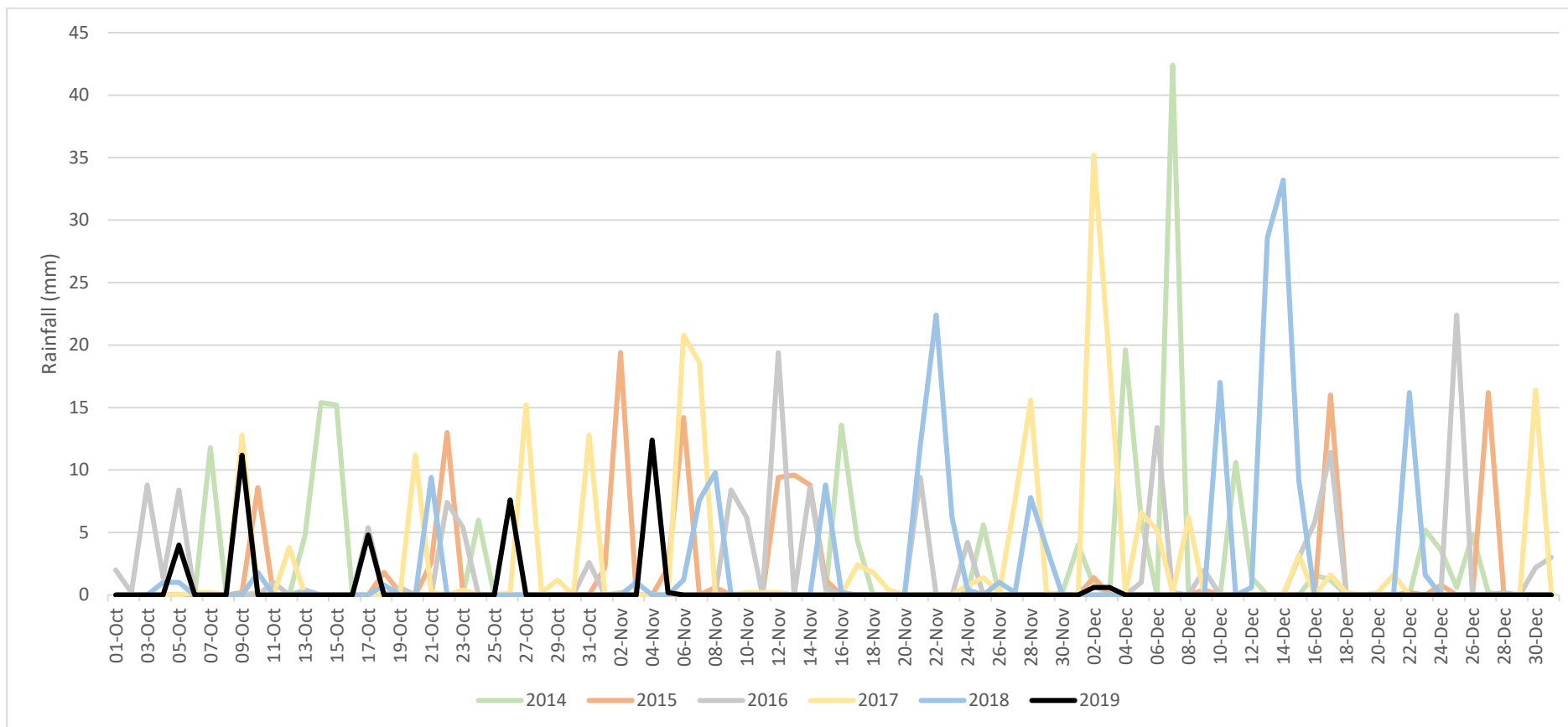
Graph 3.1 Monthly rainfall at Canberra Airport (2014-2019)



Graph 3.2. Monthly average daily maximum and minimum temperature at Canberra Airport (2019 vs 2013-2018 average)



Graph 3.3 Maximum daily soil temperature at Canberra Airport leading up to and during the GSM flying period (1 October – 31 December 2014-2019)



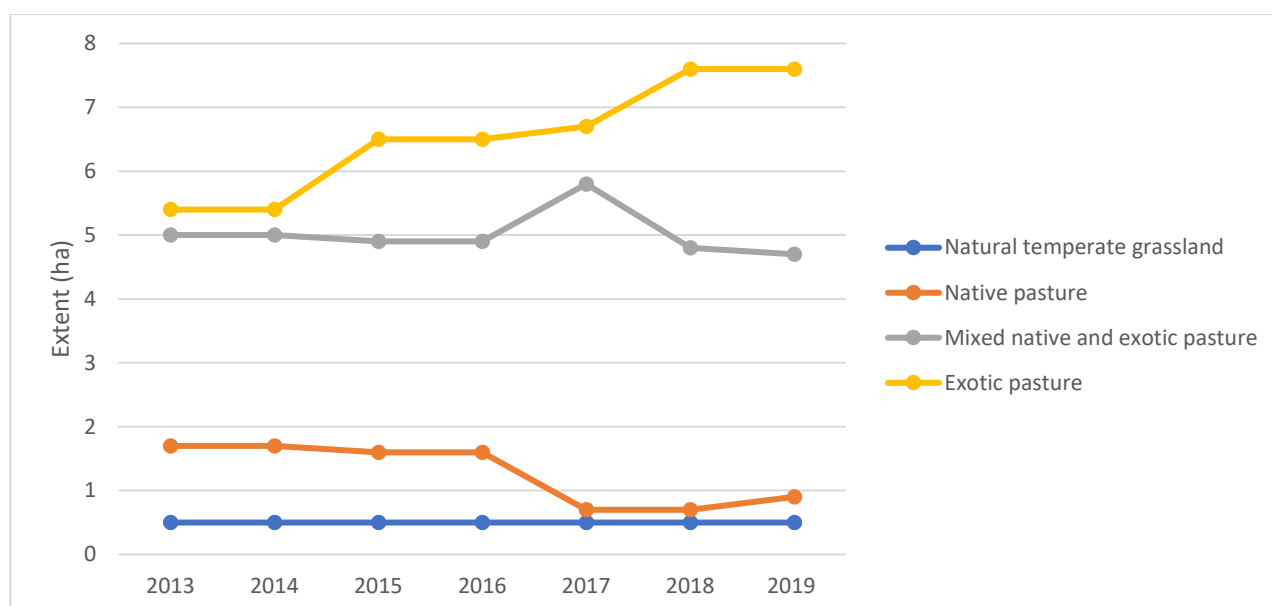
Graph 3.4 Daily rainfall at Canberra Airport leading up to and during the GSM flying period (1 October – 31 December, 2014-2018)

4.0 Discussion and Analysis

4.1 Vegetation and GSM Habitat

Changes in the extent of vegetation types and land uses reported in the OMP (RJPL 2014a), and year 0 (RJPL 2014b), year 1, year 2, year 3 and year 4 and year 5 monitoring reports (RJPL 2015; SMEC 2016, SMEC 2017, SMEC 2018, Umwelt 2019) to 2019 are summarised in **Appendix F**. Trends in the extent of NTG and other grassland types within YEP are shown in **Graph 4.1**.

While the extent of NTG has remained stable since 2013, the extent of native dominated pasture has declined substantially (i.e. more than halved) though it increased slightly in 2019. The decline in native pasture areas in recent years has been driven by the invasion of native pasture areas by perennial exotic tussock grasses, particularly African lovegrass, and Chilean needle grass, resulting in the reclassification of substantial areas as mixed native and exotic pasture. The extent of exotic pasture remained stable from 2018 to 2019, after increasing in previous years.

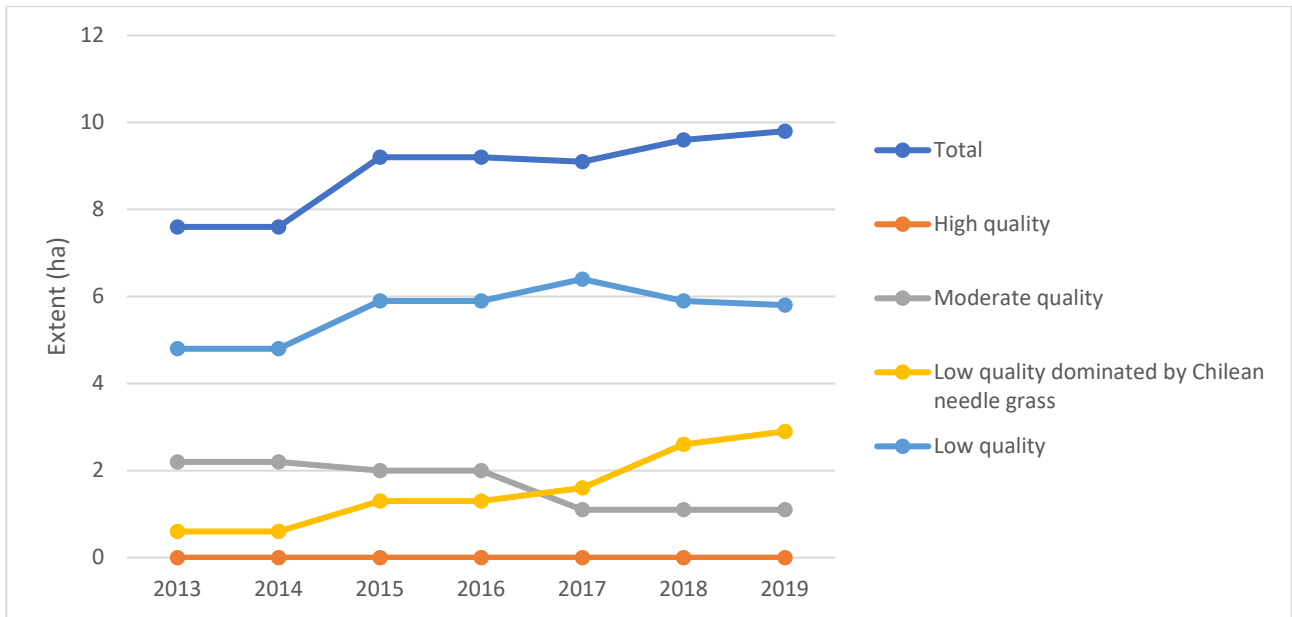


Graph 4.1 Changes in grassland extent at Yarralumla Equestrian Park (2013-2019)

The extent of African lovegrass and Chilean needle grass recorded annually at YEP since 2013 is summarised in **Appendix F**. Trends in the extent of Chilean needle grass and African lovegrass since 2013 are shown in **Graph 4.2**. The extent of African lovegrass at YEP increased by 19% between November 2018 and November 2019 from 2.7 to 3.2 hectares following considerable increases in the 24 months leading up to November 2018. Large tracts of African lovegrass are now dominant across much of the central and eastern parts of YEP threatening existing areas of NTG (**Figure 3.2**). The coverage of Chilean needle grass increased by 10% between November 2018 and November 2019 from 2.9 to 3.2 hectares. The rate of change in the increase in extent of this species at YEP has remained largely consistent since 2015.

GSM habitat extent reported in the OMP (RJPL 2014a) and the year 0 (i.e. 2013) (RJPL 2014b), year 1 (RJPL 2015), year 2 (SMEC 2016), year 3 (SMEC 2017), year 4 (SMEC 2018) and year 5 (Umwelt 2019) monitoring reports are summarised in **Appendix F**. Overall, the extent of GSM habitat has increased since 2013 due to a 2-hectare increase in the extent of low quality habitat dominated by Chilean needle grass (**Graph 4.2**). The total extent of GSM habitat at YEP was slightly greater in 2019 than in the previous year. This difference in the extent of GSM habitat is due to the spread of Chilean needle grass at YEP. The extent of

moderate quality GSM habitat remains lower than pre-2015 due to the spread of perennial exotic grasses whilst the extent of low quality GSM habitat has declined slightly since 2017.



Graph 4.2 Change in the extent of golden sun moth habitat at Yarralumla Equestrian Park (2013-2019)

4.2 Weed Spraying in 2019

Spraying treatment of serrated tussock, African lovegrass, Chilean needle grass with glyphosate, flupropanate and blue dye respectively was undertaken by Core Enviro Solutions during 22-25 October 2019. St John’s Wort, blackberry, and other weeds were treated with fluroxypyr, Wetter 1000, metsulfuron-methyl, and blue dye during November 2019 (CoreEnviro Solutions 2019a, CoreEnviro Solutions 2019b). Observations made during the vegetation assessment and GSM surveys in November 2019 indicated that the spraying of target species at YEP was widespread and targeted. However, the impacts of this control on weed distribution were not necessarily captured in the vegetation data collected from 29 October – 1 November 2019 due to the very small period of time between spraying and vegetation assessment. The effectiveness of spraying conducted in 2019 will be assessable following completion of vegetation assessment and mapping during the 2020 Spring GSM monitoring period.

4.3 Native Pasture and Natural Temperate Grassland Monitoring

Floristic scores (after Rehwinkel 2007) and grassland ranking scores for the 4 x 4 metre plot each survey season are shown in **Table 4.1** and **Table 4.2** respectively. Three quadrats, i.e. quadrats 1, 5 and 9 were not located within predominantly native vegetation, consistent with previous years. A high level of inter-annual variability in floristic value scores is present within each monitoring quadrat which is the result of variable seasonal conditions and survey timing.

In 2019, three quadrats had a floristic value score of four or greater, compared with two in 2018, two quadrats in 2017 and seven quadrats in 2016. Three quadrats achieved a floristic value score of 0 in 2019 compared with four in 2018, six in 2017, three in 2016, four in 2015, three in 2014 and two in 2013. Floristic value scores were lower than the 2013 – 2018 average at nine quadrats and higher than average at the remaining three quadrats. Exotic species richness was greater than native species richness in 11 of the 12 monitoring quadrats. At least one significant weed species was recorded in nine of the quadrats.

Table 4.1 Summary of floristic value scores (2013-2019)

Quadrat	Floristic value score 2013	Floristic value score 2014	Floristic value score 2015	Floristic value score 2016	Floristic value score 2017	Floristic value score 2018	Floristic value score 2019
1	0	0	0	0	0	0	0
2	4	7	1	7	1	1	1
3	7	4	2	1	2	1	1
4	2	2	1	5	0	0	0
5	1	0	0	1	0	0	1
6	4	8	1	5	0	1	1
7	1	5	1	0	2	3	2
8	2	2	0	11	5	3	4
9	0	0	0	0	0	0	0
10	2	5	1	5	2	4	8
11	4	4	1	5	0	1	1

Quadrat	Floristic value score 2013	Floristic value score 2014	Floristic value score 2015	Floristic value score 2016	Floristic value score 2017	Floristic value score 2018	Floristic value score 2019
12	6	14	1	9	5	4	5
Average	2.75	4.25	0.75	3.83	1.42	1.5	2.0

Note: During data review, 2016 data for quadrat 4 and quadrat 5 appeared to have been switched. This table has been updated to reflect the correct data.

The average floristic value score in 2019 was higher than recorded the previous year and similar to the 2013-2019 average. Floristic value scores recorded at YEP show a high level of inter-annual variation. Inter-annual variation in grassland composition and structure (and hence, site floristic scores) at YEP can be strongly influenced by rainfall during the months leading up to each annual vegetation survey. For example, rainfall during winter and spring 2016 was well above average in Canberra (i.e. 511 mm cf. average of 296 mm), which led to favorable conditions for exotic grassland species that following spring/summer (SMEC 2017). Rainfall in Canberra during winter and spring of both 2017 (SMEC 2018), 2018 (Umwelt 2019) and 2019 was far lower than average and could, therefore, have led to poorer than average growing conditions at YEP during the sampling period in these three years. The high level of inter-annual variation is likely attributable to variation in seasonal conditions. Grassland ranking scores in 2019 were similar to scores recorded in 2018. Declines in vegetation condition at YEP are associated with the invasion of perennial exotic tussock grasses, as outlined in **Section 4.1**.

Table 4.2 Summary of grassland ranking scores assessment (2013 - 2019)

Quadrat	Grassland ranking score 2013	Grassland ranking score 2014	Grassland ranking score 2015	Grassland ranking score 2016	Grassland ranking score 2017	Grassland ranking score 2018	Grassland ranking score 2019
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	3A	5A	3A	3A	4B	4B	4A
3	4A	4A	3A	1	4A	3B	4A
4	3A	3A	1	3A	3B	1	N/A
5	N/A	N/A	N/A	1	N/A	N/A	N/A
6	3A	4A	3B	4B	4A	4A	4A
7	3A	3A	3B	N/A	4A	3B	5A
8	4A	3A	N/A	4B	5B	5A	4A
9	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	3A	4A	1	3A	4A	4A	5A
11	3A	4A	2	3A	1	N/A	1
12	4A	5A	1	4A	5B	5A	5A

Note: In the application of the Grassland Quality Score, there has previously been inconsistency in the consideration of the presence of threatened species. In this case, it has been assumed that the grassland quality score refers to threatened flora species and the presence of GSM is consequently not considered in the application of the scale. The 2013 - 2019 data presented in the table above has been amended to reflect this. See the 2018 Yarralumla Equestrian Park Offset Monitoring Report (Umwelt 2019) for previously reported grassland ranking score data for the years 2013-2018.

The number of quadrats which meet natural temperate grassland criteria at YEP is greater when assessed against the 2016 listing criteria rather than the previous listing criteria. A total of nine 20x20m quadrats

meet the 2016 natural temperate grassland classification criteria whilst three of the 4x4m quadrats meet the previous natural temperate grassland classification criteria (**Table 3.5**). This indicates that in accordance with the current listing advice, natural temperate grassland is more widely distributed at YEP than was mapped under the previous listing for this community.

4.4 GSM Habitat Monitoring

GSM habitat value scores recorded in 2019 ranged between N/A (i.e. no GSM habitat) and 5 (Moderate quality NTG with a low number so GSM) (**Table 4.3**). Nine of the monitoring quadrats were determined to have some GSM habitat value, due to the presence of potential host species and GSM activity. The average 2019 GSM habitat quality score of 2.8 is slightly lower than the 2013-2019 average (i.e. 3.0). The variation in GSM habitat scores between the years is likely attributable to variation in seasonal conditions and GSM density. The steady reduction in GSM habitat scores at quadrats 4 and 11 during the monitoring period has likely been driven by the expansion of exotic perennials at such locations.

Table 4.3 GSM habitat quality scores (2013-2019)

Quadrat	GSM habitat quality score 2013	GSM habitat quality score 2014	GSM habitat quality score 2015	GSM habitat quality score 2016	GSM habitat quality score 2017	GSM habitat quality score 2018	GSM habitat quality score 2019
1	2	2	1	1	2	1	N/A
2	5	5	4	4	5	4	5
3	6	6	6	4	5	4	4
4	4	4	3	4	4	1	2
5	1	1	1	1	1	1	1
6	3	5	4	3	3	3	4
7	2	4	2	1	2	3	4
8	4	2	2	3	4	4	5
9	0	N/A	N/A	N/A	N/A	N/A	N/A
10	3	5	4	3	5	5	5
11	4	5	5	3	3	1	N/A
12	4	5	4	3	4	4	4

The average GSM habitat quality score in 2019 was slightly lower than the 2013-2019 average. The number of quadrats that were determined to contain GSM habitat dropped to 9 quadrats for the first time since monitoring began in 2013. Quadrats 1 and 11 which have experienced a gradual decline in habitat quality since 2013 both scored an N/A in 2019. This is likely a function of the invasion of perennial exotics during the past five years.

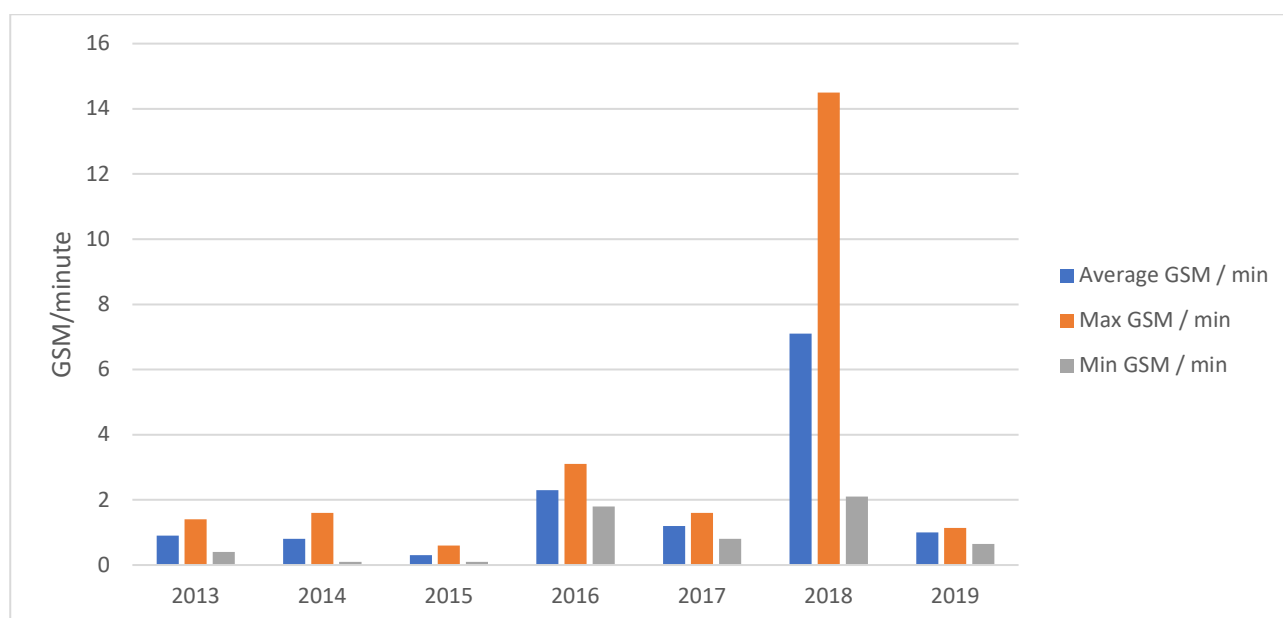
Overall, average GSM habitat ranking scores have demonstrated a slight decline at YEP since monitoring began in 2013. Some inter-annual variation in habitat ranking scores is likely due to the subjective nature of this ranking. Varying seasonal conditions may also influence scores. Declines in GSM habitat ranking scores, independent of seasonal variation and the subjectivity of assessment, are likely to be due to

perennial exotic grasses invading native grassland areas. Due to the highly subjective nature of the qualitative assessment, these comparisons are of limited value.

4.5 GSM Flying Surveys

GSM numbers recorded during the monitoring period (2013-2019), as measured by the traverse surveys and rotational point counts are presented in **Appendix G**.

Low numbers of GSM were observed during the timed traverse surveys conducted in November 2019 (**Graph 4.3**). The average total number of GSM observed along the traverse across each survey during 2019 was similar to that observed in 2013, 2014 and 2017, higher than in 2015 and far lower than during 2016 and 2018. The average number of GSM observed per minute during 2019 (i.e. 1.0) is lower than the 2013 - 2019 average of 1.9 GSM/minute. The variation in the number of moths recorded between survey day was within the anticipated range.



Graph 4.3 Comparison of yearly GSM traverse survey results (2013-2019)

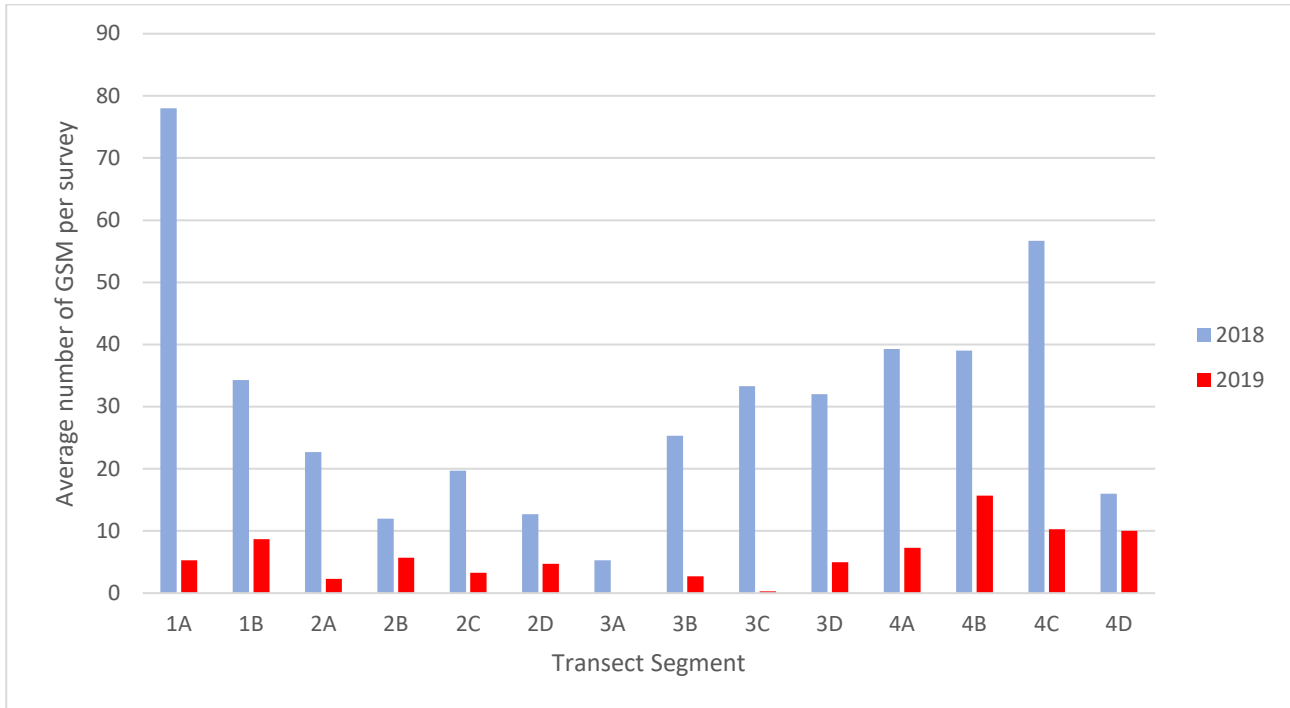
An average of 5.5 moths per transect was recorded in 2019 compared with 29.1 in 2018 when record numbers of GSM were recorded at Yarralumla Equestrian Park (**Graph 4.4, Appendix G**). The number of moths recorded was higher during 2018 than in 2019 at each of the 15 transect segments sampled. The variability in the number of observed moths both between 2018 and 2019 and between the three survey days during 2019 is likely partly due to climatic factors and normal seasonal and daily stochasticity respectively. A combination of these factors may be responsible for the absence of GSM at transect segment 3A in 2019.

GSM were recorded at eleven of twelve rotational point sites during 2018 (**Graph 4.5**). The average number of GSM recorded during the rotational point surveys in 2019 was higher than the 2013-2019 average at site 10 and lower than the 2013-2019 average at the remainder of the sites (**Graph 4.5, Appendix G**).

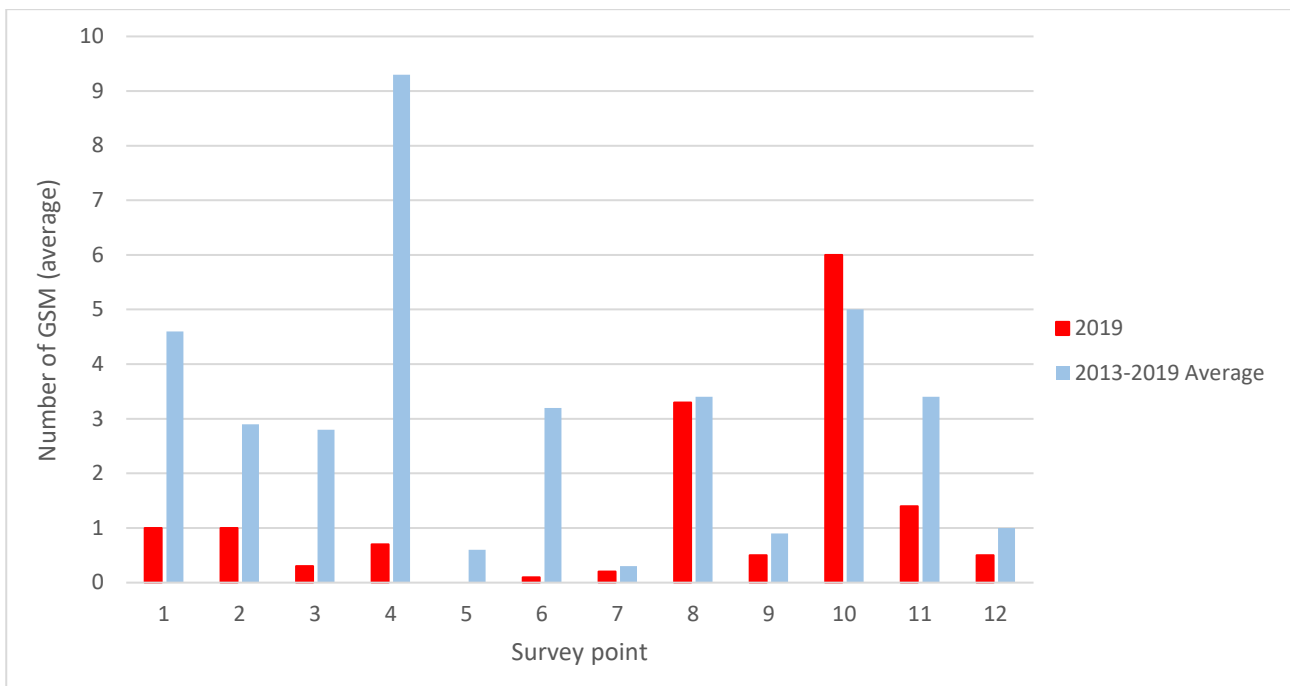
The combined data from the seven years of monitoring to date confirms that GSM activity has remained widespread throughout open areas of YEP though there has been high inter-annual variability in observed numbers characterised by large spikes in abundance such as in 2018. Overall, there were low numbers of

GSM recorded at YEP in November 2019 during the rotational point count surveys and the timed traverse surveys.

The high inter-annual variability in GSM activity levels at YEP is likely primarily a result of inter-annual climatic and site condition variability, but may also be influenced by the high variability in GSM flying levels between days, and the inability to obtain a representative sample of GSM flying levels over three survey days. Regression analysis indicates a statistically significant correlation between pre-flying season rainfall and GSM flying activity at YEP (SMEC 2018). Rainfall alone may explain certain spikes in



Graph 4.4 Average number of GSM recorded during each survey at each transect in 2018 & 2019



Graph 4.5 Average number of GSM recorded during rotational point counts (2019 vs 2013-2019 average)

5.0 Compliance with the Offset Management Plan

5.1 Survey Requirements

NTG and GSM monitoring surveys were conducted according to the methods specified in the OMP (RJPL 2014a). Quadrats were located at co-ordinates specified in the 2013 monitoring report (RJPL 2014b), which are consistent with Figure 5 of the OMP (RJPL 2014a), rather than at the incorrect co-ordinates reported in Appendix B of the OMP. In addition, to improve comparability with ACT Government monitoring at other offset sites, additional transect based sampling was implemented for the second year running. It is recommended that the sampling of such transects continues during future monitoring events.

5.2 Reporting Requirements

The OMP (RJPL 2014a) requires that annual monitoring reports:

- provide and assess the monitoring data for the previous twelve months against the previous monitoring results
- conclude whether or not there has been a lack of increase or a decline in GSM population numbers in the YEP due to equestrian activities, taking into account regional population trends and local ecological conditions
- conclude whether or not there has been no improvement or a decline in GSM habitat, and NTG quality and extent in the YEP due to equestrian activities, taking into account local ecological conditions.

The preparation of this report fulfils the reporting requirements for year 6, as specified in the OMP (RJPL 2014a).

5.3 Management Response

The recommended management responses outlined in the 2017 Yarralumla Equestrian Park Offset Report have been acted upon with weed spraying being carried out in November 2018 and October and November 2019 (SMEC 2018). A consultant has been engaged to review the OMP (RJPL, 2014b) to ensure that appropriate and targeted management actions are being undertaken. The impacts of such management actions on grassland quality and the extent of African love grass, Chilean needle grass, and serrated tussock, in particular, would be assessed during the 2020 monitoring event.

5.4 Impact Thresholds

The OMP (RJPL 2014a) includes a variety of ongoing management actions derived from the approval conditions. Subsequent active management responses are also identified should specified adverse impact response thresholds be met or exceeded. Four impact thresholds triggered in 2018 are outlined in the 2017 Yarralumla Equestrian Park Offset Report (SMEC 2018). Whilst no statistical analyses were conducted following the 2019 surveys, the findings of the 2019 Yarralumla Equestrian Park Offset Report relating to

impact thresholds were consistent with those reported in both the 2017 Yarralumla Equestrian Park Offset Report and the 2018 Yarralumla Equestrian Park Offset Report, namely:

- There has been no increase in the spatial extent of NTG and/or GSM habitat nor has there been an increase in native grassland and NTG floristic value scores over at least three consecutive years.
- There has been no increase in NTG ranking scores or GSM habitat ranking scores over at least three consecutive seasons.
- There has been no decline in flying moth numbers over at least three consecutive seasons. Though record numbers of GSM were recorded in 2018, the high degree of stochasticity (both inter- and intra-annual) in GSM numbers means that it remains unclear whether this species is undergoing a long-term increase at Yarralumla Equestrian Park.

As a result of the findings of the 2017 and 2018 Yarralumla Equestrian Park Offset Report (SMEC 2018, Umwelt 2019), a new OMP is currently being prepared. The impact thresholds defined above are difficult to implement, and consideration of updated thresholds consistent with ACT Government practices on other Commonwealth Offset sites is recommended as part of this process. Similarly, the appropriateness of monitoring approaches, and their applicability to the thresholds applied should be reviewed.

6.0 Conclusions and Recommendations

Results

The key results of the 2019 monitoring program are:

- The spatial extent of NTG has not increased or declined at YEP. The extent of native pasture has declined in recent years due to perennial exotic tussock grass invasion.
- While the total extent of GSM habitat has increased since 2013, the extent of moderate quality habitat has decreased. This is correlated with exotic perennial tussock grasses invading the site and is indicative of a general decline in GSM habitat quality at YEP.
- Floristic value scores and grassland ranking scores were close to or slightly below average in 2019.
- This is the first year the step-point transects were documented in the monitoring reports. The frequency of Chilean needle grass and African love grass at the transects was slightly lower than in 2018.
- GSM habitat ranking scores continue to gradually decline at YEP. For the first time since monitoring began 2013 three sites did not achieve a GSM habitat score compared with only one site during all previous years.
- Average numbers of flying moths were recorded in 2019. The timed traverse and rotational point count surveys indicated that the abundance of GSM in sampled areas was low. To date, there has been no evidence of a decline in the GSM population at YEP despite substantial recent changes in grassland composition across the site.

The substantial increase in the distribution of perennial exotic tussock grasses such as African lovegrass and Chilean needle grass represents a major threat to the extent and condition of native grassland and moderate-quality GSM habitat at YEP, and hence compliance with the offsetting requirement of the Commonwealth approval conditions.

Recommendations

The continuation of control of perennial exotic tussock grasses, specifically African lovegrass, Chilean needle grass, and serrated tussock is required to maintain or improve the extent, integrity, and condition of NTG and GSM habitat at the YEP. Development of a five year weed control plan is recommended as part of the OMP review process.

Until populations of exotic tussock grasses have stabilised and are demonstrably controlled under a defined plan of management, ongoing monitoring of vegetation condition and GSM habitat is recommended. Following stabilisation of exotic tussock grass populations, there is potential to revisit ongoing monitoring requirements.

The OMP review process should also include a review of impact thresholds and monitoring methods to ensure effectiveness and identify opportunities for consistency with application of thresholds and monitoring strategies at other Commonwealth offset sites in the ACT.

7.0 References

ACT Government. 2010a. Survey guidelines for determining lowland vegetation classification and condition in the ACT. Conservation Planning and Research, Canberra.

ACT Government. 2010b. Survey guidelines for golden sun moth, Conservation Planning and Research, Canberra.

Australian Government. 2011. Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory. Advice to the Minister for the Environment and Heritage from the Endangered Species Scientific Subcommittee (ESSS) on a proposal to add an ecological community to Schedule 2 of the Endangered Species Protection Act 1992 (ESP Act). Department of the Environment, Australian Government. Site accessed 17 October 2013.
<http://www.environment.gov.au/biodiversity/threatened/communities/natural-temperate-grasslands.html>.

Australian Government. 2016. Natural Temperate Grassland of the South Eastern Highlands: a nationally protected ecological community, Australian Government 2016

CoreEnviro Solutions 2019a. Spray Report – Yarralumla Equestrian Park. Conducted 22-25 October.

CoreEnviro Solutions 2019a. Spray Report – Yarralumla Equestrian Park. Conducted 25-26 November.

Hogg, D. 2010. Semi-quantitative assessment of golden sun moths. David Hogg Pty Ltd, Canberra, ACT. 6 p.

Hogg, D. 2012. Application of EPBC Act offsets assessment guide to the golden sun moth. David Hogg Pty Ltd, Canberra, ACT. 5 p.

Nash, K and Hogg, D. 2013. Application of EPBC Act offset assessment guide to natural temperate grassland of the Southern Tablelands of NSW and the Australian Capital Territory. David Hogg Pty Ltd, Canberra, ACT. 8 p.

Rehwinkel, R. 2007. A method to assess grassy ecosystem sites: Using floristic information to assess a site's quality. NSW Department of Environment and Climate Change, Sydney.

Rehwinkel, R. 2015. A revised floristic value scoring method to assess grassland condition.

Robert Jessop Pty Ltd. 2014a. Yarralumla Equestrian Park offset management plan. Report prepared for the Land Development Agency, ACT Government. Robert Jessop Pty Ltd. Canberra, ACT.

Robert Jessop Pty Ltd. 2014b. Yarralumla Equestrian Park offset. 2013 monitoring report. Report prepared for the ACT Government. Robert Jessop Pty Ltd. Canberra, ACT. 33 p.

Robert Jessop Pty Ltd. 2015. Yarralumla Equestrian Park offset management plan. 2014 Monitoring Report. Report prepared for the Land Development Agency, ACT Government. Robert Jessop Pty Ltd. Canberra, ACT.

SMEC. 2016. Yarralumla Equestrian Park offset. 2015 monitoring report. Report prepared for the ACT Government. Snowy Mountains Engineering Corporation, ACT.

SMEC. 2017. Yarralumla Equestrian Park offset. 2016 monitoring report. Report prepared for the ACT Government. Snowy Mountains Engineering Corporation, ACT.

SMEC. 2018. Yarralumla Equestrian Park offset. 2017 monitoring report. Report prepared for the ACT Government. Snowy Mountains Engineering Corporation, ACT.

Umwelt 2018. Yarralumla Equestrian Park Interim Weed Management Plan 2018 Draft. Report prepared for the ACT Government. Umwelt (Australia) Pty Ltd, ACT.

Umwelt 2019. Yarralumla Equestrian Park offset. 2018 monitoring report. Report prepared for the ACT Government. Umwelt (Australia) Pty Ltd, ACT.



APPENDIX A

**2019 vegetation and habitat
survey data**

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
Native Grasses and Rushes															
<i>Austrostipa bigeniculata</i>	tall spear grass	N	3	4	4			3	4	4	2	4		4	
<i>Austrostipa scabra</i>	rough speargrass	N			1							3			
<i>Bothriochloa macra</i>	redleg grass	N						5	4	3				5	
Carex sp.	carex sp.	N													
<i>Cynodon dactylon</i>	Couch	N					1								
<i>Elymus scabra</i>	wheat grass	N										1		1	
<i>Panicum effusum</i>	hairy panic	N													
<i>Rytidosperma caespitosum</i>	tall wallaby grass	N						4							
<i>Rytidosperma carphoides</i>	short wallaby grass	N	1	2				4	3	4				4	
<i>Rytidosperma</i> sp.	wallaby grass	N												4	
<i>Themeda australis</i>	kangaroo grass	N								5		5	2		
Native forbs															
<i>Acaena ovina</i>	sheep's burr	N													
<i>Chrysocephalum apiculatum</i>	yellow buttons	N		4			3	3	2			2	1	4	

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
<i>Crassula sieberiana</i>							2	2	2						
<i>Euchiton</i> sp.	cudweed sp.	N						2		1		2			
<i>Erodium cicutarium</i>	blue storksbill	N													
<i>Lomandra bracteata</i>	mat-rush sp.	N													
<i>Lomandra filiformis</i> subsp. <i>coriacea</i>	mat-rush sp.	N			1				1			1		2	
<i>Lomandra multiflora</i>	mat-rush sp.	N													
<i>Oxalis</i> sp.															
<i>Plantago varia</i>		N												4	
<i>Rumex brownii</i>	swamp dock	N					1				1			1	
<i>Triptilodiscus pygmaeus</i>		N										2			
<i>Wahlenbergia communis</i>	tufted bluebell	N		2										1	
<i>Wahlenbergia luteola</i>	bluebell sp.	N													
<i>Wurmbea dioica</i>	early Nancy														
Exotic grasses															
<i>Aira</i> sp.	hairgrass	E												1	

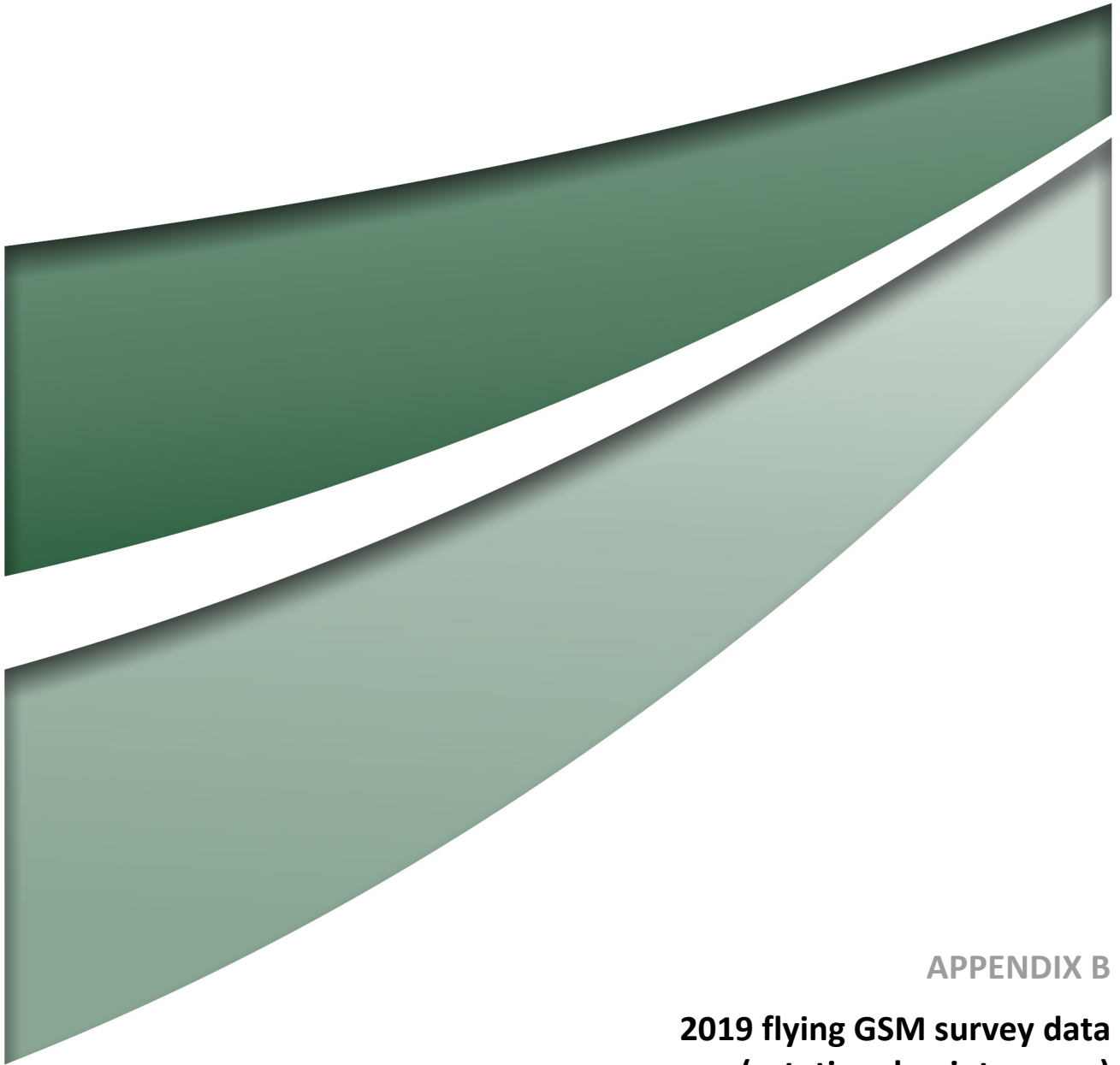
Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
<i>Avena</i> sp.	oats	E	5			4		3		1	4	2	3		
<i>Briza minor</i>	shivery grass	E													
<i>Bromus catharticus</i>	prairie grass	E	5			4									
<i>Bromus diandrus</i>	rippgut brome	E													
<i>Bromus hordeaceus</i>	soft brome	E		3		6	3	3	4	3	3	4	3	3	
<i>Bromus</i> sp.	bromes	E													
<i>Dactylis glomerata</i>	cocksfoot	E		2											
<i>Eragrostis curvula</i>	African lovegrass	E	1		2		4	5		2	5		6	1	ACT C; WoNS
<i>Eleusine tristachya</i>		E		1	4	4	3	4							
<i>Festuca arundinacea</i>	tall fescue	E									2	3			
<i>Hordeum</i> sp.	Barley	E													
<i>Lolium perenne</i>	perennial ryegrass	E						2							
<i>Nassella neesiana</i>	Chilean needle grass	E			1		6	3		1	3			1	ACT P, C; WoNS
<i>Paspalum dilatatum</i>	paspalum	E													
<i>Nassella trichotoma</i>	serrated tussock	E													ACT P, C; WoNS
<i>Phalaris aquatica</i>	tall phalaris	E													

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
<i>Poa annua</i>	annual meadow grass	E													
<i>Poa bulbosa</i>	bulbous bluegrass	E							3						
<i>Sporobolus africanus</i>	Parramatta grass	E													
<i>Vulpia muralis</i>		E		3			3		4	3	1				
<i>Vulpia</i> sp.	rat's tail fescue	E										3		3	
Exotic forbs															
<i>Arctotheca calendula</i>	Cape weed	E			3										
<i>Cathamus lanatus</i>	saffron thistle	E										2			
<i>Centaureum</i> sp.	centaury sp.	E													
<i>Cerastium glomeratum</i>	mouse-ear chickweed	E					2				1		2		
<i>Chondrilla juncea</i>	skeleton weed	E			1		2				3	1			
<i>Echium vulgare</i>	viper's bugloss	E													
<i>Echium plantagineum</i>	Patterson's Curse	E							1	1		2			
<i>Erodium botrys</i>	stork's bill sp.	E													
<i>Erodium cicutarium</i>	common storksbill	E	2												
<i>Hirschfeldia incana</i>	hairy mustard	E	2	1	3		2			1	2	1			

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
<i>Hypericum perforatum</i>	St John's wort	E		2						1		3		1	ACT C
<i>Hypochaeris glabra</i>	flatweed	E													
<i>Hypochaeris radicata</i>	flatweed	E		2			1	2	3	1		3	3		
<i>Lepidium africanum</i>		E	1	1											
<i>Lactuca serriola</i>		E							1					1	
<i>Marrubium vulgare</i>		E							1						
<i>Malva</i> sp.	mallow	E													
<i>Medicago</i> sp.	medick	E	1	4	3		3								
<i>Moenchia erecta</i>	erect chickweed	E													
<i>Oenothera glazioviana</i>	large-flowered evening-primrose	E													
<i>Onopodum acanthium</i>		E					1								
<i>Paronychia brasiliensis</i>	Brazilian whitlow	E							1						
<i>Petrorhagia nanteuillii</i>	proliferous pink	E							3			3	3	1	
<i>Plantago lanceolata</i>	narrow leaf plantain	E	1	3			2			3		3	3		
<i>Rumex crispus</i>	hooked dock	E													

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
Sonchus sp.		E									2				
Spergularia rubra	red sand-spurrey	E													
Taraxacum officinale	Dandelion					4	1					1			
Tolpis barbarta	yellow hawkweed	E													
Tragopogon sp.		E							1				1		
Trifolium arvensis	haresfoot clover	E		1			3		2			1			
Trifolium campestre	hop trefoil	E										2	2		
Trifolium glomeratum		E						2							
Trifolium sp.	clover	E													
Trifolium subterraneum	subterranean clover	E	4												

Transect	Condition	Cryptogram	Bare	Rock	Litter	Chilean needle grass	Serrated Tussock	African love grass	Exotic Annual grass	Other Exotic Perennial grass	Exotic forb	Wallaby grass	Speargrass	Other Native perennial grass	Native Other
1	Mixed native and exotic	0	16	0	14	0	0	0	12	2	5	0	1	0	0
2	Native grassland	0	8	0	8	0	0	2	7	4	2	0	10	6	3
3	Native grassland	0	16	0	12	0	0	0	0	8	0	5	9	0	0
4	Native pasture	0	9	0	8	0	0	14	13	3	1	0	1	0	1
5	Exotic pasture	0	2	0	5	12	0	0	22	3	6	0	0	0	0
6	Native pasture	0	5	0	7	1	0	4	1	8	1	5	7	4	5
7	Native grassland	0	0	0	4	0	0	0	8	5	2	3	10	15	2
8	Native grassland	0	5	0	15	0	0	1	5	3	4	0	9	7	1
9	Mixed native and exotic	0	7	0	11	12	0	2	6	8	0	0	4	0	0
10	Native grassland	0	3	0	11	1	0	0	1	3	1	1	11	13	5
11	Mixed native and exotic	0	4	0	6	0	0	15	2	21	0	0	0	1	0
12	Native grassland	0	6	0	5	0	0	1	3	2	1	2	2	24	4

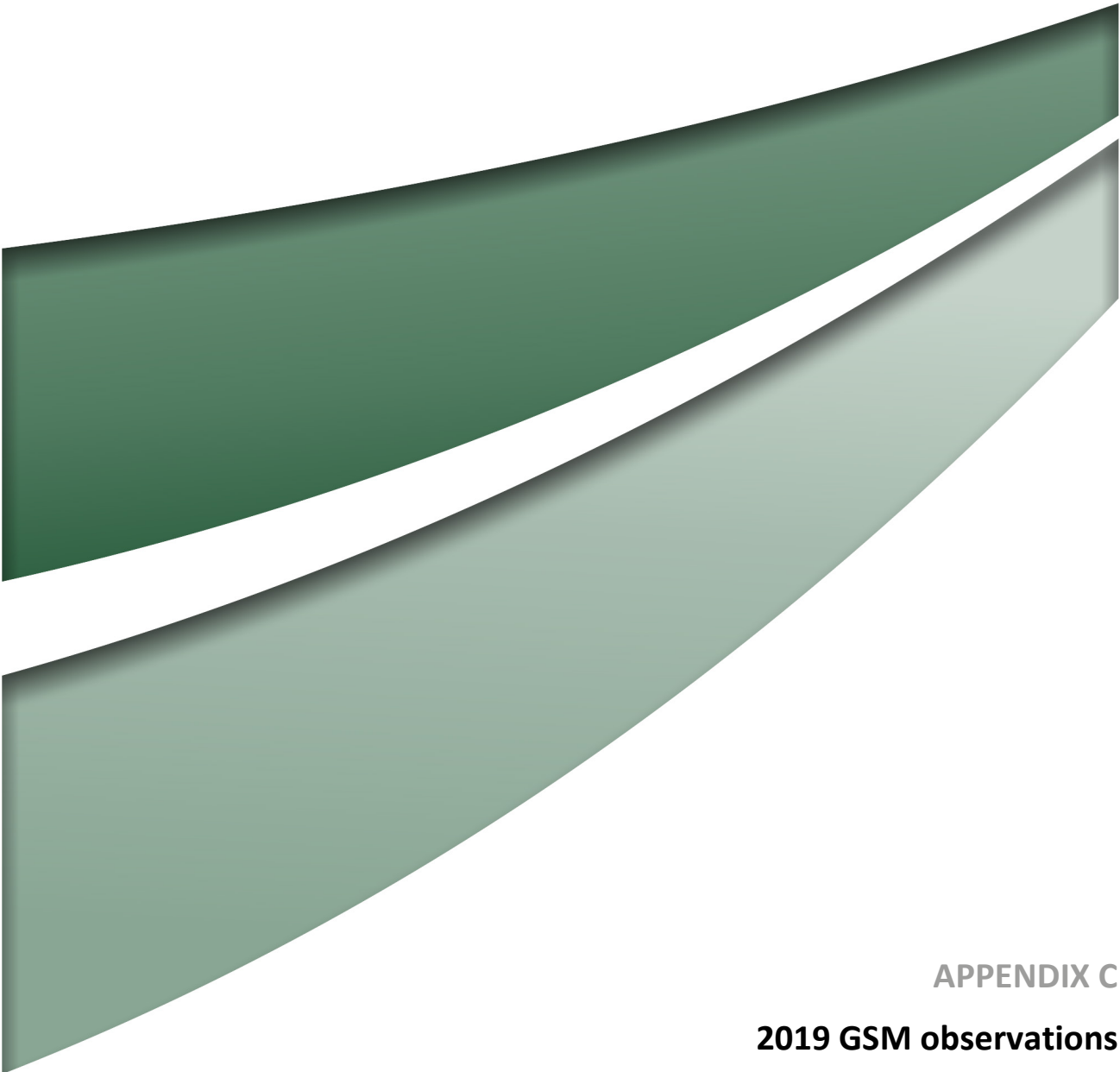


APPENDIX B

**2019 flying GSM survey data
(rotational point survey)**

Date	Survey	Quadrat	Turn 1	Turn 2	Turn 3	Turn 4	Turn 5	Turn 6	Turn 7	Turn 8	Turn 9	Turn 10	Total	Average
2019-10-30	1	1	1	0	0	0	0	0	0	0	0	0	1	0.1
2019-10-30	1	4	0	0	0	0	0	0	0	0	1	0	1	0.1
2019-10-30	1	5	0	0	0	0	0	0	0	0	0	0	0	0
2019-10-30	1	6	0	0	0	0	0	1	0	0	0	0	1	0.1
2019-10-30	1	7	0	0	0	0	2	1	0	0	0	0	3	0.3
2019-10-30	1	8	0	0	0	0	0	0	0	0	0	0	0	0
2019-10-30	1	9	0	0	0	0	0	0	0	0	0	0	0	0
2019-10-30	1	10	0	0	0	0	0	0	0	0	0	0	0	0
2019-10-30	1	11	0	0	0	0	0	0	0	0	0	0	0	0
2019-10-30	1	12	0	0	0	0	0	0	0	0	0	0	0	0
2019-11-15	2	1	0	0	0	0	0	0	0	0	0	0	0	0
2019-11-15	2	2	0	0	0	0	0	0	0	0	0	0	0	0
2019-11-15	2	3	0	0	0	0	0	0	0	0	0	2	2	0.2
2019-11-15	2	4	0	0	0	0	0	0	0	0	0	0	0	0
2019-11-15	2	5	0	0	0	0	0	0	0	0	0	3	3	0.3
2019-11-15	2	6	0	0	0	0	0	0	0	0	0	0	0	0
2019-11-15	2	7	0	0	0	0	0	0	0	0	0	0	0	0
2019-11-15	2	8	5	8	1	5	3	0	4	3	6	0	35	3.5
2019-11-15	2	9	1	0	0	0	0	0	0	0	0	10	11	1.1
2019-11-15	2	10	2	0	0	1	3	2	0	5	6	0	19	1.9
2019-11-15	2	11	0	0	0	0	0	3	0	1	0	0	4	0.4
2019-11-15	2	12	0	0	0	0	0	0	0	0	0	0	0	0
2019-11-20	3	1	1	0	5	0	4	3	6	3	4	1	27	2.7
2019-11-20	3	2	4	5	3	3	4	1	3	4	2	3	32	3.2
2019-11-20	3	3	0	2	1	1	0	2	0	0	2	13	21	2.1

2019-11-20	3	4	3	2	0	0	0	1	0	2	1	6	15	1.5
2019-11-20	3	5	0	0	0	0	0	0	0	0	0	1	1	0.1
2019-11-20	3	6	1	0	0	0	1	0	0	1	0	0	3	0.3
2019-11-20	3	7	0	0	0	0	1	1	0	0	0	0	2	0.2
2019-11-20	3	8	4	12	15	4	5	4	2	4	6	4	60	6
2019-11-20	3	9	1	1	2	1	2	0	2	3	1	2	15	1.5
2019-11-20	3	10	19	12	10	24	16	12	12	16	25	0	146	14.6
2019-11-20	3	11	2	10	3	5	5	4	1	4	1	0	35	3.5
2019-11-20	3	12	0	2	2	1	3	0	2	2	2	0	14	1.4



APPENDIX C
2019 GSM observations

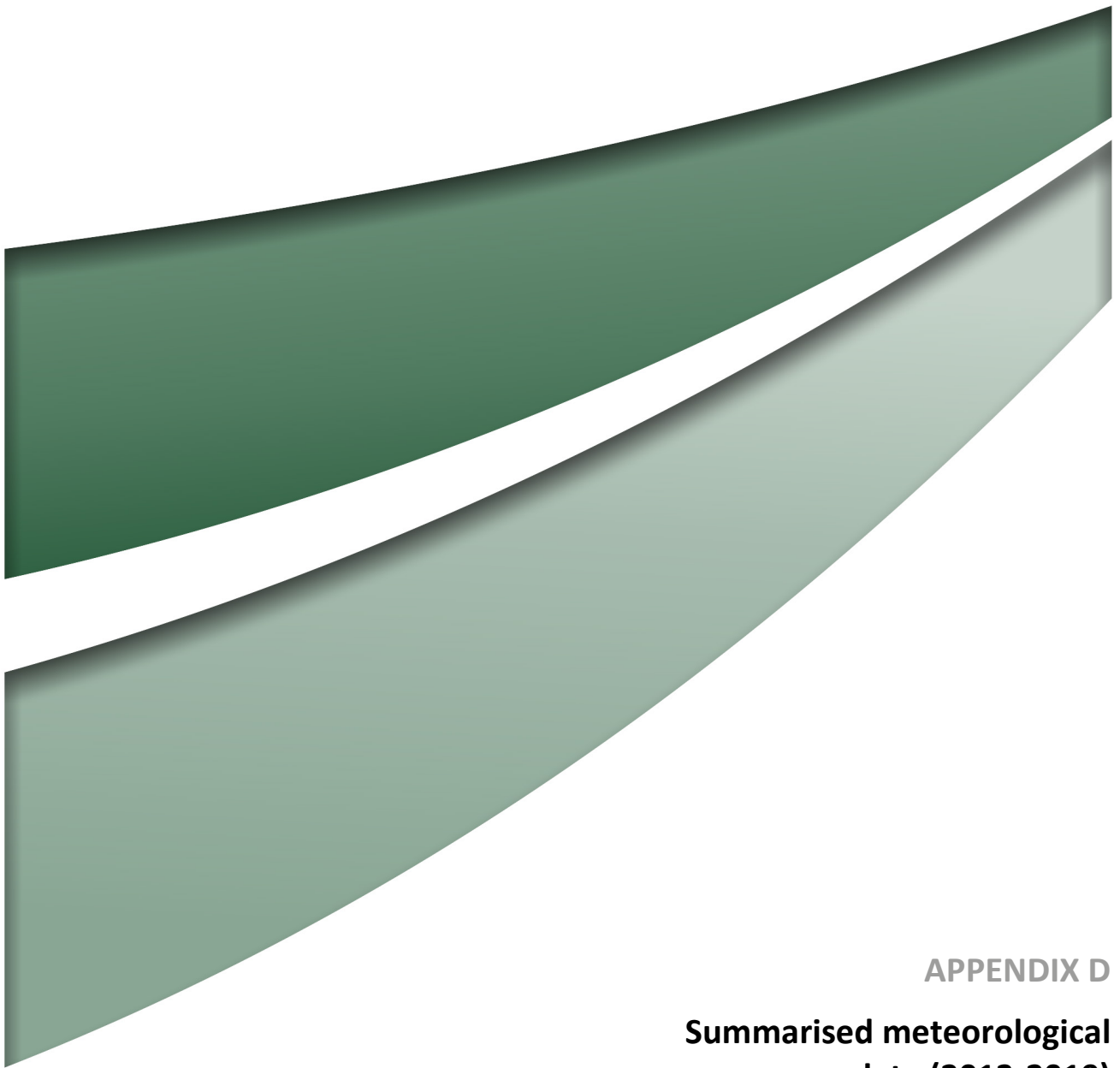
Date	Survey	X	Y	Number of GSM	Sex/Pupae Case	Survey Type
2019-10-30	1	688426.6	6090897	2	Male	Traverse
2019-10-30	1	688540.1	6090728	2	Male	Traverse
2019-10-30	1	688531.6	6090734	2	Male	Traverse
2019-10-30	1	688524.3	6090750	1	Male	Traverse
2019-10-30	1	688509.7	6090773	1	Male	Traverse
2019-10-30	1	688508	6090777	1	Male	Traverse
2019-10-30	1	688478.1	6090860	1	Male	Traverse
2019-10-30	1	688468.7	6090889	1	Male	Traverse
2019-10-30	1	688463.6	6090935	2	Male	Traverse
2019-10-30	1	688396.4	6090907	5	Male	Traverse
2019-10-30	1	688380	6090852	4	Male	Traverse
2019-10-30	1	688380.8	6090844	10	Male	Traverse
2019-10-30	1	688338.7	6090671	1	Male	Traverse
2019-10-30	1	688425.5	6090681	1	Male	Traverse
2019-10-30	1	688422.6	6090683	1	Male	Transect
2019-10-30	1	688429.1	6090690	1	Male	Rotational Point
2019-10-30	1	688422	6090866	1	Male	Rotational Point
2019-10-30	1	688534.7	6090755	1	Male	Rotational Point
2019-10-30	1	688534	6090755	3	Male	Rotational Point
2019-11-01	-	688789.1	6090715	2	Male	Incidental
2019-11-01	-	688790.7	6090716	3	Male	Incidental
2019-11-01	-	688703.6	6090761	5	Male	Incidental
2019-11-01	-	688682	6090774	5	Male	Incidental
2019-11-01	-	688697	6090785	7	Male	Incidental
2019-11-01	-	688629.7	6090828	3	Male	Incidental
2019-11-01	-	688606.8	6090959	1	Male	Incidental
2019-11-01	-	688589.3	6090902	1	Male	Incidental
2019-11-01	-	688610.3	6090883	2	Male	Incidental
2019-11-01	-	688660.9	6090767	2	Male	Incidental
2019-11-01	-	688578.8	6090698	1	Male	Incidental
2019-11-01	-	688571.4	6090685	4	Male	Incidental
2019-11-01	-	688535	6090641	2	Male	Incidental
2019-11-01	-	688519.3	6090732	4	Male	Incidental
2019-11-01	-	688513.2	6090752	3	Male	Incidental
2019-11-01	-	688442.7	6090922	2	Male	Incidental
2019-11-01	-	688449	6090961	3	Male	Incidental
2019-11-01	-	688396.9	6090972	2	Male	Incidental

Date	Survey	X	Y	Number of GSM	Sex/Pupae Case	Survey Type
2019-11-01	-	688493.8	6090828	4	Male	Incidental
2019-11-01	-	688391.6	6090686	2	Male	Incidental
2019-11-01	-	688431	6090624	1	Male	Incidental
2019-11-01	-	688292.9	6090703	1	Male	Incidental
2019-11-01	-	688379.8	6090685	1	Male	Incidental
2019-11-15	2	688787.4	6090594	1	Male	Traverse
2019-11-15	2	688803	6090591	1	Male	Traverse
2019-11-15	2	688843.5	6090587	1	Male	Traverse
2019-11-15	2	688710.7	6090701	3	Male	Traverse
2019-11-15	2	688700.3	6090740	1	Male	Traverse
2019-11-15	2	688660.2	6090790	1	Male	Traverse
2019-11-15	2	688622.4	6090848	1	Male	Traverse
2019-11-15	2	688620.4	6090870	3	Male	Traverse
2019-11-15	2	688563.3	6090971	2	Male	Traverse
2019-11-15	2	688541.8	6090963	1	Male	Traverse
2019-11-15	2	688563.1	6090939	1	Male	Traverse
2019-11-15	2	688581	6090908	1	Male	Traverse
2019-11-15	2	688619.2	6090830	1	Female	Traverse
2019-11-15	2	688640.9	6090804	2	Male	Traverse
2019-11-15	2	688652.1	6090777	4	Male	Traverse
2019-11-15	2	688657.8	6090742	2	Male	Traverse
2019-11-15	2	688662.1	6090720	5	Male	Traverse
2019-11-15	2	688681.6	6090682	1	Male	Traverse
2019-11-15	2	688708.3	6090650	2	Male	Traverse
2019-11-15	2	688691	6090574	1	Female	Traverse
2019-11-15	2	688567.3	6090684	1	Female	Traverse
2019-11-15	2	688564.5	6090691	3	Male	Traverse
2019-11-15	2	688547.9	6090709	1	Male	Traverse
2019-11-15	2	688520.6	6090718	3	Male	Traverse
2019-11-15	2	688495.6	6090746	5	Male	Traverse
2019-11-15	2	688491.8	6090786	4	Male	Traverse
2019-11-15	2	688492.1	6090818	2	Male	Traverse
2019-11-15	2	688481.9	6090845	1	Male	Traverse
2019-11-15	2	688447.6	6090927	1	Male	Traverse
2019-11-15	2	688449.8	6090990	2	Male	Traverse
2019-11-15	2	688405.9	6090978	1	Male	Traverse
2019-11-15	2	688388.7	6090926	1	Male	Traverse
2019-11-15	2	688382.3	6090900	1	Female	Traverse

Date	Survey	X	Y	Number of GSM	Sex/Pupae Case	Survey Type
2019-11-15	2	688382.4	6090896	5	Male	Traverse
2019-11-15	2	688316.5	6090723	2	Male	Traverse
2019-11-15	2	688299.5	6090695	3	Male	Traverse
2019-11-15	2	688340.5	6090672	1	Male	Traverse
2019-11-15	2	688434.6	6090680	2	Male	Traverse
2019-11-15	2	688551.5	6090573	1	Male	Traverse
2019-11-15	2	688425.1	6090683	10	Pupae Case	Traverse
2019-11-15	2	688566.2	6090651	1	Female	Traverse
2019-11-15	2	688500.5	6090671	1	Male	Transect
2019-11-15	2	688420.4	6090683	1	Male	Transect
2019-11-15	2	688300	6090673	1	Male	Transect
2019-11-15	2	688309.8	6090703	2	Male	Transect
2019-11-15	2	688356.9	6090806	1	Male	Transect
2019-11-15	2	688370.5	6090834	1	Male	Transect
2019-11-15	2	688406.1	6090921	1	Male	Transect
2019-11-15	2	688414.3	6090940	1	Male	Transect
2019-11-15	2	688478.4	6090910	2	Male	Transect
2019-11-15	2	688498.8	6090859	1	Male	Transect
2019-11-15	2	688547.2	6090748	1	Male	Transect
2019-11-15	2	688786.9	6090643	1	Male	Transect
2019-11-15	2	688780	6090670	2	Male	Transect
2019-11-15	2	688580.8	6090935	1	Male	Transect
2019-11-15	2	688599.6	6090902	3	Male	Transect
2019-11-15	2	688621.5	6090851	1	Male	Transect
2019-11-15	2	688631	6090824	2	Male	Transect
2019-11-15	2	688649.5	6090796	4	Male	Transect
2019-11-15	2	688665.3	6090759	1	Male	Transect
2019-11-15	2	688682.6	6090722	3	Male	Transect
2019-11-15	2	688695.3	6090698	2	Male	Transect
2019-11-15	2	688721.1	6090661	2	Male	Transect
2019-11-15	2	688387.7	6090808	2	Male	Rotational Point
2019-11-15	2	688437.6	6091040	3	Male	Rotational Point
2019-11-15	2	688735.9	6090652	35	Male	Rotational Point
2019-11-15	2	688783.2	6090722	11	Male	Rotational Point
2019-11-15	2	688686.1	6090777	19	Male	Rotational Point
2019-11-15	2	688633.3	6090836	4	Male	Rotational Point
2019-11-20	3	688349.4	6090685	2	Female	Traverse
2019-11-20	3	688378.3	6090839	2	Pupae Case	Traverse

Date	Survey	X	Y	Number of GSM	Sex/Pupae Case	Survey Type
2019-11-20	3	688400.5	6090912	3	Pupae Case	Traverse
2019-11-20	3	688658.9	6090788	1	Pupae Case	Traverse
2019-11-20	3	688672.6	6090786	1	Female	Traverse
2019-11-20	3	688670.8	6090788	1	Pupae Case	Traverse
2019-11-20	3	688732.1	6090647	3	Pupae Case	Traverse
2019-11-20	3	688751.8	6090737	1	Female	Traverse
2019-11-20	3	688776.1	6090731	2	Female	Traverse
2019-11-20	3	688522.6	6090765	3	Pupae Case	Traverse
2019-11-20	3	688415.9	6090691	1	Pupae Case	Traverse
2019-11-20	3	NA	NA	80	Male	Traverse
2019-11-20	3	688594.8	6090884	1	Female	Traverse
2019-11-20	3	688553.8	6090933	1	Female	Traverse
2019-11-20	3	688670.6	6090784	1	Female	Traverse
2019-11-20	3	688527.9	6090662	14	Male	Transect
2019-11-20	3	688422	6090689	25	Male	Transect
2019-11-20	3	688277.5	6090636	4	Male	Transect
2019-11-20	3	688317.9	6090727	16	Male	Transect
2019-11-20	3	688378.6	6090816	9	Male	Transect
2019-11-20	3	688391.9	6090884	12	Male	Transect
2019-11-20	3	688417.8	6091029	0	Male	Transect
2019-11-20	3	688460.9	6090943	5	Male	Transect
2019-11-20	3	688496.4	6090847	1	Male	Transect
2019-11-20	3	688527	6090762	14	Male	Transect
2019-11-20	3	688747	6090592	28	Male	Transect
2019-11-20	3	688693.2	6090703	25	Male	Transect
2019-11-20	3	688660.1	6090788	40	Male	Transect
2019-11-20	3	688617.1	6090868	18	Male	Transect
2019-11-20	3	688796.1	6090700	1	Male	Transect
2019-11-20	3	688416.6	6090675	27	Male	Rotational Point
2019-11-20	3	688331.5	6090694	32	Male	Rotational Point
2019-11-20	3	688385.1	6090814	21	Male	Rotational Point
2019-11-20	3	688419.5	6090865	15	Male	Rotational Point
2019-11-20	3	688445.1	6091030	1	Male	Rotational Point
2019-11-20	3	688536.3	6090758	3	Male	Rotational Point
2019-11-20	3	688853.1	6090617	2	Male	Rotational Point
2019-11-20	3	688739	6090648	60	Male	Rotational Point
2019-11-20	3	688783.7	6090719	15	Male	Rotational Point
2019-11-20	3	688744.2	6090771	146	Male	Rotational Point

Date	Survey	X	Y	Number of GSM	Sex/Pupae Case	Survey Type
2019-11-20	3	688636.5	6090838	35	Male	Rotational Point
2019-11-20	3	688615.9	6090951	14	Male	Rotational Point



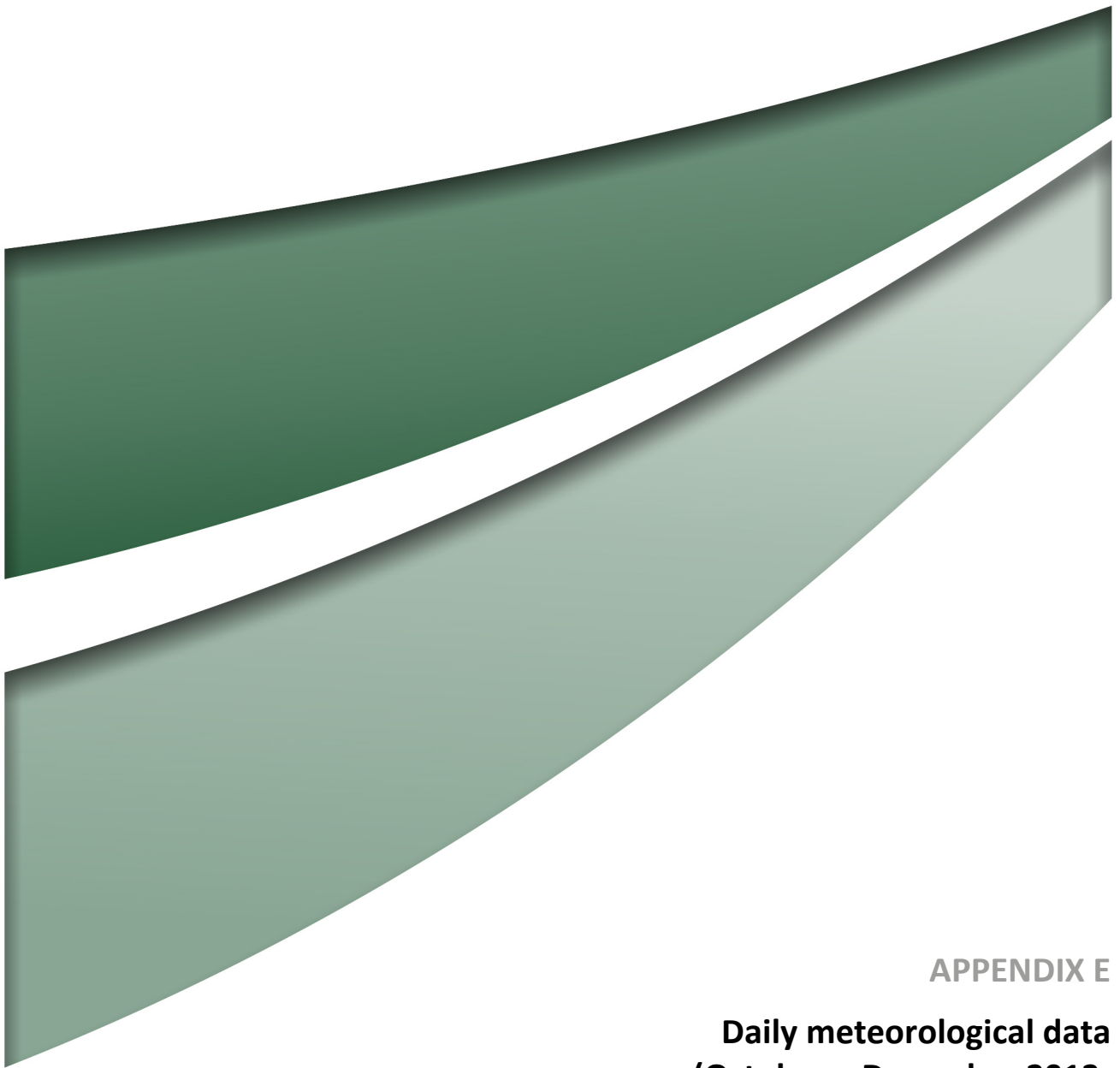
APPENDIX D

**Summarised meteorological
data (2013-2019)**

Year	Month	Average Maximum Daily Air Temperature (°C)	Average Minimum Daily Air Temperature (°C)	Monthly Precipitation (mm)	Average Maximum Daily Soil Temperature (°C at 10cm depth)	Average Minimum Daily Soil Temperature (°C at 10cm depth)
2013	January	32.3	13.9	72.6	33.2	23.8
2013	February	27.4	12.8	30	30	21.4
2013	March	25.7	9.6	26.6		
2013	April	22.1	5.5	9.8		
2013	May	17.4	1.3	6.6		
2013	June	13.9	1.6	85.2		
2013	July	13.4	1.7	42.8	10.5	6.2
2013	August	14.8	2.4	27	12.1	6.6
2013	September	19.9	4	91	17.8	10.8
2013	October	21.9	3.8	13.4	21.7	13.3
2013	November	23.8	6.7	105.6	25.3	16.3
2013	December	28.5	11.5	23.2	33.7	23.6
2014	January	31.6	12.1	4.8	35.7	24.8
2014	February	29.4	13.5	83.6	33.2	23.8
2014	March	24.2	12.2	88	25	18.7
2014	April	19.7	7.4	69.2	19.3	13.9
2014	May	17.6	2.7	14.4	14.7	9.5
2014	June	13.2	2.8	57.2	10.7	7.3
2014	July	12.2	0	16.2	9.1	4.9
2014	August	14.3	-0.8	26.8	11.8	5.7
2014	September	17.9	2.7	28.8	16.9	9.5
2014	October	22.5	5.4	53.4	22.5	13.9
2014	November	27.9	10.2	24.2	29.5	19.9
2014	December	27.7	12.7	102	29.5	20.4
2015	January	27.4	13.9	97	29.6	21.4
2015	February	28.1	13.1	30.2	30	21.4
2015	March	26.3	9.1	12.4	27.1	18.6
2015	April	19.4	7.2	91.8	17.7	12.6
2015	May	16.3	2.7	12.2	14	8.8
2015	June	13.8	-0.8	55.2	10.6	5.7
2015	July	11.5	-0.7	37.2	8.6	3.9
2015	August	13.7	1	66.8	10.7	5.3
2015	September	17.4	1.5	13.6	17.3	8.7
2015	October	24.8	8.3	26.6	24.6	16.2
2015	November	25.3	10.9	67.6	26.1	17.9

Year	Month	Average Maximum Daily Air Temperature (°C)	Average Minimum Daily Air Temperature (°C)	Monthly Precipitation (mm)	Average Maximum Daily Soil Temperature (°C at 10cm depth)	Average Minimum Daily Soil Temperature (°C at 10cm depth)
2015	December	29.3	11.4	35	32.3	21.9
2016	January	28.5	14	106.4	29	21.5
2016	February	29.3	13.3	23.4	31.5	22.6
2016	March	27.7	12.6	28.4	28.1	20.2
2016	April	23.9	8.3	6.8	22.8	16.3
2016	May	17.4	4.8	47.6	15	9.9
2016	June	13	3	144.2	10.4	6.6
2016	July	12.7	2.2	71	10.2	5.8
2016	August	14.3	1.1	46.2	11.9	5.8
2016	September	15.8	4.8	149.2	14.7	8.7
2016	October	18.5	5.2	43.6	19.5	11
2016	November	24.8	8.6	56.8	28	17.6
2016	December	28.7	13.5	64.6	29.8	21.4
2017	January	32.8	14.9	8.4		
2017	February	30.1	12.9	20.6		
2017	March	25.9	12.8	85.2		
2017	April	19.9	5.5	31.6		
2017	May	16.4	1.6	34.2		
2017	June	13.6	-1.4	2.4		
2017	July	12.9	-2.3	17		
2017	August	13.9	0.5	49.2		
2017	September	18.1	2.7	13.4		
2017	October	23.2	7.1	58.4		
2017	November	24.3	9.6	70.4		
2017	December	27.8	13.9	95.2		
2018	January	31.6	14.4	38	33.4	23.4
2018	February	29	12.8	86.4	31.5	22.0
2018	March	26.3	10.4	7.2	27.7	19.0
2018	April	25	8.7	19.6	23.9	16.6
2018	May	17.5	2.2	15	15.1	8.8
2018	June	13.2	1.8	27.8	10.7	6.1
2018	July	13.3	-1.7	7.8	10.6	4.2
2018	August	13.9	0.8	29	12.2	5.7
2018	September	18	1.8	38.2	17.8	9.1
2018	October	22.8	7.3	14.2	23.5	14.9

Year	Month	Average Maximum Daily Air Temperature (°C)	Average Minimum Daily Air Temperature (°C)	Monthly Precipitation (mm)	Average Maximum Daily Soil Temperature (°C at 10cm depth)	Average Minimum Daily Soil Temperature (°C at 10cm depth)
2018	November	24.5	10.5	82.4	25.6	16.8
2018	December	29.3	13.7	106.4	31.1	21.1
2019	January	34.5	17.7	61.2	35.4	25.0
2019	February	29.1	12.9	42.8	32.5	22.3
2019	March	26	12	76.2	26.9	18.9
2019	April	22.6	7.5	10	22.3	14.5
2019	May	16.6	3.3	46.2	14.5	8.5
2019	June	14.1	-0.1	18	11.2	5.2
2019	July	13.7	0.7	5	11.4	5.4
2019	August	14.2	0.1	17.8	13.0	6.0
2019	September	18.8	2.1	40	17.7	9.1
2019	October	23.6	6.2	27.6	24.0	14.0
2019	November	26.8	9.5	12.6	28.3	18.3
2019	December	31.7	13.4	1.2	32.3	22.7



APPENDIX E

**Daily meteorological data
(October – December 2013-
2019)**

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2013	October	1	0	22	8.7	16.7	13.3
2013	October	2	0.4	17.3	4.1	18.4	10
2013	October	3	0	16.8	6.2	17.3	12
2013	October	4	0	18.5	-1.5	20.6	9.5
2013	October	5	0	20.3	0.5	18.3	10.8
2013	October	6	0	26.1	3.5	20.3	11.8
2013	October	7	0	20.2	2.9	22	12.5
2013	October	8	0	19.1	1.7	20.5	13.3
2013	October	9	0	24.8	1.6	22.2	12.5
2013	October	10	0	28.5	6.6	23	15
2013	October	11	0	20.9	4.7	23.5	15.5
2013	October	12	0	24	0.5	23.6	13.7
2013	October	13	0	26.4	2.6	23.8	14.7
2013	October	14	2.2	15.6	1.5	21	13.5
2013	October	15	0	19.4	-2.6	21.5	11.6
2013	October	16	0	23.3	1.1	21.9	12.7
2013	October	17	0	21.2	13.7	20	15.1
2013	October	18	0	20.5	-3.4	23.4	11.6
2013	October	19	0	24.4	0.9	24.2	13.1
2013	October	20	0	27.2	2.5	24	14.3
2013	October	21	0	32.1	5.8	24.9	15.4
2013	October	22	6.6	22.3	13.6	21.7	18.2
2013	October	23	4.2	19.9	15.5	20.8	16.9
2013	October	24	0	16	7.9	22.5	14
2013	October	25	0	19	-2.3	23.7	12.1
2013	October	26	0	22.1	-0.7	25.1	13
2013	October	27	0	21	0.9		
2013	October	28	0	23.1	10.1		
2013	October	29	0	20.4	6		
2013	October	30	0	22.1	0.6		
2013	October	31	0	24.6	3.3		
2013	November	1	0	25.9	9.2	28.7	19
2013	November	2	0	27	5.1	25.8	17.8
2013	November	3	0	26.1	5.7	27	17
2013	November	4	0	18.6	-1.5	26.3	15.6

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2013	November	5	0	23.5	-0.3	28.7	15.2
2013	November	6	0	26.8	1.9	29.9	16.7
2013	November	7	0	30.8	5.2	29.9	18.1
2013	November	8	0	32	9.9	27.8	20.1
2013	November	9	6	22.1	13	27.5	18.4
2013	November	10	0.2	11.9	8.9	20.8	14.4
2013	November	11	27.2	14.6	6.4	14.9	12.7
2013	November	12	38.6	23	9.5	22.2	12.7
2013	November	13	0	20	4.2	19.3	13.7
2013	November	14	0	21.3	5.7		
2013	November	15	0	23.1	4.6		
2013	November	16	4	19	10.3		
2013	November	17	0	21.4	4.3		
2013	November	18	0	22.5	4.8		
2013	November	19	0	27.9	4.2		
2013	November	20	1	29.3	7.4		
2013	November	21	0	27.7	11.5		
2013	November	22	26.6	26	12.9		
2013	November	23	0	23.3	6.8		
2013	November	24	0	22.5	5.7		
2013	November	25	1.2	20.6	7.4		
2013	November	26	0.2	22.9	2.9		
2013	November	27	0	27.3	5		
2013	November	28	0	31.6	8.6		
2013	November	29	0.4	21.8	13.7		
2013	November	30	0.2	22.7	6.9		
2013	December	1	0	23.5	7.9		
2013	December	2	0	29.3	7.9		
2013	December	3	0	31.5	10.2		
2013	December	4	0	32.4	14.9		
2013	December	5	10.2	17.4	11.9		
2013	December	6	2.4	19.6	5.2		
2013	December	7	0	24.1	2.7		
2013	December	8	0	28.2	6.6		
2013	December	9	0	32.6	13		
2013	December	10	0	22.8	15.6		

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2013	December	11	0	23.3	5.6		
2013	December	12	0	26.5	4.9		
2013	December	13	0	28.7	5.7	32.5	20.3
2013	December	14	0	25	13.1	32.3	23
2013	December	15	1.8	26.5	13.8	30.7	22.1
2013	December	16	0	27.3	14.8	32.2	22.9
2013	December	17	4.4	30.7	12.1	32.5	21.8
2013	December	18	0	31.9	13.8	35.9	23.2
2013	December	19	0	35.1	12.7	36.1	24.4
2013	December	20	0	37.2	14.4	36.8	25.5
2013	December	21	0	31.3	17.2	36.8	26.7
2013	December	22	0	38.1	16.9	34.9	26.8
2013	December	23	0	27.6	19	30	26.4
2013	December	24	0	24.9	9.4	33.1	22.2
2013	December	25	0	21.9	15	26.9	24.4
2013	December	26	0.4	29.9	8.9	33.6	20.5
2013	December	27	4	30.2	10.3	33.1	21.8
2013	December	28	0	33.1	13.3	35.3	23.1
2013	December	29	0	30.4	14.7	36.4	24
2013	December	30	0	30.4	13.3	36.1	24.9
2013	December	31	0	31.4	10.6	36	24.8
2014	October	1	0	16.9	4.8	22.5	13.1
2014	October	2	0	20	-2	21.3	11.6
2014	October	3	0	20.9	-0.7	23.3	11.6
2014	October	4	0	22.5	10.1	24.2	15.7
2014	October	5	0	27.5	3.7	24.1	14.1
2014	October	6	0	28.1	6.7	24.7	15.8
2014	October	7	11.8	19.8	11	20.5	16
2014	October	8	0	19.8	2	21.4	12.1
2014	October	9	0	20.2	2.2	22.6	12.9
2014	October	10	0.2	22.1	0.4	22	13
2014	October	11	0	26.6	3.1	25.1	13.7
2014	October	12	0	27.6	4.5	25	14.9
2014	October	13	4.8	21.1	13.7	20.1	16.8
2014	October	14	15.4	8.7	6.2	15	11.2
2014	October	15	15.2	15.9	6.3	14.8	9.2

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2014	October	16	0	17.1	-0.7	17.3	8.8
2014	October	17	0	17.1	1.1	17.9	9.7
2014	October	18	0	20.4	0.6	21.8	10.2
2014	October	19	0	25.1	2.5	23.3	12.4
2014	October	20	0	17.1	6.9	19.5	15.1
2014	October	21	0	17.6	9.5	19.7	14.1
2014	October	22	0	24.9	9.7	24.7	14.5
2014	October	23	0	27.2	8.3	23.3	16
2014	October	24	6	28.4	9.7	23.2	15.7
2014	October	25	0	30	7.8	25.9	15.6
2014	October	26	0	29.2	8	26.7	17.2
2014	October	27	0	24.6	8.5	22.8	18
2014	October	28	0	19.8	7.2	23.4	14.7
2014	October	29	0	23.9	7	26.4	15.4
2014	October	30	0	26.5	4.4	26.6	16
2014	October	31	0	32	5.1	27.5	16.6
2014	November	1	0	26.5	14.6	23.9	19.8
2014	November	2	0.2	20	4.6	25.3	14.9
2014	November	3	0	22.6	3.3	27.5	15.3
2014	November	4	0	25.2	10.4	28	18.8
2014	November	5	0	27.2	9.3	26	18.3
2014	November	6	0	24.4	11.8	28.1	18.8
2014	November	7	0	27.4	5.3	30.6	18.2
2014	November	8	0	30	5.5	31	19.4
2014	November	9	0	33.3	7.7	31.9	19.8
2014	November	10	0	29.3	13.9	33.1	22.3
2014	November	11	0	26.9	8.4	31.8	21.3
2014	November	12	0	27.9	9.6	32.1	21.2
2014	November	13	0	31.2	9.8	32.7	21.9
2014	November	14	0	37.2	9.6	32.5	22.5
2014	November	15	0	29.4	14.5	27.2	22.7
2014	November	16	13.6	18	13.9	21.4	17.4
2014	November	17	4.4	23.6	9.3	23.6	13.8
2014	November	18	0	25.7	5.1	28.2	15.1
2014	November	19	0	27.8	13	30.2	19.5
2014	November	20	0	31.4	7.4	30.3	19

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2014	November	21	0	30.2	12.6	32	21.6
2014	November	22	0	31.8	12.5	32.7	22.5
2014	November	23	0	39	11.2	34.8	22.6
2014	November	24	0.2	26.4	18.8	28.8	24.6
2014	November	25	5.6	25.4	14.2	29.1	19.2
2014	November	26	0	26.7	6.5	31.3	18.8
2014	November	27	0	25.9	14.2	29.7	22
2014	November	28	0	27.5	5.7	32.9	19.9
2014	November	29	0	29.7	9.9	31.6	22.2
2014	November	30	0.2	27.9	13.5	27.3	23.1
2014	December	1	4	32.7	11.6	30.1	19.9
2014	December	2	0.8	33	13.8	31.7	21.3
2014	December	3	0	31.8	13.5	28.1	22.6
2014	December	4	19.6	28.2	14.5	25.4	20.2
2014	December	5	6	28.4	13.4	25.9	19.1
2014	December	6	0	22.6	15.8	22.5	19.5
2014	December	7	42.4	27.5	10.4	23.9	16.8
2014	December	8	0	29.1	11	27.3	17.2
2014	December	9	0	29.4	16	31.4	19.9
2014	December	10	0	30.8	13.8	30.5	21.6
2014	December	11	10.6	22.6	15	23.6	19.8
2014	December	12	1.4	22.2	11.6	24.2	15.6
2014	December	13	0	22.5	12	28.4	17.3
2014	December	14	0	28.1	7.2	29.9	17.5
2014	December	15	0	30.8	9.6	33.1	19.3
2014	December	16	1.6	32.6	16.2	30.3	22.1
2014	December	17	1.2	25.9	14.4	32.9	20.9
2014	December	18	0	27.4	9.6	32.6	21.2
2014	December	19	0	25.3	8.6	33.5	21.1
2014	December	20	0	27.4	10.7	34.7	22.5
2014	December	21	0	30.2	12.4	35.3	24
2014	December	22	0	30.8	14.3	33.3	24.6
2014	December	23	5.2	29	16.4	29.5	23
2014	December	24	3.6	24.9	17.2	26.6	22.3
2014	December	25	0.6	27	16.8	26.1	21
2014	December	26	4.8	24.6	15	29.4	19.8

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2014	December	27	0.2	22.7	11.6	29.4	19.7
2014	December	28	0	26.7	9.7	31.3	19.9
2014	December	29	0	29.7	11.2	29.2	21.3
2014	December	30	0	25	11	30.5	20.7
2014	December	31	0	29.2	7.9	34.4	20.5
2015	October	1	0	23.1	11.1	23.9	15.1
2015	October	2	0	24.9	0.9	25.3	12.5
2015	October	3	0	26.5	2.8	24.8	13.4
2015	October	4	0	28.3	6.7	23.3	14.1
2015	October	5	0	31.7	9.1	25.4	15.4
2015	October	6	0	31.8	6.8	26.4	15.7
2015	October	7	0	18.6	7.4	22.1	16.6
2015	October	8	0	20	8.5	23.2	15.5
2015	October	9	0.2	27.1	7.6	26.4	15.5
2015	October	10	8.6	27.4	5.9	23.8	15
2015	October	11	0	22.1	6.5	20.5	14.5
2015	October	12	0	25	7.7	24.7	14.8
2015	October	13	0	21.3	11.3	23.6	16.8
2015	October	14	0	26.1	11	26.6	17
2015	October	15	0	28.5	7.7	27.5	16.9
2015	October	16	0	30.1	8.2	27.8	17.5
2015	October	17	0	27.8	11.1	25.2	19.8
2015	October	18	1.8	21.6	11.5	25.2	17.5
2015	October	19	0.2	27.6	12.1	28.3	17.9
2015	October	20	0	29.5	9.4	28.2	19
2015	October	21	2.6	23.8	15	22.4	19.7
2015	October	22	13	19	12.4	19.7	17.2
2015	October	23	0.2	16.7	9.8	19.2	14.2
2015	October	24	0	23.1	6.8	23.8	13.6
2015	October	25	0	26.5	4.7	26.4	14.2
2015	October	26		27	7.6	25	16.4
2015	October	27	0	17.4	9.6	24.9	16.7
2015	October	28	0	22.5	8	28.6	16.6
2015	October	29	0	25.3	5.2	30	17.1
2015	October	30	0	25	5	28.2	18
2015	October	31	0	22.5	8.9	23.3	18.9

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2015	November	1	2.2	25.3	8.9	23.4	16.2
2015	November	2	19.4	25.4	14	22.3	17.4
2015	November	3	0	21.3	13.8	21.5	17
2015	November	4	0	20.8	13.9	19.3	16.8
2015	November	5	2.2	22.3	13.5	19.5	16
2015	November	6	14.2	23.7	14.7	20.9	17.1
2015	November	7	0	23.2	9.6	25.3	15.7
2015	November	8	0.6	20.7	10.2	25.3	16.5
2015	November	9	0	27.8	9.7	29.5	16.7
2015	November	10	0	30.7	9.7	30.6	18.7
2015	November	11	0	18.7	13.2	23.2	19.9
2015	November	12	9.4	22.7	13.7	21.4	17.3
2015	November	13	9.6	23.6	12.3	23.1	16.8
2015	November	14	8.8	15.3	11.6	18.7	16.8
2015	November	15	1.2	21.1	10.7	-	-
2015	November	16	0	23.3	4.9	26.8	13.5
2015	November	17	0	26.5	7	28	16.5
2015	November	18	0	30	9.6	29.3	17.9
2015	November	19	0	34.8	10.6	30.1	19.1
2015	November	20	0	36.1	13.1	32.3	20.9
2015	November	21	0	26.5	15.2	33.5	22.6
2015	November	22	0	25.3	13.5	30.4	22.5
2015	November	23	0	26.1	8	31.5	20.6
2015	November	24	0	27.4	6.9	32	20.4
2015	November	25	0	30.3	5.2	31.6	19.9
2015	November	26	0	23.7	19.5	29.3	23.3
2015	November	27	0	22.9	0.5	30.1	17.8
2015	November	28	0	27.4	9.2	30.3	20
2015	November	29	0	27.4	15.9	31.5	22.7
2015	November	30	0	28.4	7.9	32.3	20.9
2015	December	1	0	35	10.4	31.3	21.7
2015	December	2	1.4	23.2	12	31	20.3
2015	December	3	0	26.8	6.6	32.8	19.7
2015	December	4	0	29.8	7.8	34.2	20.6
2015	December	5	0	32	8.1	33.8	21.9
2015	December	6	0	32.7	11.2	34.8	23

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2015	December	7	0	28.8	15.7	31.4	23.9
2015	December	8	0	28.2	16.8	27.4	23.7
2015	December	9	0.4	30.6	17.2	32.7	22.5
2015	December	10	0	31.6	12.2	33.7	22.8
2015	December	11	0	27.4	10.8	32.5	23.5
2015	December	12	0	26.1	3.8	34	21.3
2015	December	13	0	27.7	7.3	32.5	21.8
2015	December	14	0	32.2	6.5	35.4	21.3
2015	December	15	0	30.3	12.4	30.6	23.6
2015	December	16	0	27	13.1	31.6	23
2015	December	17	16	30.2	10.4	29.9	18.5
2015	December	18	0	33.6	13.6	34.6	21
2015	December	19	0	36.3	15.4	35.9	23.9
2015	December	20	0	37	16.2	36.6	25.5
2015	December	21	0	27.9	19.3	30.8	26.2
2015	December	22	0.2	24.9	14	29.5	23.1
2015	December	23	0	25.4	13.6	30.8	22.4
2015	December	24	0.8	26.2	10.9	31.8	20.7
2015	December	25	0	28.7	9.2	34	21.6
2015	December	26	0	22.4	11.4	26.9	22.9
2015	December	27	16.2	24	11	27.4	17.5
2015	December	28	0	24.7	6.4	29.8	16.7
2015	December	29	0	30.2	9.2	33.1	19.8
2015	December	30	0	32.4	9.4	34.8	21.3
2015	December	31	0	34	11.4	35.7	22.9
2016	October	1	2	14.1	6.5	16.6	8.6
2016	October	2	0.2	19.4	5.3	16.6	11
2016	October	3	8.8	14.3	7.3	13.5	8.3
2016	October	4	1.4	14	6.5	12.4	6.4
2016	October	5	8.4	14.6	3.6	15.8	8
2016	October	6	0	21.2	7.8	15.8	10.5
2016	October	7	0	22.9	7.6	17.9	11.2
2016	October	8	0	18.9	8.5	16.2	8.9
2016	October	9	0	17.4	1.4	15.2	10.8
2016	October	10	0	18.6	6.2	15.6	7.7
2016	October	11	1	14.2	5.2	18	7.7

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2016	October	12	0	16	-0.9	18.8	9.1
2016	October	13	0.4	16.2	1.7	21.6	9.5
2016	October	14	0	18.9	-0.3	21.4	10.7
2016	October	15	0	20	1	22.2	12.7
2016	October	16	0	23.6	9	21.1	14
2016	October	17	5.4	16.1	9.7	18.6	9.9
2016	October	18	0	17.5	5.2	19.4	10.1
2016	October	19	0.6	16	4.6	19.7	10.5
2016	October	20	0	19.4	1.5	21.1	11.1
2016	October	21	0	21.6	1.4	20.8	14.2
2016	October	22	7.4	13.8	10.4	16.4	8.5
2016	October	23	5.4	16.4	0.7	20.7	8.5
2016	October	24	0	18.2	-1	21.6	10.8
2016	October	25	0	20.7	1.2	23	13.8
2016	October	26	0	24.1	8.4	25.9	14.9
2016	October	27	0	23.2	7	25.2	15.9
2016	October	28	0	18.6	8.9	23.8	16
2016	October	29	0	24	11	24.2	16.7
2016	October	30	0	22.4	10.2	22.5	12.2
2016	October	31	2.6	16.5	5.6	22.2	11.3
2016	November	1	0	18.1	-1.3	24	12.7
2016	November	2	0	20.6	4.5	26.1	13.9
2016	November	3	0	23	2.5	26.2	14.9
2016	November	4	0	24.5	3.6	26.1	17.4
2016	November	5	0	17.6	11.6	26	15.1
2016	November	6	0	19.9	6.6	26.9	16.1
2016	November	7	0	25.3	6.5	26.4	17.3
2016	November	8	0	28.6	7.9	24.9	17.8
2016	November	9	8.4	24.8	11.7	24.2	17.2
2016	November	10	6.2	24	10.6	28.5	16.4
2016	November	11	0	26.1	8.5	28.2	18.9
2016	November	12	19.4	26.5	14.6	22.3	15
2016	November	13	0	18.6	10.1	19.6	14.1
2016	November	14	8.6	19.8	7.9	21.9	12.8
2016	November	15	0.6	20.6	4	27.1	13.6
2016	November	16	0	25.3	5.2	29.7	17.9

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2016	November	17	0	25.5	11	30.4	18.5
2016	November	18	0	30	9.1	32.1	20.5
2016	November	19	0	31.1	11.7	33	21.9
2016	November	20	0	31.1	13.4	29.4	21.4
2016	November	21	9.4	30.2	14.4	31.6	20.2
2016	November	22	0	31.2	11.9	28	21.2
2016	November	23	0	20.4	13.4	25.8	13.8
2016	November	24	4.2	21.2	2.5	28.5	15.6
2016	November	25	0	24.3	4.7	30.4	18.3
2016	November	26	0	24.7	7.9	30.9	19.3
2016	November	27	0	26.5	9.2	32.7	22
2016	November	28	0	27.7	14.7	32.9	20.7
2016	November	29	0	28	7.9	33	22
2016	November	30	0	30.1	10.4	33.5	22.7
2016	December	1	0	28.8	12.1	32.6	21.5
2016	December	2	0	30.3	8.5	33.4	22.7
2016	December	3	0	30.9	11.7	32	22.8
2016	December	4	0	32.8	10.6	29.5	24.4
2016	December	5	1	31.4	17.7	27.9	22.4
2016	December	6	13.4	23.1	16.9	28.8	17.5
2016	December	7	0.2	26.9	8.9	28.4	19.2
2016	December	8	0	31.3	10.1	27.6	17.2
2016	December	9	2	21.6	11	30.5	18.1
2016	December	10	0	25.2	7.3	32.7	21.3
2016	December	11	0	28	12.8	33.8	23.2
2016	December	12	0	31.2	15.3	31	22.8
2016	December	13	0	33.9	10.6	28.9	25.1
2016	December	14	0	28.6	21.6	24.4	20.1
2016	December	15	3	14.8	12.8	21	17.6
2016	December	16	5.8	20.1	12.3	24.4	18.5
2016	December	17	11.4	27.9	13.5	28.3	17.6
2016	December	18	0	24.9	11.4	29.6	19.5
2016	December	19	0	26.5	11.1	28.4	20.2
2016	December	20	0	30.8	9.7	31.6	20.1
2016	December	21	0	28.7	8.9	32.2	22.6
2016	December	22	0	26.6	14.6	34	23.4

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2016	December	23	0	31.8	14.6	32.7	24.9
2016	December	24	0	32.5	14.1	29	19.9
2016	December	25	22.4	30.9	11.3	30.2	21.3
2016	December	26	0	31.5	14	30.5	23.5
2016	December	27	0	31.9	18.4	28.7	23.3
2016	December	28	0.2	31.9	16.3	27.7	24.5
2016	December	29	0	29.9	21.8	29.3	23.4
2016	December	30	2.2	32.8	20.3	31.6	22.5
2016	December	31	3	31.5	18.9	31.6	22.5
2017	October	1	0	19.8	-0.7	22.7	11.7
2017	October	2	0	22.5	1.7	24.1	13.7
2017	October	3	0	25	4.5	24.5	13.7
2017	October	4	0	25.4	2.4	23.2	16.5
2017	October	5	0	26.6	8.3	23.8	15.6
2017	October	6	0.2	21.5	11.1	24.1	13.7
2017	October	7	0.2	21.1	1.3	20.5	15.1
2017	October	8	0	20.1	5.2	21.1	16.2
2017	October	9	12.8	25.4	12.2	22.7	12.5
2017	October	10	0	22.7	4.5	24.7	15.8
2017	October	11	0	25.6	10.8	21.6	16
2017	October	12	3.8	20.6	12.3	23.4	13.2
2017	October	13	0	21.3	2.8	20.2	16.1
2017	October	14	0	17.9	10.8	25.8	14.9
2017	October	15	0	24.7	6.7	27.2	16
2017	October	16	0	25.2	6.1	28.4	16.4
2017	October	17	0	27.4	3.7	28.4	17.5
2017	October	18	0	27.5	5.5	25.7	18.9
2017	October	19	0	27.3	9.2	21.5	17.6
2017	October	20	11.2	21.1	14.2	22.9	13
2017	October	21	0.2	19.9	1.4	23	15.6
2017	October	22	0	19.1	9.1	25.9	13.5
2017	October	23	0.4	22.6	3.1	23.3	15.1
2017	October	24	0	24.7	3.6	23.7	17.3
2017	October	25	0	25.8	12.5	24.4	17.6
2017	October	26	0.2	23.8	12.2	22.2	15.7
2017	October	27	15.2	22.7	10.8	22.6	15.6

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2017	October	28	0.2	26.4	9.7	24.7	16.7
2017	October	29	1.2	25.4	11.2	24.6	16.3
2017	October	30	0	21.5	9.7	20.9	13.7
2017	October	31	12.8	17.7	3.6	22.9	11.7
2017	November	1	0	21.4	4.8	25.1	13.9
2017	November	2	0	23.1	5.8	23.9	15.1
2017	November	3	0	19.7	4.3	26.5	16.4
2017	November	4	0	21.3	9.5	25.3	16.8
2017	November	5	0	19.4	8.3	19.6	14.6
2017	November	6	20.8	14.6	10.4	21.1	10.9
2017	November	7	18.6	19.3	2.5	23.6	13
2017	November	8	0	20.7	7	26.8	13.5
2017	November	9	0	25.5	3.1	27.8	15.2
2017	November	10	0.2	25.6	4.5	27.3	18
2017	November	11	0.2	24.1	11.1	27.8	18.1
2017	November	12	0.2	23.5	13	27.2	18.5
2017	November	13	0	22.8	11.6	29.9	17.8
2017	November	14	0	25.7	7.1	31	19.3
2017	November	15	0	28.2	8.2	24.3	20.3
2017	November	16	0	20.1	11	23.6	18
2017	November	17	2.4	24.3	12.9	19.8	17.5
2017	November	18	1.8	19	14.5	26.4	16.1
2017	November	19	0.4	24.4	12.5	29.7	16.9
2017	November	20	0	25.5	8.4	31.1	19.1
2017	November	21	0	26.1	7.4	32	20.1
2017	November	22	0	27.2	9.1	30.4	22.4
2017	November	23	0	27	12.2	30.8	19.2
2017	November	24	0.8	29.8	8.9	31.7	18.9
2017	November	25	1.4	31	10.9	26.4	21.4
2017	November	26	0.2	25.9	11.4	26.5	20.3
2017	November	27	7.6	26.6	16.1	26.7	18.1
2017	November	28	15.6	28.4	11.5	31.1	19.7
2017	November	29	0.2	29.1	16.4	32.1	21.2
2017	November	30	0	30.6	12.8	29.1	22.8
2017	December	1	0	30.6	15	23.7	19.9
2017	December	2	35.2	19.6	17.7	21.4	16.8

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2017	December	3	18.4	19.9	12.2	16.9	15.8
2017	December	4	0.2	15.7	10.7	18.3	14.6
2017	December	5	6.6	20	11.4	18.7	14.9
2017	December	6	5.2	20.2	11.9	23.6	14
2017	December	7	0.2	26.7	8.7	23.9	16.8
2017	December	8	6.2	22.5	12	26.9	16.1
2017	December	9	0	25	7.8	29.7	18.1
2017	December	10	0	28	10.9	30.7	20.4
2017	December	11	0	29.7	12	32.3	22.8
2017	December	12	0	30.6	16.4	32.3	23
2017	December	13	0	32.7	12.5	29.4	23.3
2017	December	14	0	32.9	13.6	28.7	23.4
2017	December	15	3.2	30.5	17.9	31.5	22.5
2017	December	16	0	32.6	14.1	32	23.8
2017	December	17	1.6	31.6	16.3	30.4	24.4
2017	December	18	0.2	32.6	16.4	31	24.7
2017	December	19	0	34.3	18	28	23.9
2017	December	20	0.2	27.5	22.8	29.2	20
2017	December	21	1.6	26.7	9.4	30.1	22.7
2017	December	22	0	29.5	12.5	31.2	23.1
2017	December	23	0	31.8	11.9	29.5	23.6
2017	December	24	0	34.8	13.2	27.5	23.1
2017	December	25	0	23	13.4	26.8	21.9
2017	December	26	0	22.4	10.8	29.7	22.6
2017	December	27	0	29.1	15.8	30.3	22.9
2017	December	28	0	32.4	12.9	29.5	24.6
2017	December	29	0	33.4	18.3	28	23.3
2017	December	30	16.4	28.3	18.6	29.8	21.6
2017	December	31	0	27.9	14.9	34.4	21.1
2018	October	1	0	22.6	0.4	23	11.4
2018	October	2	0	24.7	0	23.1	11.9
2018	October	3	0	17.6	6.5	17.3	14.8
2018	October	4	1	14	9.1	14.2	12.9
2018	October	5	1	16.4	8.2	17.2	10.9
2018	October	6	0	18.6	3.7	22.5	10.9
2018	October	7	0	21.2	2.3	21.6	11.2

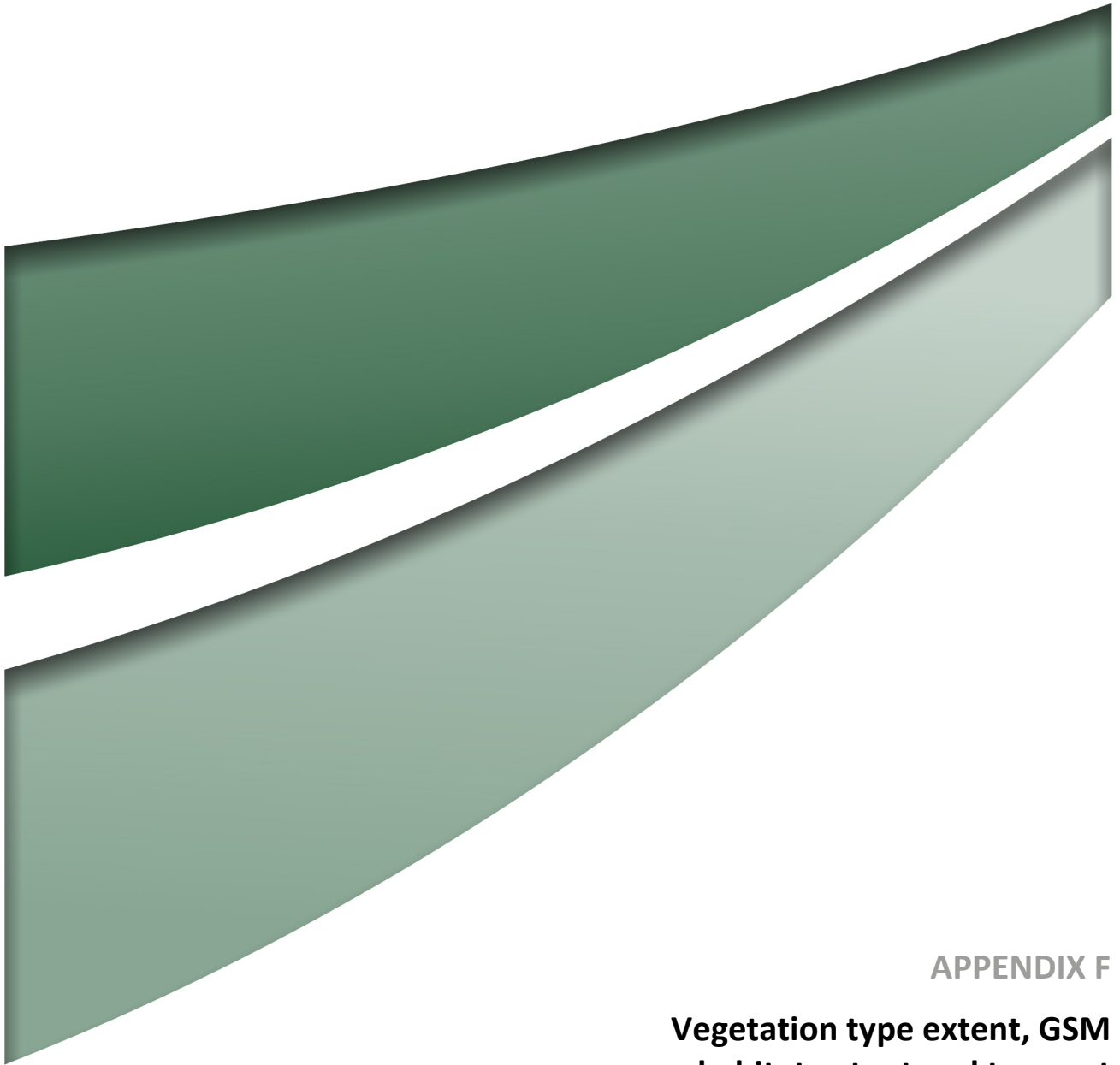
Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2018	October	8	0	23.5	8.5	24	14
2018	October	9	0	24.2	5	23.1	14.6
2018	October	10	1.8	13.2	10.9	17.9	14
2018	October	11	0	14.7	6.2	17	11.7
2018	October	12	0	16.8	6	18.1	12.3
2018	October	13	0.2	21.3	5.7	20.8	12.7
2018	October	14	0	18	10.8	18.5	14.4
2018	October	15	0	23.7	11.8	24.2	15
2018	October	16	0	26.1	14.8	25.2	17.5
2018	October	17	0	22.9	11.6	22.1	17.8
2018	October	18	0.8	24.9	11.4	24.5	16.5
2018	October	19	0	27.8	5.5	26.9	15.6
2018	October	20	0	27.2	10.3	21.7	17.7
2018	October	21	9.4	21.9	4.7	23.9	13.1
2018	October	22	0	25.5	8.8	26.6	15.5
2018	October	23	0	28.9	4.6	26.5	14.8
2018	October	24	0	21.4	9.9	27.4	17.4
2018	October	25	0	25.2	8.8	27.3	17.4
2018	October	26	0	26.4	7.6	28.2	16.9
2018	October	27	0	27.9	6.4	28	17.6
2018	October	28	0	24.2	5.9	28.3	16.9
2018	October	29	0	24.6	6	28.7	17.4
2018	October	30	0	29.1	8.4	29.2	19.5
2018	October	31	0	31.1	6.4	30.4	17.9
2018	November	1	0	34.2	8.1	30.5	19.3
2018	November	2	0	33.4	17.4	26.7	22.8
2018	November	3	1	27.5	15.9	28.3	19.6
2018	November	4	0	30.3	6.8	28.9	18.1
2018	November	5	0	27.5	11.8	24.8	20.2
2018	November	6	1.2	26.8	16	24.8	19.9
2018	November	7	7.6	18.1	14.8	21	15.2
2018	November	8	9.8	19	4.1	20.3	11.5
2018	November	9	0	20.8	3.6	23.8	12
2018	November	10	0	24.2	3.2	24.7	13.2
2018	November	11	0	26.5	5.6	29.3	14.9
2018	November	12	0	29.5	8.6	30.6	17.9

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2018	November	13	0	31.2	12.1	30.3	20.6
2018	November	14	0	22	16.5	24.2	20.3
2018	November	15	8.8	27.1	12.7	25.2	17.4
2018	November	16	0.2	23.7	11.4	27.6	17.1
2018	November	17	0	21.9	11	25.5	18.3
2018	November	18	0	22.2	10.7	27.5	17.8
2018	November	19	0	26.1	10	31.1	18.4
2018	November	20	0	30.2	9.7	31	19.9
2018	November	21	12	23.7	16.3	24.1	20.4
2018	November	22	22.4	15.2	9.6	18.8	14.4
2018	November	23	6.2	15.2	6.9	14.5	11.6
2018	November	24	0.4	20.8	8.7	20.5	11.6
2018	November	25	0	23.1	5.5	25.7	13.1
2018	November	26	1	23.8	8	27.5	14.3
2018	November	27	0.2	24.2	11.9	26.7	18.2
2018	November	28	7.8	18.2	13.6	19.8	16.8
2018	November	29	3.8	23.4	10.8	25.4	13.1
2018	November	30	0	25.9	13	28.3	17.1
2018	December	1	0	29.3	9	29.9	17.4
2018	December	2	0	26.1	9.7	27.2	18.4
2018	December	3	0	23.9	9.1	27.6	16.7
2018	December	4	0	28.6	13	31.8	18.4
2018	December	5	0	24.7	14.2	29.7	21.3
2018	December	6	0	29.3	12.1	32.9	20.8
2018	December	7	0	32.5	11.5	35.2	21.9
2018	December	8	0	33.5	12.6	34.1	23.4
2018	December	9	0	32.9	14.5	31.8	23.6
2018	December	10	17	29	16	26.8	22.2
2018	December	11	0	25	16.1	26.9	19.9
2018	December	12	0.6	28.4	14.9	32	19.6
2018	December	13	28.6	24.4	16.8	25.5	21.2
2018	December	14	33.2	23	15.1	24	18.9
2018	December	15	9.2	26.4	16.1	25.5	19
2018	December	16	0	27.8	13.6	27	18.4
2018	December	17	0	28.5	10.7	32.4	18
2018	December	18	0	30.6	14.2	34.1	20.9

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2018	December	19	0	29.3	17.8	31.2	23.4
2018	December	20	0	33.3	17.1	35.9	23.4
2018	December	21	0	22.9	15.3	27.8	24.1
2018	December	22	16.2	22.5	11.1	24.4	18.4
2018	December	23	1.6	23.6	7.6	29.7	15.9
2018	December	24	0	28.6	9.5	33	18.6
2018	December	25	0	31.8	11.2	34.9	20.7
2018	December	26	0	34.4	13.2	35.5	22.8
2018	December	27	0	36.5	15	36	24.4
2018	December	28	0	36.8	17.8	35.8	25.5
2018	December	29	0	36.7	16.9	37.3	26.1
2018	December	30	0	34.5	16.7	34.2	26.2
2018	December	31	0	34.1	17.7	33.1	25.5
2019	October	1	0	21.1	5.6	24.4	13.4
2019	October	2	0	24.7	1.8	23.8	12.4
2019	October	3	0	28	4.2	25	13.2
2019	October	4	0	28.1	5.7	25.2	14.3
2019	October	5	4	19.2	12.1	21.2	16.4
2019	October	6	0	30.4	11.4	24.2	15.1
2019	October	7	0	23.7	8.6	23.8	16
2019	October	8	0	18.7	8.4	18.9	12.1
2019	October	9	11.2	16.3	1.7	18.7	9.2
2019	October	10	0	19.2	1	21.6	9.3
2019	October	11	0	17.1	8.5	20.4	13.7
2019	October	12	0	15.9	6.6	19.1	12.5
2019	October	13	0	19.8	1.8	22.8	12.1
2019	October	14	0	22.7	4.3	22.3	13.3
2019	October	15	0	28	6.6	26	13.7
2019	October	16	0	24.8	7.8	23.2	16.4
2019	October	17	4.8	16.1	9.5	19.6	13.4
2019	October	18	0	21	5.8	22.1	11
2019	October	19	0	19.2	8.8	22	13.2
2019	October	20	0	20.9	-0.2	24.3	11.7
2019	October	21	0	26.7	3.1	27.2	13.6
2019	October	22	0	28.5	5.8	28.2	15.8
2019	October	23	0	29.2	5.8	28	16.8

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2019	October	24	0	31.2	6.8	29.6	17.2
2019	October	25	0	31.1	9.1	26.6	18.4
2019	October	26	7.6	18.2	12.3	19.8	14.9
2019	October	27	0	20.5	4.6	23.3	11.8
2019	October	28	0	22.9	3.7	26.6	13.4
2019	October	29	0	27.4	5.6	27.7	15.7
2019	October	30	0	29.3	8.8	27.5	17.2
2019	October	31	0	31.7	7	30.5	17.6
2019	November	1	0	32.5	10.4	31.2	19.4
2019	November	2	0	31.3	13.9	28.7	21.3
2019	November	3	0	25.8	15.8	24.6	18.8
2019	November	4	12.4	22.6	11.5	22.1	16.6
2019	November	5	0.2	19	8.6	25.7	14
2019	November	6	0	23.7	7.2	25.3	14.3
2019	November	7	0	19.4	11.3	24.8	17.1
2019	November	8	0	18.8	12.7	23.1	16.8
2019	November	9	0	16.7	1.6	23.6	13.2
2019	November	10	0	20.4	8.4	23.2	14.4
2019	November	11	0	26.4	3.7	26.9	14.4
2019	November	12	0	26.6	5.8	24	16.2
2019	November	13	0	20.8	6.7	25.6	15
2019	November	14	0	24.7	7.1	27	15.7
2019	November	15	0	25.7	11.8	27.1	17.1
2019	November	16	0	25.7	8.4	28.4	17.3
2019	November	17	0	25.1	9.6	30	18.4
2019	November	18	0	27	6.8	29	18.9
2019	November	19	0	32.5	8.4	31.1	18.9
2019	November	20	0	31.4	8.4	32.9	19.6
2019	November	21	0	39	10.9	34.4	21.6
2019	November	22	0	34.9	16.9	32.2	24.1
2019	November	23	0	33.1	12.9	33.2	22.8
2019	November	24	0	28.6	8.1	32.1	21.5
2019	November	25	0	31.5	10.7	31.8	21.9
2019	November	26	0	27.3	15.4	27.7	21.4
2019	November	27	0	27.1	1.6	29.8	17.4
2019	November	28	0	30.3	5.6	32.1	19.1

Year	Month	Day	Precipitation 24 hours before 9 am (mm)	Max temp (°C)	Min temp. (°C)	Max soil temp. at 10 cm depth (°C)	Min soil temp. at 10 cm depth (°C)
2019	November	29	0	33.1	12.6	32.9	21.8
2019	November	30	0	23.8	11.8	26.6	21.6
2019	December	1	0	21.5	4.6	26.3	18.1
2019	December	2	0.6	15.1	7.4	20.3	16.7
2019	December	3	0.6	20.8	8.5	25.6	15.2
2019	December	4	0	24.1	12.6	27.6	17.7
2019	December	5	0	28.2	11.2	29.3	18.2
2019	December	6	0	28	15.7	30.4	20.4
2019	December	7	0	29.7	11.1	31	20
2019	December	8	0	29.9	11.1	31.7	21.1
2019	December	9	0	34.9	14.9	33.1	23.3
2019	December	10	0	38.1	12.2	34	22.6
2019	December	11	0	32.7	11.3	33.4	22.9
2019	December	12	0	30.5	12.8	33.9	23.2
2019	December	13	0	27.8	12.8	31.7	23.2
2019	December	14	0	29.6	9.2	32.1	21.9
2019	December	15	0	29	12.9	27.5	22.8
2019	December	16	0	32	10.6	33.7	21
2019	December	17	0	32.5	12.1	33.8	22.8
2019	December	18	0	36.8	12.2	34.7	23.1
2019	December	19	0	39.3	15.8	35.2	25.2
2019	December	20	0	39	12.8	35.2	24.1
2019	December	21	0	41.1	14.7	34.7	24.9
2019	December	22	0	24.9	15.5	32.6	25.2
2019	December	23	0	32.4	8.6	33.7	22
2019	December	24	0	28.8	15.3	32.9	24.3
2019	December	25	0	32.2	15.1	34.6	24.2
2019	December	26	0	35	15.6	36.3	25.2
2019	December	27	0	36.8	15.3	36.7	25.6
2019	December	28	0	37.7	17.1	35.6	26.8
2019	December	29	0	36.1	19.6	33.6	27
2019	December	30	0	39.8	17.6	36.5	26
2019	December	31	0	38	19.8	34.5	27.7



APPENDIX F

**Vegetation type extent, GSM
habitat extent and transect
data**

Appendix F-1: Revised vegetation and land use mapping compared with 2013 and 2018

Vegetation type / land use	2013 (ha)	2014 (ha)	2015 (ha)	2016 (ha)	2017 (ha)	2018 (ha)	2019 (ha)	Change since 2013 (ha) (%)	Change since 2018 (ha) (%)
Natural temperate grassland	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0
Native pasture	1.7	1.7	1.6	1.6	0.7	0.7	0.9	-0.8 (47%)	+0.2 (12%)
Mixed native and exotic pasture	5.0	5.0	4.9	4.9	5.8	4.8	4.7	-0.3 (6%)	-0.1 (2%)
Exotic pasture	5.4	5.4	6.5	6.5	6.7	7.6	7.6	+2.2 (41%)	0
(Construction area)	0.8	0.8	0	0	0	0	0	NA	NA
(Non-grassland areas (e.g. buildings, riparian margins, woodland))	8.0	8.0	8.0	8.0	8.0	8.0	8.0	NA	NA
Total Project Area	21.6	21.6	21.6	21.6	21.6	21.6	21.7¹	NA	NA
Chilean needle grass	1.2	1.2	1.1	1.4	1.8	2.9	3.2	+2.0 (166%)	+0.3 (10%)
African lovegrass	0	0	0	0.3	2.1	2.7	3.2	+3.2 (NA)	+0.5 (19%)

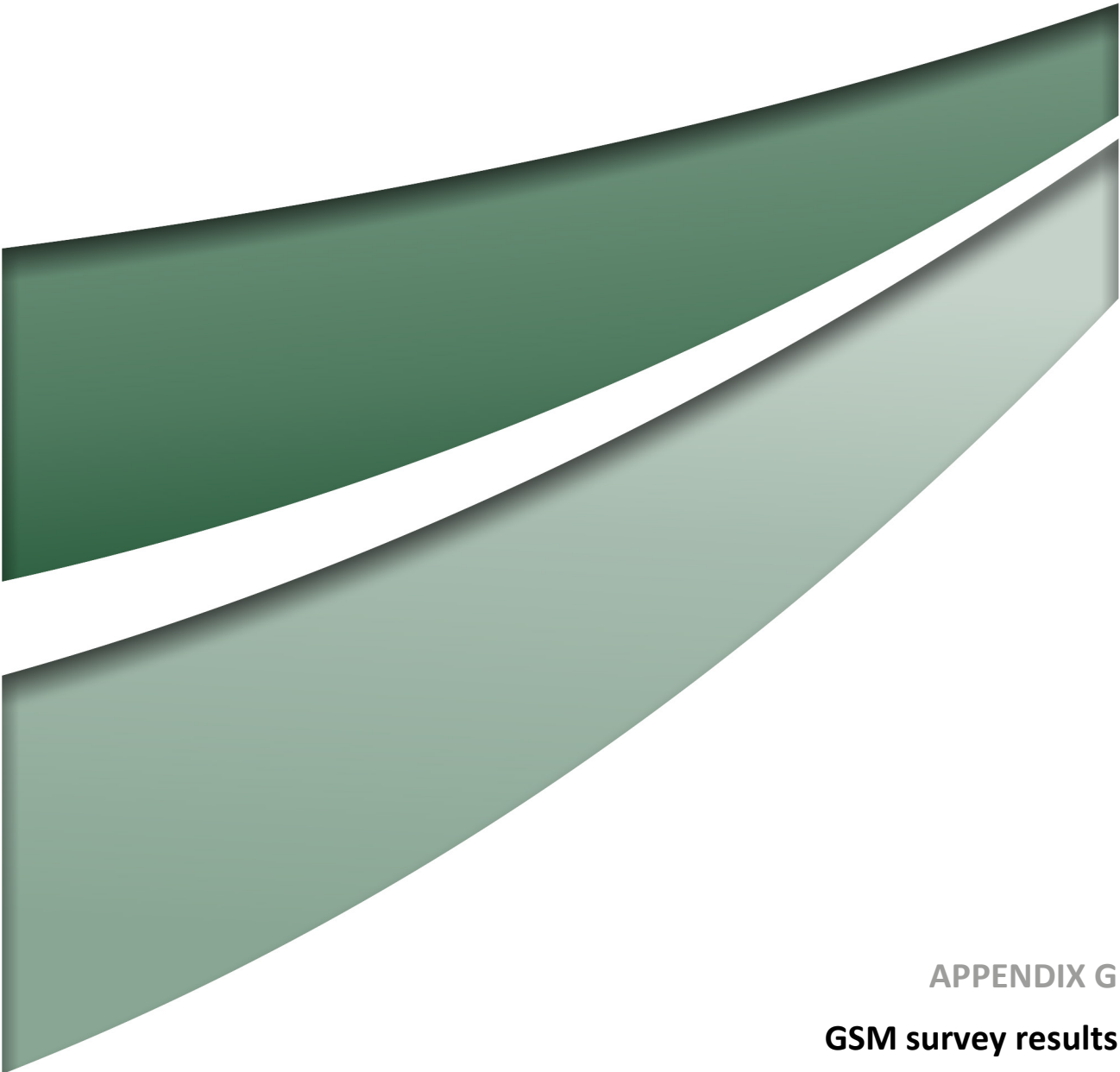
1. A recalculation of the total project area was undertaken and has resulted in an increase in the total size, however, this would not have a substantial effect on the results.

Appendix F-2: Revised 2018 GSM habitat areas compared with 2013-2017

GSM habitat area	2013 (ha)	2014 (ha)	2015 (ha)	2016 (ha)	2017 (ha)	2018 (ha)	2019 (ha)	Change since 2013 (ha) (%)	Change since 2018 (ha) (%)
Low quality	4.8	4.8	5.9	5.9	6.4	5.9	5.8	-1.0 (-20%)	-0.1 (-1%)
Low quality dominated by Chilean needle grass	0.6	0.6	1.3	1.3	1.6	2.6	2.9	+2.3 (+383%)	0.3 (+11%)
Moderate quality	2.2	2.2	2.0	2.0	1.1	1.1	1.1	-1.1 (-50%)	0.0
High quality	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	7.6	7.6	9.2	9.2	9.1	9.6	9.8	+2.2 (+28%)	+0.2 (+2%)

Appednix F-3: 2019 step-point transect compared to 2018

Category	2018 (Total counts)	2019 (Total counts)	Change since 2018 (total counts)
Cryptogram	1	0	-1
Bare	54	81	+27
Rock	0	0	0
Litter	180	106	-74
Chilean needle grass	45	26	-19
Serrated tussock	0	0	0
African love grass	85	39	-46
Annual exotic grass	31	80	+49
Perennial exotic grass	69	70	+1
Exotic forb	23	23	0
Wallaby grass	2	16	+14
Speargrass	50	64	+14
Perennial native grass	83	70	-13
Native other	24	21	-3



APPENDIX G
GSM survey results

Appendix G-1: GSM traverse survey results (2013-2019)

Year	Total GSM	Max # GSM	Average # GSM / min	Max # GSM / min	Min # GSM / min
2013	64.0	8.3	0.9	1.4	0.4
2014	74.3	9.7	0.8	1.6	0.1
2015	25.7	3.7	0.3	0.6	0.1
2016	277.0	92.0	2.3	3.1	1.8
2017	87.0	8.3	1.2	1.6	0.8
2018	549.7	971	7.1	14.5	2.1
2019	60.7	10.0	1.0	1.1	0.7

Appendix G-2: Summary of transect survey results

Transect	Total (2018)	Average (2018)	Total (2019)	Average (2019)
1A	234	78.0	16	5.3
1B	103	34.3	26	8.7
2A	68	22.7	7	2.3
2B	36	12.0	17	5.7
2C	59	19.7	10	3.3
2D	38	12.7	14	4.7
3A	16	5.3	0	0.0
3B	76	25.3	8	2.7
3C	100	33.3	1	0.3
3D	96	32.0	15	5.0
4A	118	39.3	22	7.3
4B	117	39.0	47	15.7
4C	170	56.7	31	10.3
4D	48	16.0	30	10.0
5A	33	11.0	4	1.3

Appednix G-3: Average and maximum numbers of GSM at rotational survey sites (2013-2019)

Point	Average (1DP)2013	Average (1DP)2014	Average (1DP)2015	Average (1DP)2016	Average (1DP)2017	Average (1DP)2018	Average (1DP) 2019	Average (1DP) 12-19	Maximum 2013	Maximum 2014	Maximum 2015	Maximum 2016	Maximum 2017	Maximum 2018	Maximum 2019
1	2.1	3.4	1.7	2.2	5.0	16.9	1.0	4.6	6	14	3	8	24	65	6
2	2.3	2.3	2.4	0.5	1.2	10.8	1.0	2.9	7	7	5	2	4	40	5
3	3.0	6.3	2.3	3.6	0.7	3.3	0.3	2.8	8	20	5	14	3	14	2
4	3.9	8.9	5.6	43.2	1.5	1.3	0.7	9.3	14	26	9	129	12	9	10
5	0.4	0.6	0.4	1.7	0.0	1.4	0	0.6	5	2	1	7	1	9	0
6	0.8	1.9	3.8	4.4	0.5	10.8	0.1	3.2	4	5	6	13	3	38	1
7	0.1	0.0	0.0	0.0	0.0	1.7	0.2	0.3	1	1	0	0	0	9	2
8	0.2	0.0	0.0	12.1	0.2	8.1	3.3	3.4	3	0	0	51	1	33	15
9	0.0	0.8	1.3	1.4	0.0	2.6	0.5	0.9	0	2	3	4	1	10	3
10	0.1	0.7	1.2	11.8	0.1	15.4	6.0	5.0	1	2	3	46	1	63	25
11	0.2	0.7	1.1	2.1	0.2	18.1	1.4	3.4	2	1	1	7	2	62	10
12	0.0	0.5	0.0	0.5	0.2	5.2	0.5	1.0	1	1	0	6	2	23	3



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