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GREAT VICTORIA DESERT MALLEEFOWL MOUND DETECTION VIA LIDAR

FINAL REPORT

June 2019

GREAT VICTORIA DESERT BIODIVERSITY TRUST

GREAT VICTORIA DESERT MALLEEFOWL MOUND DETECTION VIA LIDAR

FINAL REPORT

Prepared by
Anditi Pty Ltd
on behalf of
Great Victoria Desert Biodiversity Trust

Project Manager: Gareth Evans
Report No. 0574_GVD Malleefowl Mound Detection_FINAL
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Document Status

Rev No.	**Reviewer**		**Approved for Issue**	
	Name	**Date**	**Name**	**Date**
1	Gareth Evans	14 June 2019	Peter Jamieson	14 June 2019
FINAL	Gareth Evans	20 June 2019	Peter Jamieson	20 June 2019

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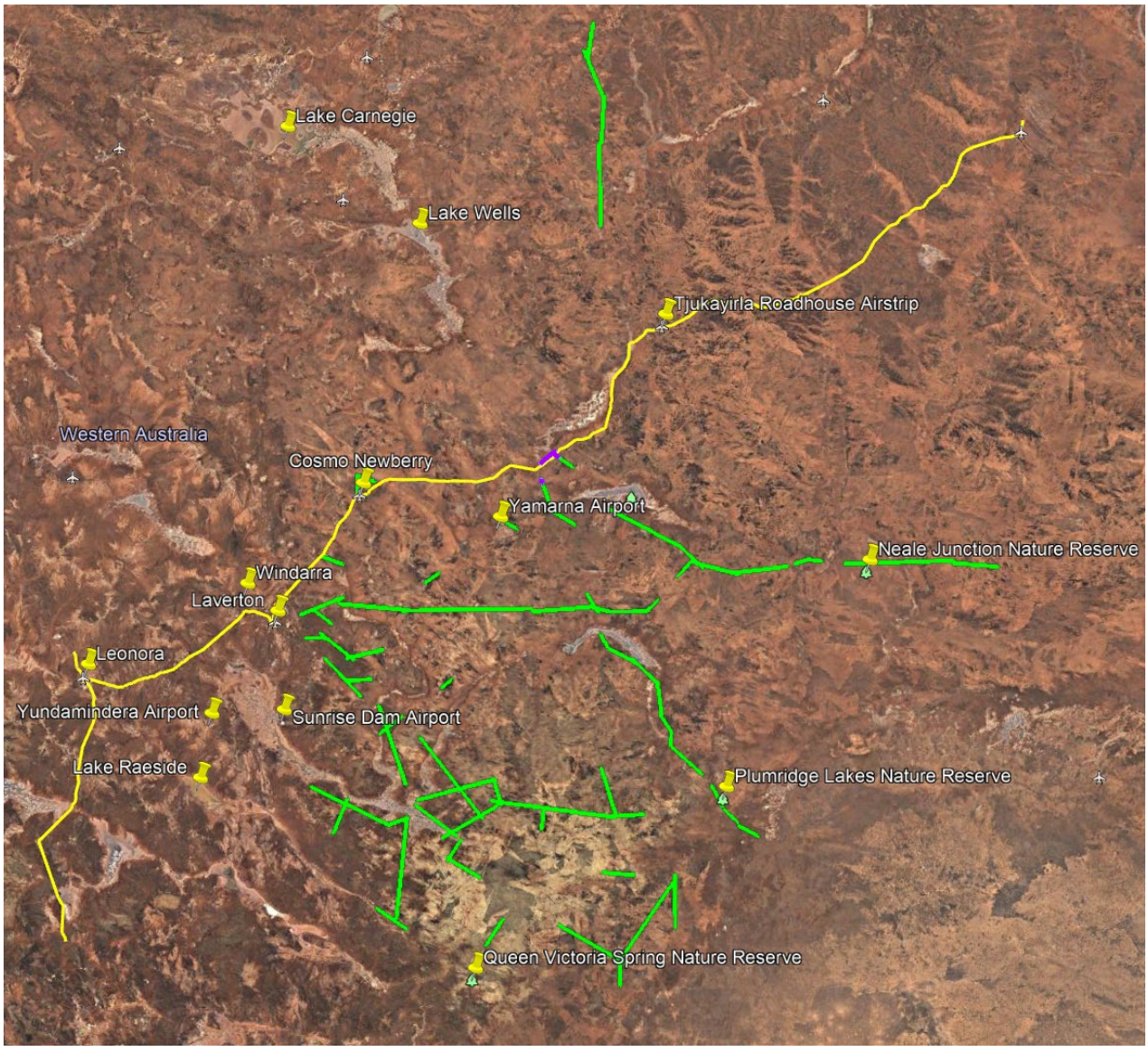
1.0 Project outline

In December 2018, the Great Victoria Desert Biodiversity Trust Fund (GVDBT) and AngloGold Ashanti Australia Limited finalised Professional Services Contract No. GVD-P-18-011 with Anditi. This project was for aerial laser scanning and aerial photography of approximatley1000km² of the Great Victoria Desert in a series of corridors provided by the GVDBT as a precursor to finding existing and new Malleefowl mounds through automated analysis. Anditi sub-contracted McMullen Nolan Group (MNG) to complete the aerial survey using their high accuracy Riegl LiDAR system. The aerial survey was undertaken in extremely hot conditions in January 2019. Once MNG had processed the raw laser point cloud to a 3D LAS point cloud, Anditi were then able to load the point cloud into the Anditi Engine software and classify the data for analysis for Malleefowl mound-like features.

Project area and corridors



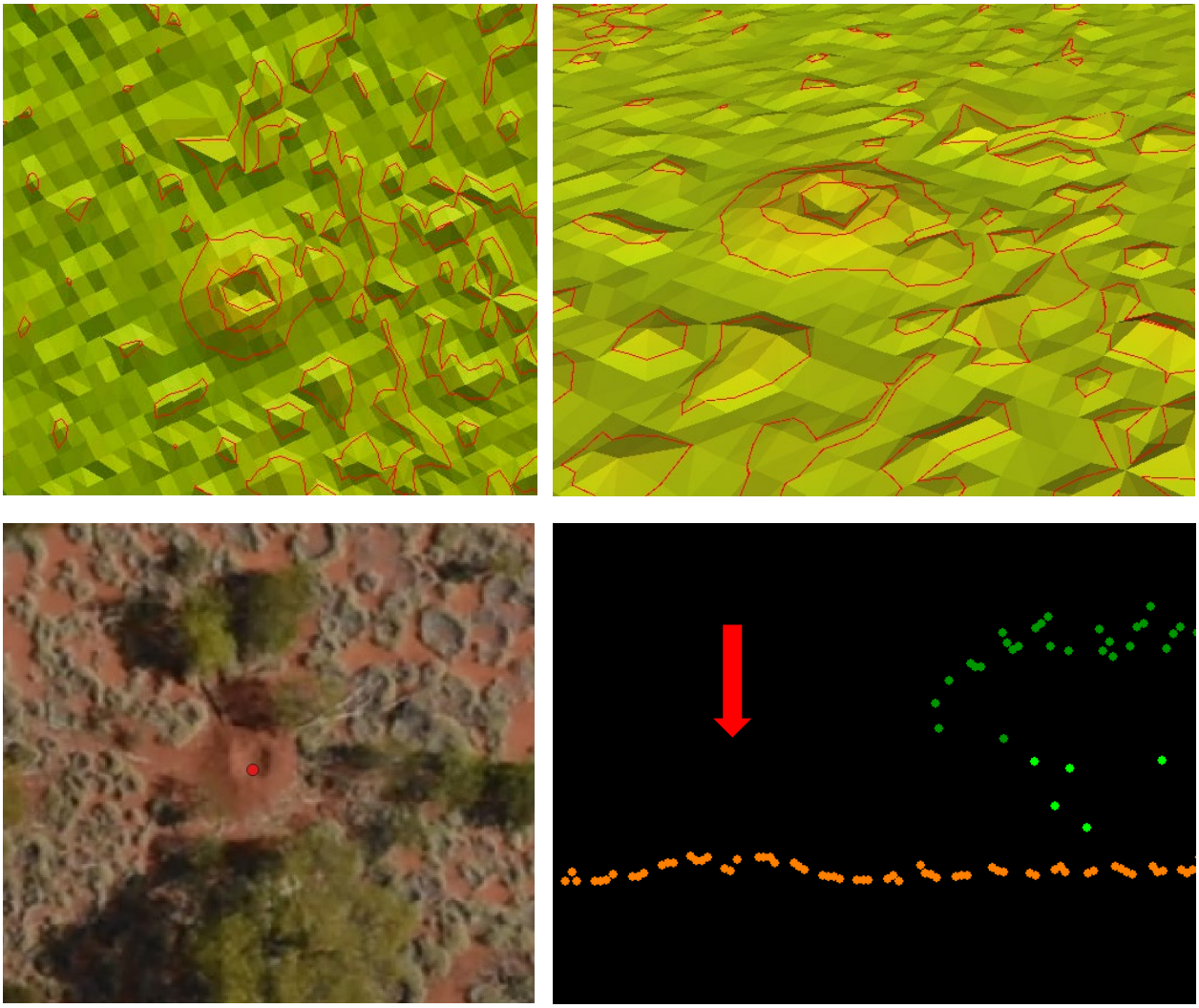
2.0 Anditi Pty Ltd

Anditi Pty Ltd (Anditi) is a spatial analytics company that is focussed on providing high quality geospatial services to clients across the globe. Anditi provides Geographic Information Systems and Services including basic mapping but with our efficient proprietary spatial engine software we are able to tackle complex queries and problems through deep analysis of data in a way that no other GIS solutions can match.

Anditi combines more than 18 years' experience in advanced spatial analytics with the latest high-performance computing technologies. Our ingenious solutions unlock the potential of LiDAR, imagery and other spatial big data where precision, flexibility and scale make the difference.

Using cutting-edge data processing algorithms, machine learning and advanced cloud computing, Anditi provides businesses, organisations and the community with complete solutions for spatial empowerment.

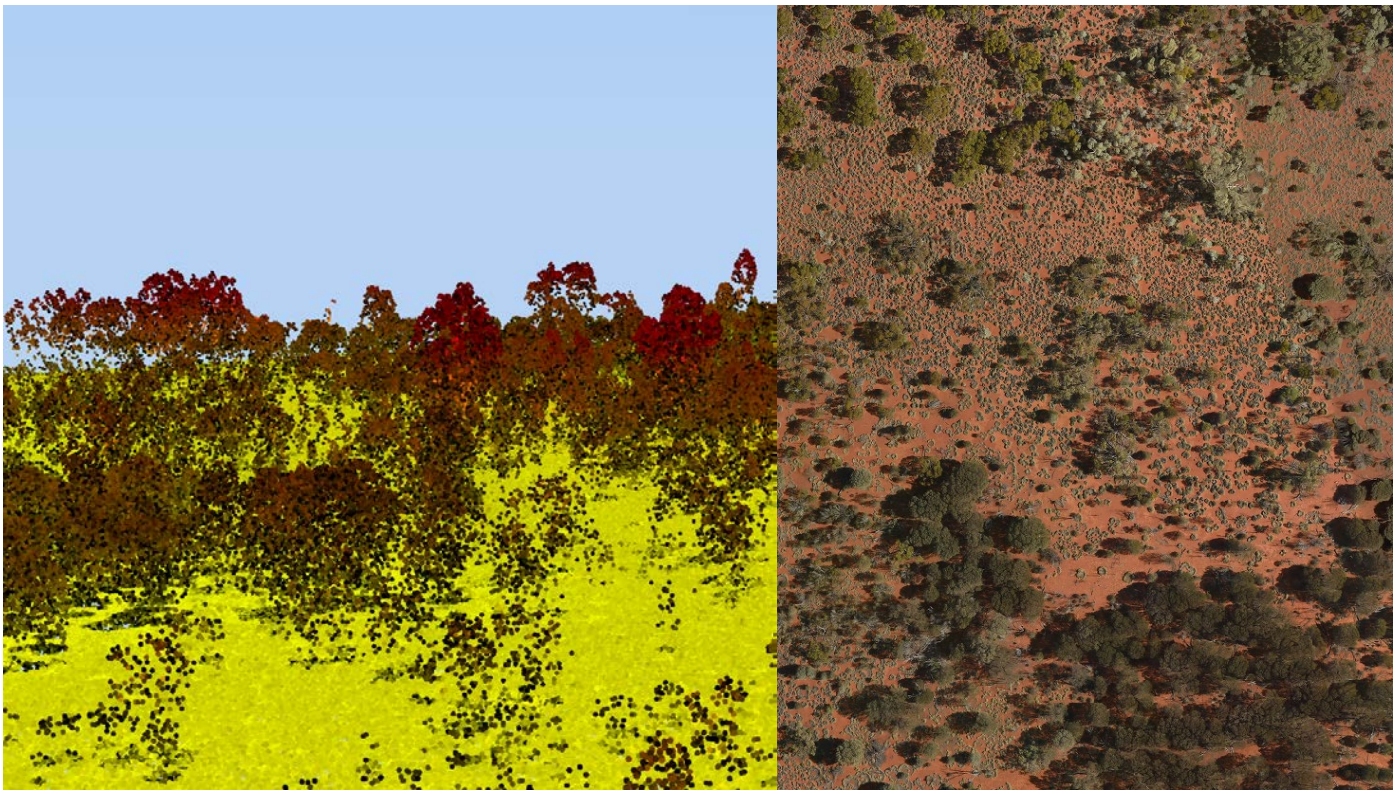
A Malleefowl mound in orthophoto and 3D LiDAR point cloud



3.0 MNG LiDAR

McMullen Nolan Group (MNG) are an innovative survey company that has developed a deep specialisation in laser scanning for survey purposes. Having successfully developed a high accuracy mobile laser scanning system in 2009, they took that knowledge and developed a high accuracy aerial LiDAR system in 2014. Both of these laser systems are supported by years of research and MNG patented methodology. MNG produces very consistent and homogenised point clouds for easier analysis by Anditi systems.

MNG LiDAR Point Cloud and Aerial Images

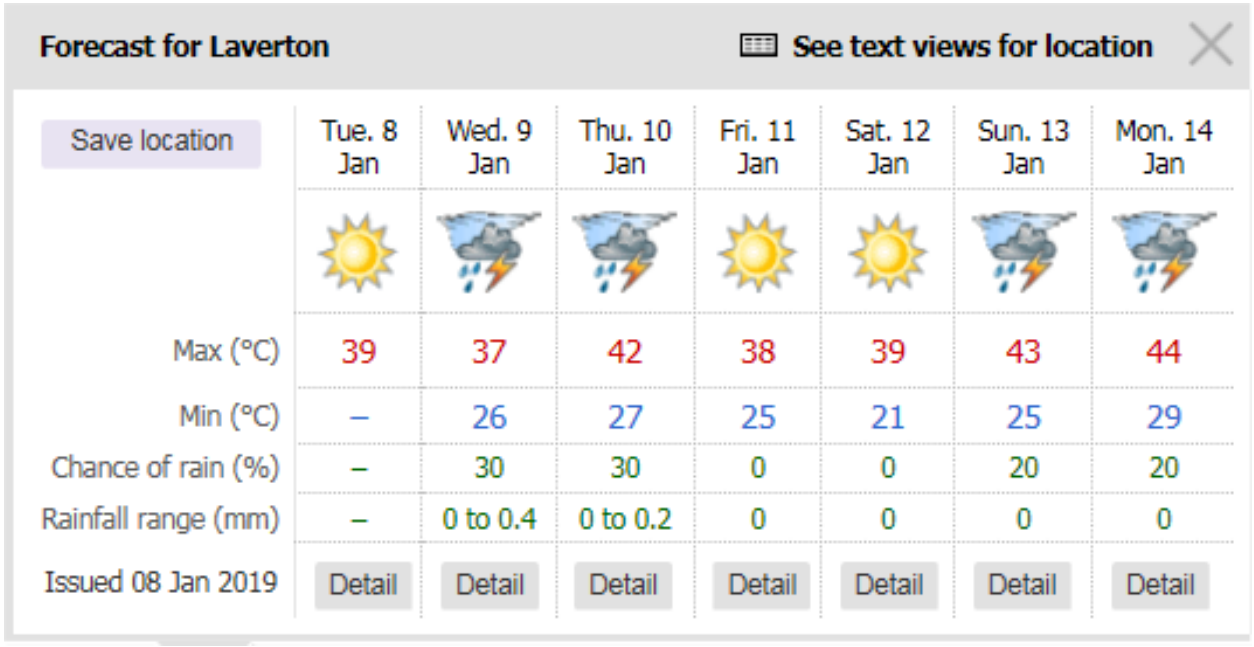


The MNG LiDAR system uses a Riegl VZ2000 laser scanner that has a bench rated accuracy of ±8 mm with a precision of ±5 mm. Flying low and scanning at 300,000 points per second achieves approximately 4-5 points per m² on the ground with each laser point being about 300 mm across in an eye-invisible Near infrared spectrum. MNG flew the entire site twice to ensure a point density on open flat ground of 8-10 points per m². The MNG LiDAR system achieves approximately ±70 mm absolute accuracy with minimal ground control and can achieve ±50 mm accuracy with sufficient control.

4.0 Project safety

A Safe Work Method Statement was developed prior to commencement of the survey. This was provided to the GVD Biodiversity Trust. This was verified through Take 5 checks and reviewed regularly during the survey.

Flying commenced on 9 January. Possible afternoon storms, very hot temperatures and strong winds were anticipated. On commencement of flying it was evident that afternoon survey flying would be unsuitable due to heat and wind conditions.



Forecast for Laverton — **See text views for location**

Save location	Tue. 8 Jan	Wed. 9 Jan	Thu. 10 Jan	Fri. 11 Jan	Sat. 12 Jan	Sun. 13 Jan	Mon. 14 Jan
Max (°C)	39	37	42	38	39	43	44
Min (°C)	–	26	27	25	21	25	29
Chance of rain (%)	–	30	30	0	0	20	20
Rainfall range (mm)	–	0 to 0.4	0 to 0.2	0	0	0	0
Issued 08 Jan 2019	Detail	Detail	Detail	Detail	Detail	Detail	Detail

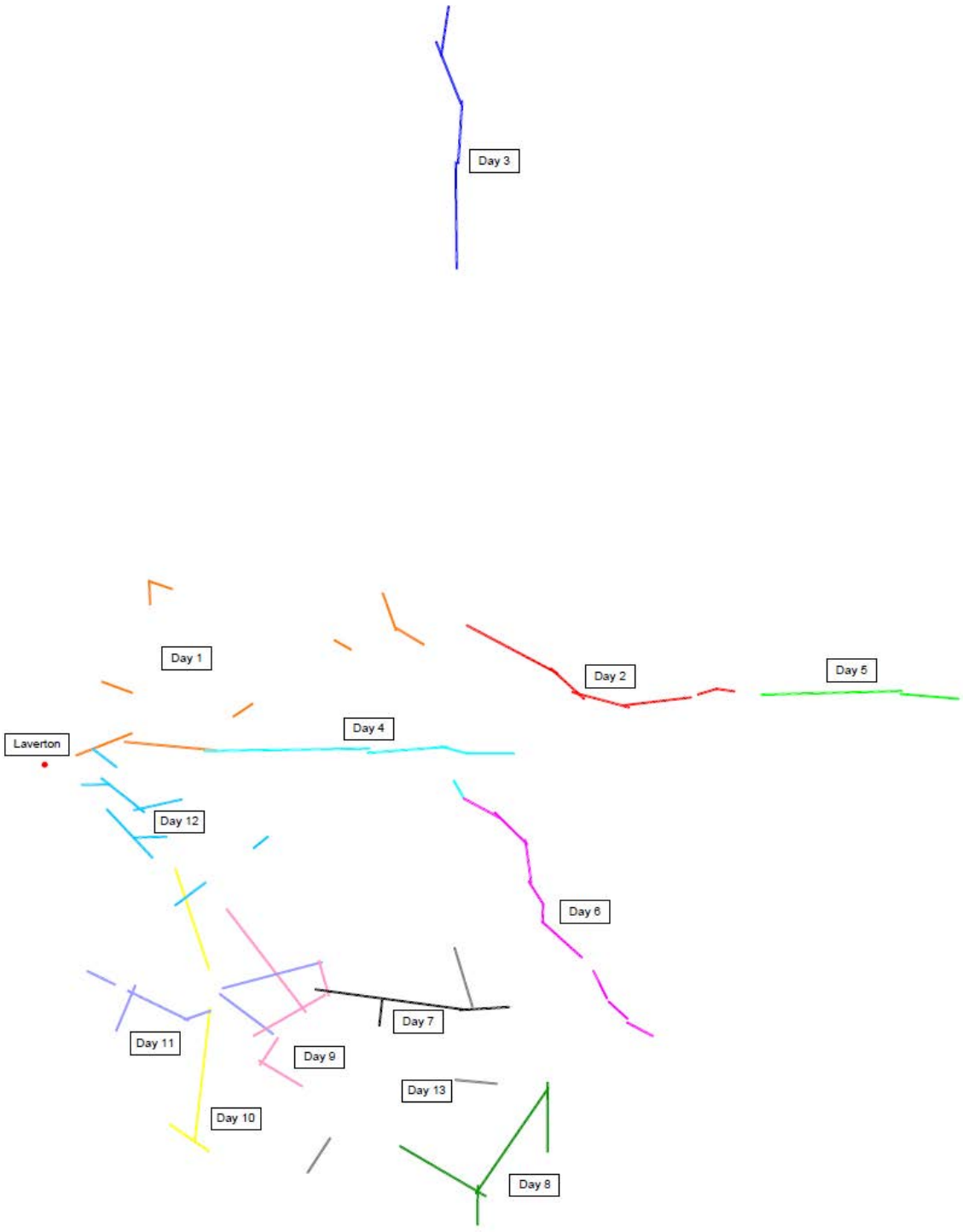
A Pilot duty day was taken on Sunday, 13 January.

Aviation flight tracking software and login details were provided to the GVD Biodiversity Trust. The TracPlus Rockair system was used. It was labelled VH-YJG for the survey. The system was set to 15 sec logging for Cellular coverage, and 2 min Iridium Satellite logging.

Extreme heat was encountered, and this forced some survey parameter changes including flying faster and higher to prevent engine overheating. This affected the survey completion and required some in-fill flying to complete coverage. Fatigue management routines were initiated.

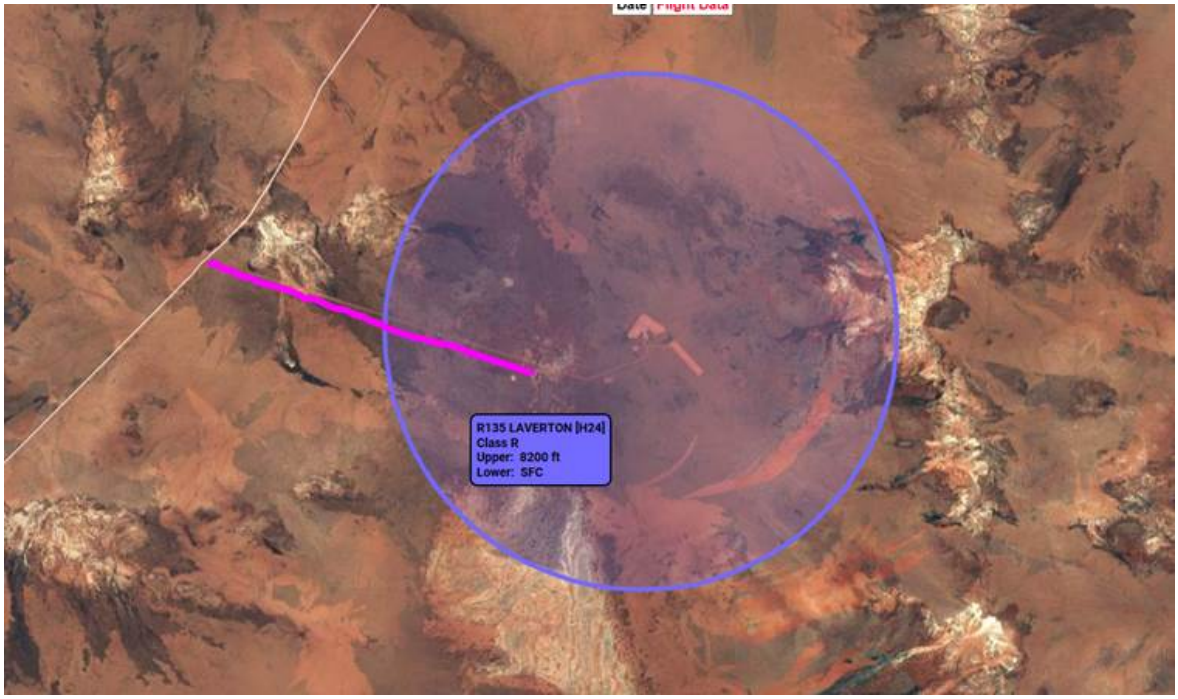
5.0 Survey area flight path

An Initial flight plan was provided (below) with regular updates to the initial plan submitted as the project progressed.



6.0 Military restricted zone

During the survey MNG and Oberon became aware that the small block 50 km north-east of Laverton lands within restricted military airspace (24/7). Enquiries in regard to access were successful and the site was flown at a later date.



7.0 Initial survey

The aerial survey commenced on 9 January and was completed on the 24 January 2019. On completion of the survey, MNG reduced all trajectory information and generated the initial point cloud data.

The point clouds were assessed for completion, and a few areas were identified as requiring additional capture to fill in data gaps. These gaps were due to the adjustments to the proposed flight planning due to weather conditions, namely due to the high temperatures and plane capture speed not providing enough ventilation to cool the engine.

The first visit encountered the following:

- Extreme weather (heat and strong wind).
- Planned capture speed and conditions caused aircraft to experience high temperatures, requiring flight planning to be redesigned to accommodate airflow cooling of aircraft.
- Time of flying was adjusted to early mobilisations before land mass high temperatures were reached. This minimised aircraft turbulence and pilot fatigue. Flight durations were also limited to approximately 5 hrs. Take off from Laverton airport was before 8 am in attempt to commence works before the temperatures increased to peak levels, but generally works required an hour (plus) of ferry/transit time to get to site before imagery was captured over site, so we were typically capturing imagery within preferred time windows where the sun angle was above 30°. For the specific dates and location the preferred sun angle range was actually 7.30 am – 4 pm.
- Plane battery flat on one day due to low fluids/evaporation. Refilled, recharged and checked.
- Restricted airspace encountered for one corridor. Liaison with military airspace control in South Australia was required. Area successfully flown.
- IMU gaps experienced in some data blocks requiring the recapture of some blocks.
- Heavy storm clouds late in the day caused dark imagery, requiring the recapture of some blocks.
- Smoke from bush fires in the central area prevented certain blocks from being captured when planned. Areas were monitored and captured under suitable conditions.

7.1 Flying height impacts

The initial planning was for capture at approximately 900 ft above ground level at 90 knots. The heat forced an increase of aircraft speed to 100 knots, which meant that to achieve the point density with the same flight pattern, a lower height above ground level (800 ft) was required. The lower height meant that the LiDAR swath footprint and therefore overlap was, with some voids experienced and a revisit required.

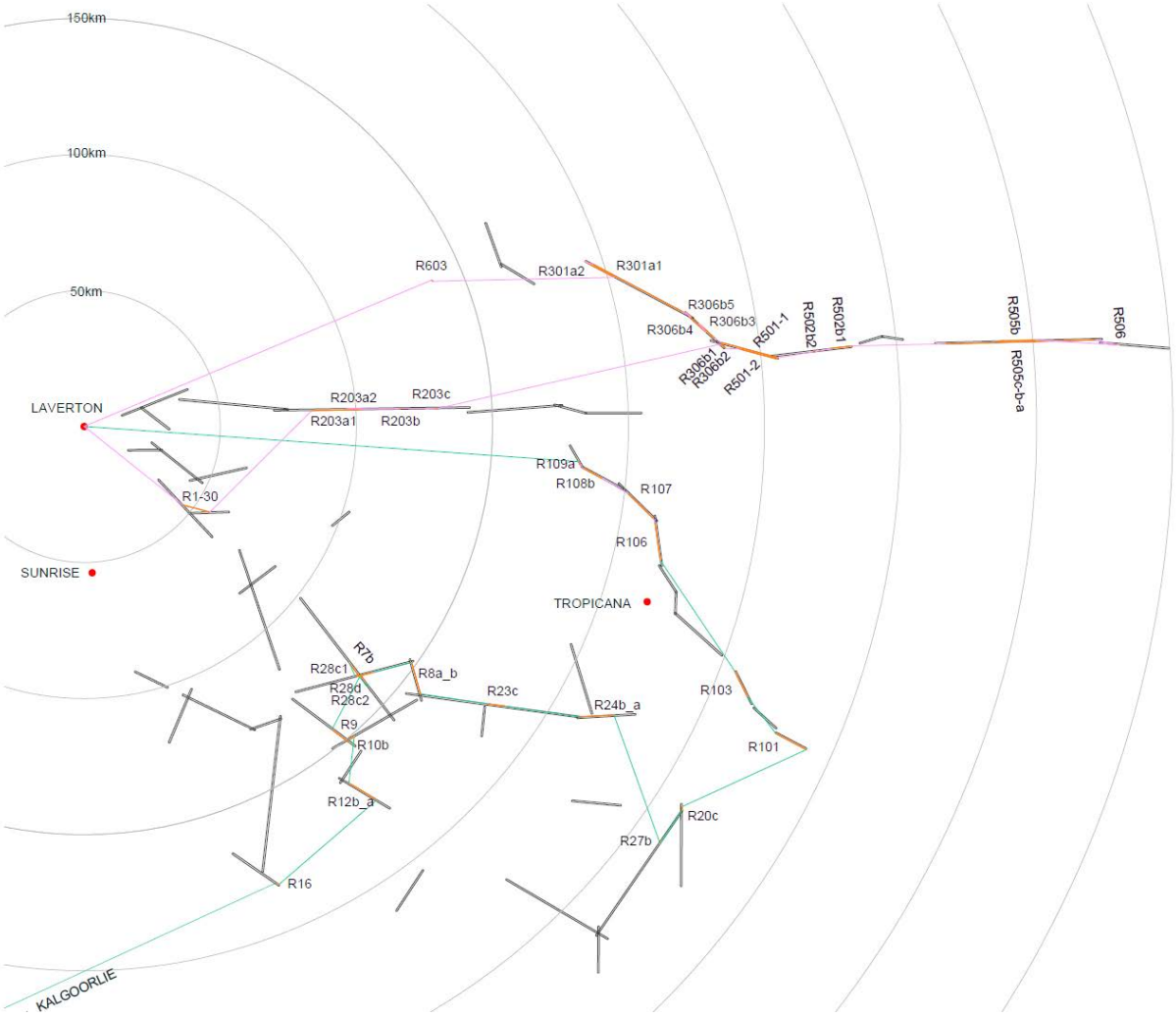
7.2 Resultant point cloud density and image resolution

The project requirements were 5 pts/m². The re-visit to site and infill survey was based around ensuring coverage of point cloud, whilst maintaining 5 pts/m². As the flights were captured a little lower than expected, the imagery resolution in some flights may be of finer GSD (6 cm) but would be output to a consistent resolution for the overall region of around 8-10 cm GSD.

8.0 Gap in-fill remobilisation

Due to small data gaps, a second aerial survey was commenced on Friday 8 February and completed on Saturday 9 February.

A new flight plan was submitted to the GVD Biodiversity Trust (below).



Green and Magenta Lines represent the two days of infill survey.

8.1 Project outcome

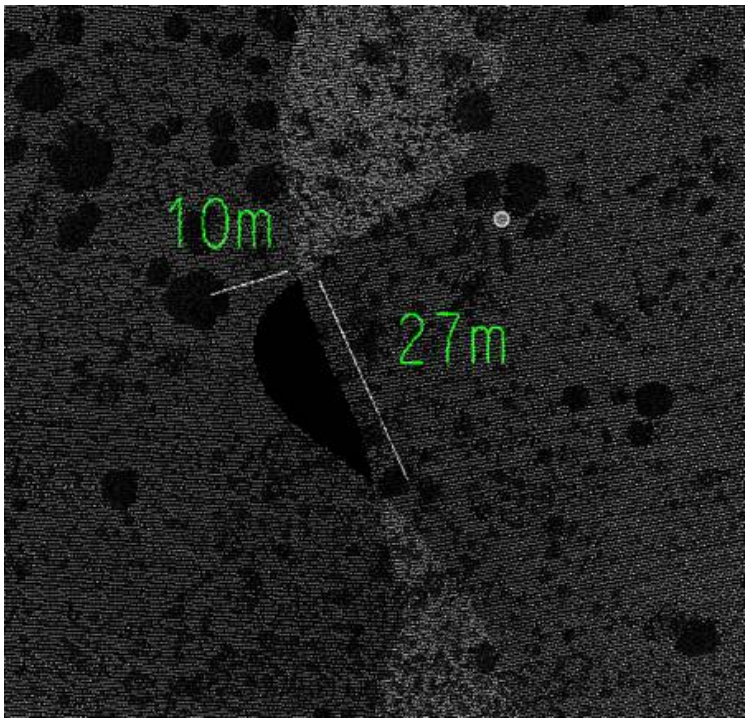
As at 18 February 2019, final capture was assessed and accepted for completeness, with point cloud processing close to final stages. Swaths were aligned

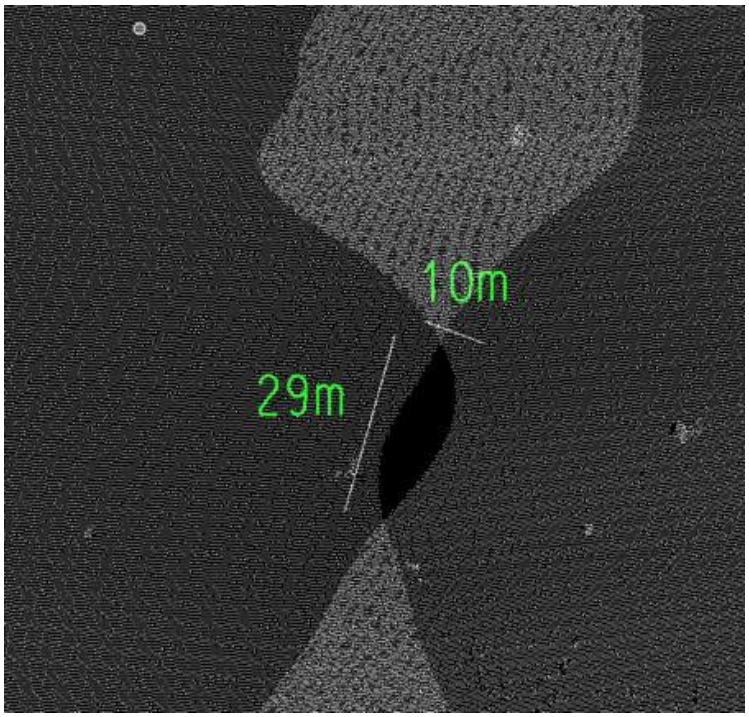
Imagery was still being processed. Imagery was supplied on 28 May 2019

9.0 Northern data gaps

An area in the northern blocks was discovered to have two small voids – refer below images. For similar voids MNG intends to infill, but this region requires a ferry time of 3.5 hrs to revisit.

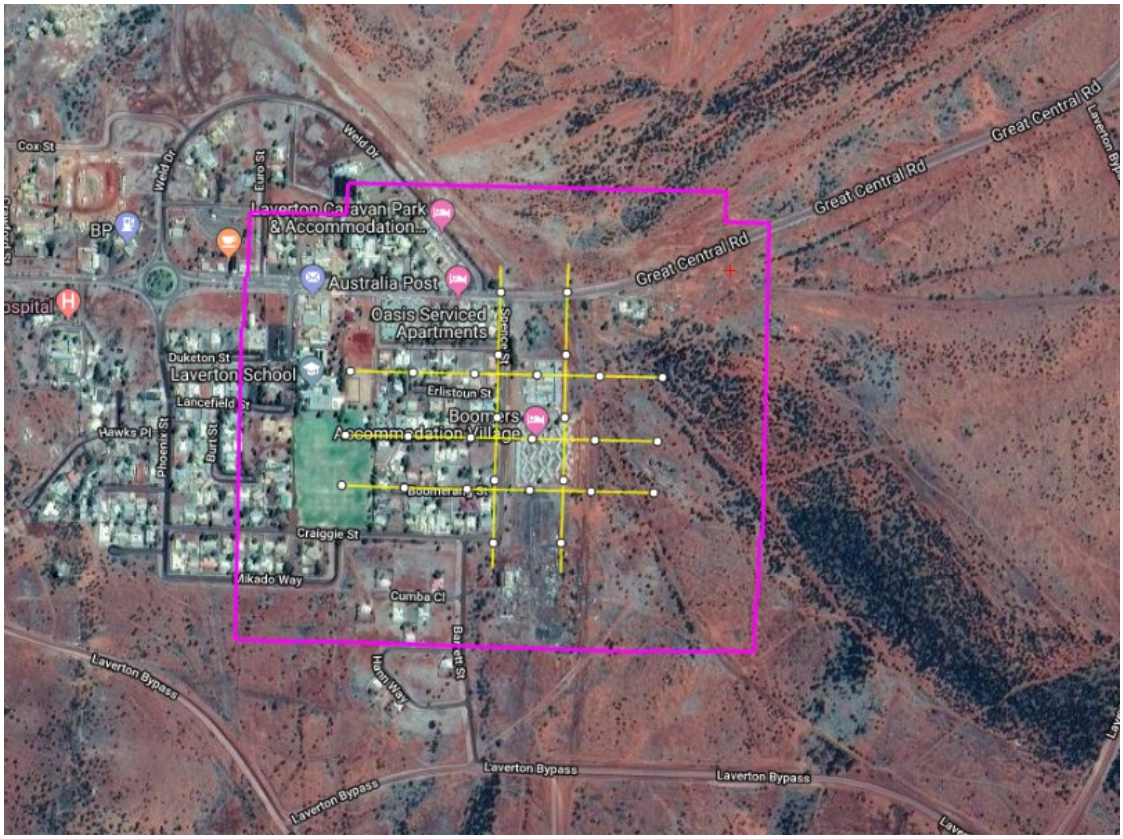
GVD Biodiversity Trust was contacted and after discussion of the issue with Anditi, agreed to allow MNG to leave these data gas without requiring an in-fill survey.





10.0 Calibration flying

Calibration flights were undertaken over the site shown below.

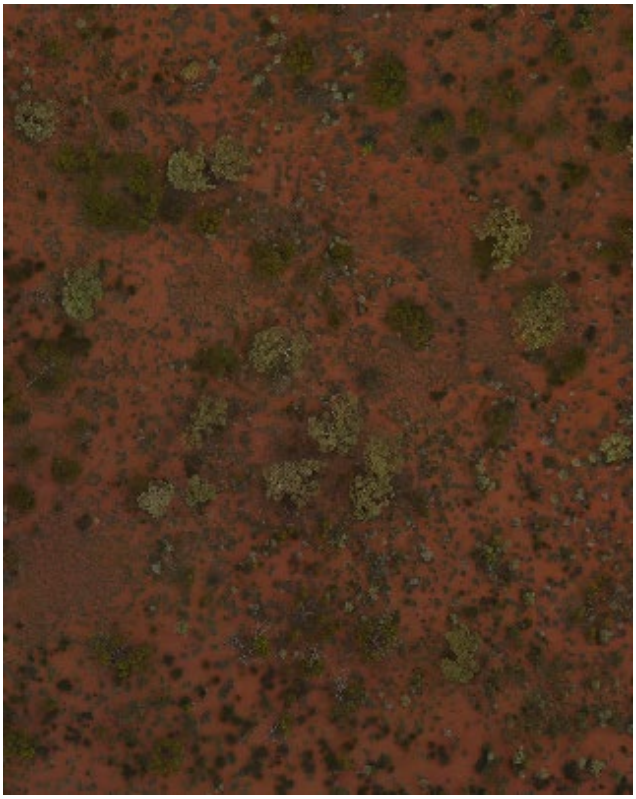


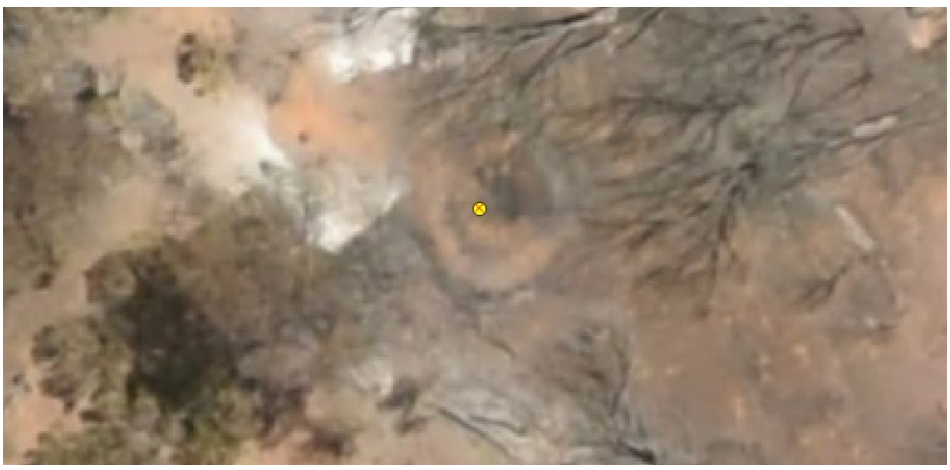
Calibration Value	1st Calibration – 09/01/19	2nd Calibration – 08/02/19
Heading	558	614
Roll	21227	18529
Pitch	558	614
H Shift	-0.0409	+0.0217
R Shift	-0.0129	-0.0077
P Shift	-0.0205	-0.0036
Starting avg 3d mismatch	0.02142	0.01524
Starting avg xy mismatch	0.04449	0.03441
Starting avg z mismatch	0.02113	0.01503
Final avg 3d mismatch	0.01566	0.01320
Final avg xy mismatch	0.03647	0.02370
Final avg z mismatch	0.01542	0.01310

11.0 Orthophoto

The orthophoto was produced using Agisoft Photoscan/Pix4D software. The orthophoto is a true orthophoto meaning there is no significant lean of higher features such as trees. This is useful for producing a coloured point cloud and for analysis using the imagery. The high overlap also helps in viewing the Malleefowl mound which can be in close proximity to vegetation which could obscure the mound in traditional perspective orthophotos.

Due to the heat encountered during the aerial survey, flying early and late was necessary to reduce heat effects on pilot, equipment and LiDAR operator. This meant that some of the imagery is darker although features are quite discernible. Colour balancing is being improved. There was a fire during the aerial survey, in some images this can be clearly seen with all vegetation burnt and some Malleefowl mounds affected.

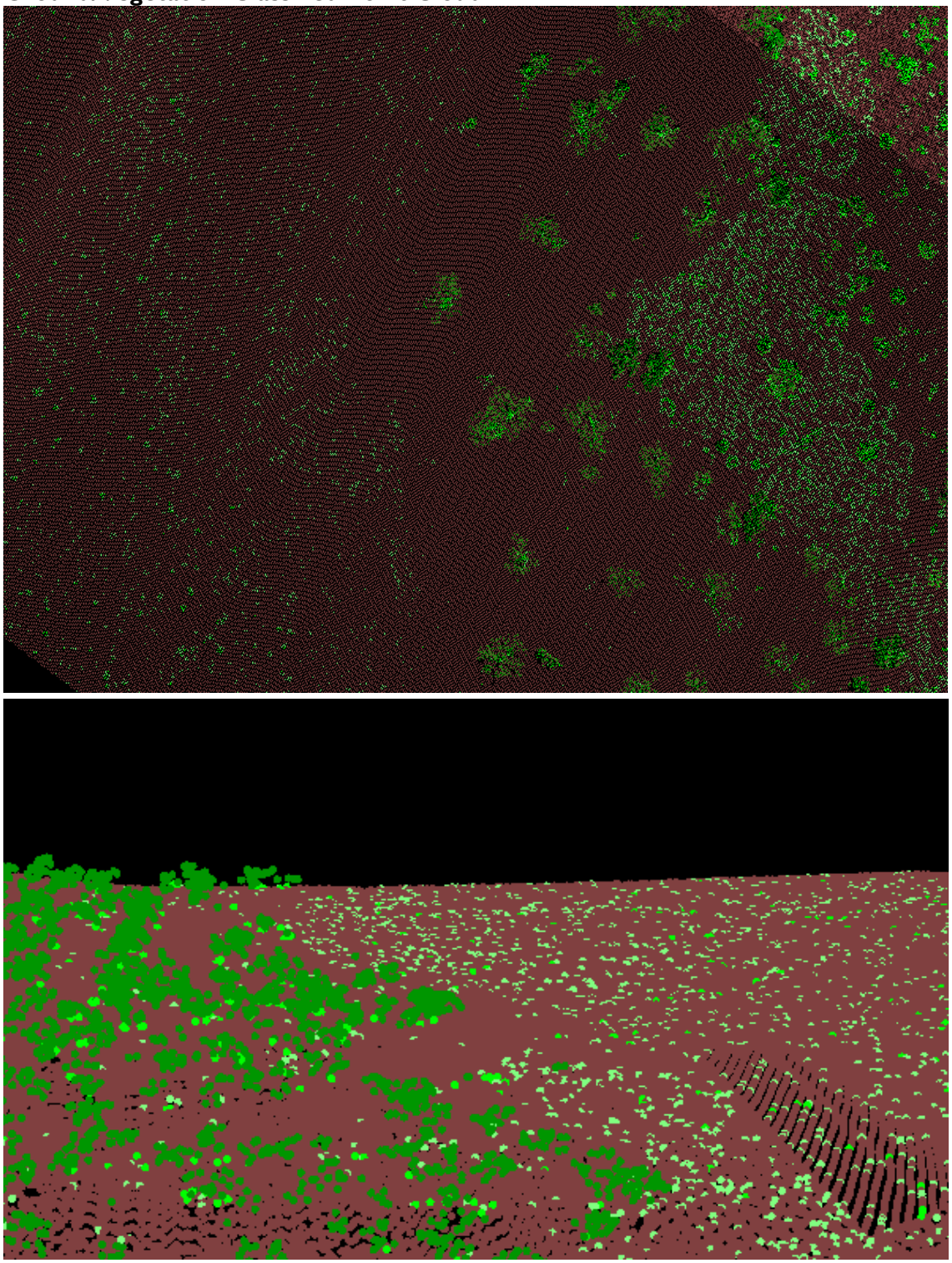




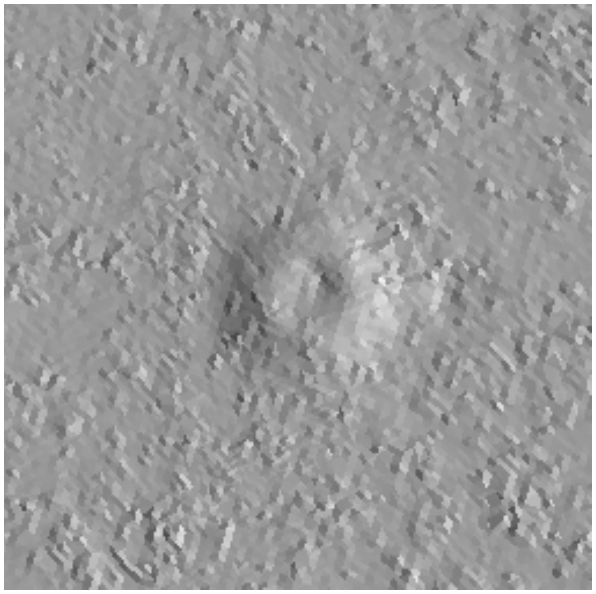
12.0 Data analysis

The point cloud provided by MNG Survey was classified in two separate passes using a 55-degree slope angle which aids in finding Malleefowl mounds but may include some low vegetation types and a more rigorous 36-degee slope angle that removes most low vegetation to create a good quality Digital Elevation Model.

Ground/Vegetation Classified Point Cloud



Class 1 Malleefowl mound in the point cloud



Class 1 Malleefowl mound in the Orthophoto

Example Class 2 mound

Example Vegetation 'mound' Example Class 3

mound

13.0 Data checking procedures

Manual Checking

Manual checking is usually completed using the Anditi point cloud reviewing tools.

We use the following criteria for category 1 mounds:

- The mound should be fairly circular in shape and look like a classic Malleefowl mound shape.
- Contours displayed on the mound should be concentric.
- There must not be any obvious human activity, like digging, water dams, road clearing, close to the mound.
- There must not be a tree originating from the mound.
- The mound should not be on a very steep surface. Normally mounds are found on flat surface, however at times in the past we have found mounds on ground with a gentle slope.
- In this project due to the very high instance of spinifex that meets all of the above criteria in the point cloud, once we received the orthophoto we also checked the mounds using this. Due to the late provision of the orthophoto by MNG, this check had not yet been carried out during the first submission of the data and report.
- There was no reason in this instance to re-run the model as the spinifex is so Malleefowl mound-like it would not have made any difference to the results. Anditi is working on some criteria that may filter many of these automatically in the future.

Classes reviewed

All Class 1 and 2 mounds were checked manually using all available methods and where false positives were detected, these are moved to Class 4.

No data is currently deleted, mounds that are not considered Class 1 or 2 are moved to Class 4. This may be reviewed in the future.

Reliability of the data

The orthophoto is an invaluable resource for reviewing the mounds in this project due to the difficulty distinguishing actual Malleefowl mounds from the widely prevalent spinifex clumps. Approximately 95% of Class 1 mounds appear to be Malleefowl mounds in all the checks performed and approximately 90% of Class 2 mounds appear to be Malleefowl mounds in all the checks performed. As this is a remote sensing survey, we cannot be 100% certain in every instance that a mound is a Malleefowl mound as it may be under vegetation or otherwise difficult to verify. None are retained unless there is a reasonably certainty that they could be a Malleefowl mound based on all available checks.

14.0 Data analysis results

The Anditi Malleefowl mound analysis algorithms look for ground features in the point cloud that best approximate a typical Malleefowl mound shape. Based on the algorithm match to shape a finding is classed from 1 to 4.

1 = Very closely matches a typical Malleefowl mound shape and is highly likely to be a Malleefowl mound

2 = Is similar to a Malleefowl mound shape and could be a Malleefowl mound

3 = Is a mound shape that is approximately within the parameters of size for a Malleefowl mound but isn't very similar to a typical Malleefowl mound. This could be an old Malleefowl mound, a mound of earth around living or dead tree/vegetation, natural hummocks around waterways, etc.

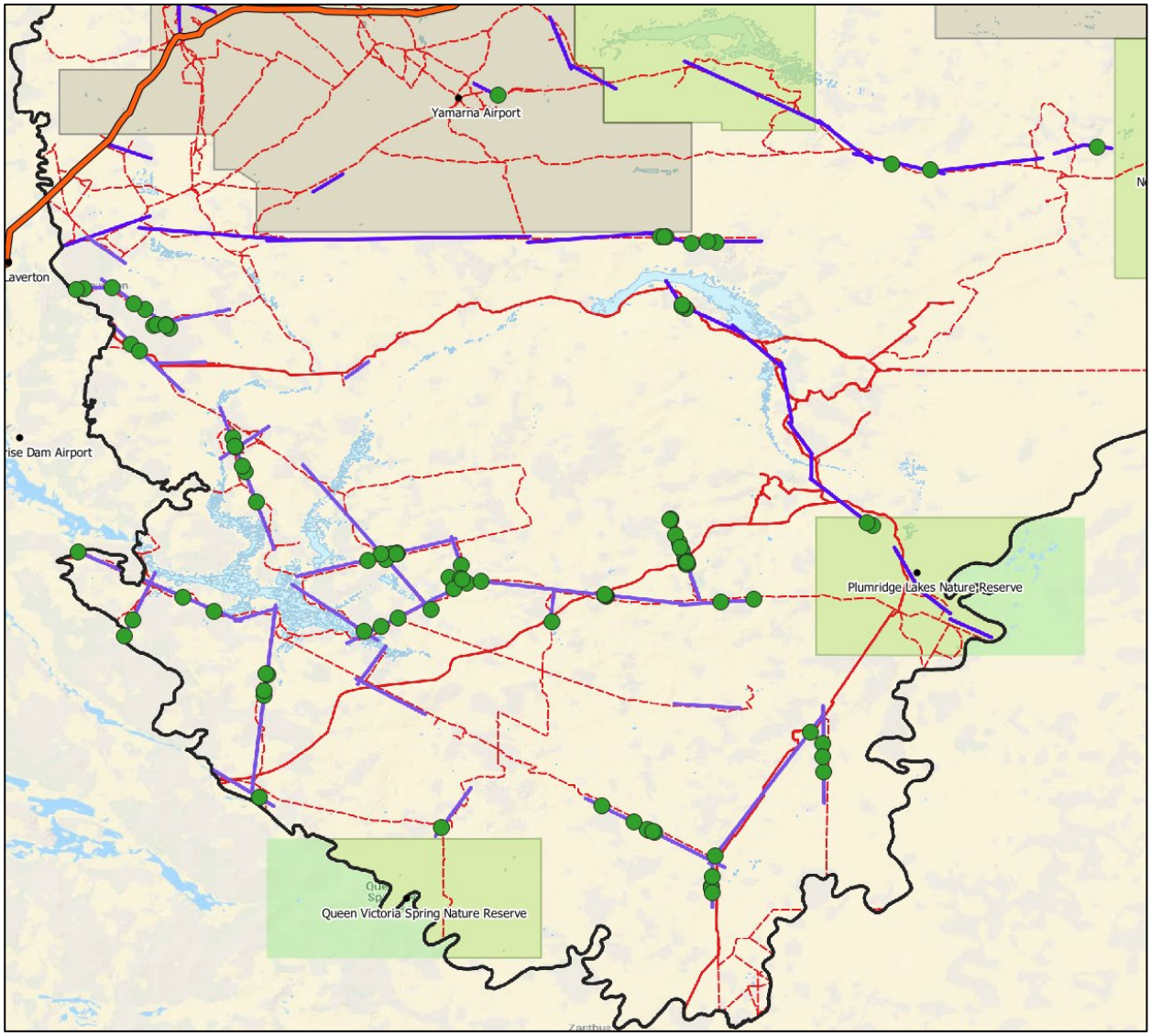
4 = Is a mound shape that is approximately within the parameters of size for a Malleefowl mound but isn't very similar to a typical Malleefowl mounds. This could be a broken Malleefowl mound, a mound of earth around living or dead tree/vegetation, natural hummocks around waterways, tussock vegetation etc.

Attributes:

id	rating	position x	position y	elevation	radius	height
57996	1	620876.8851	6841318.116	426.78359	3.4	0.710483

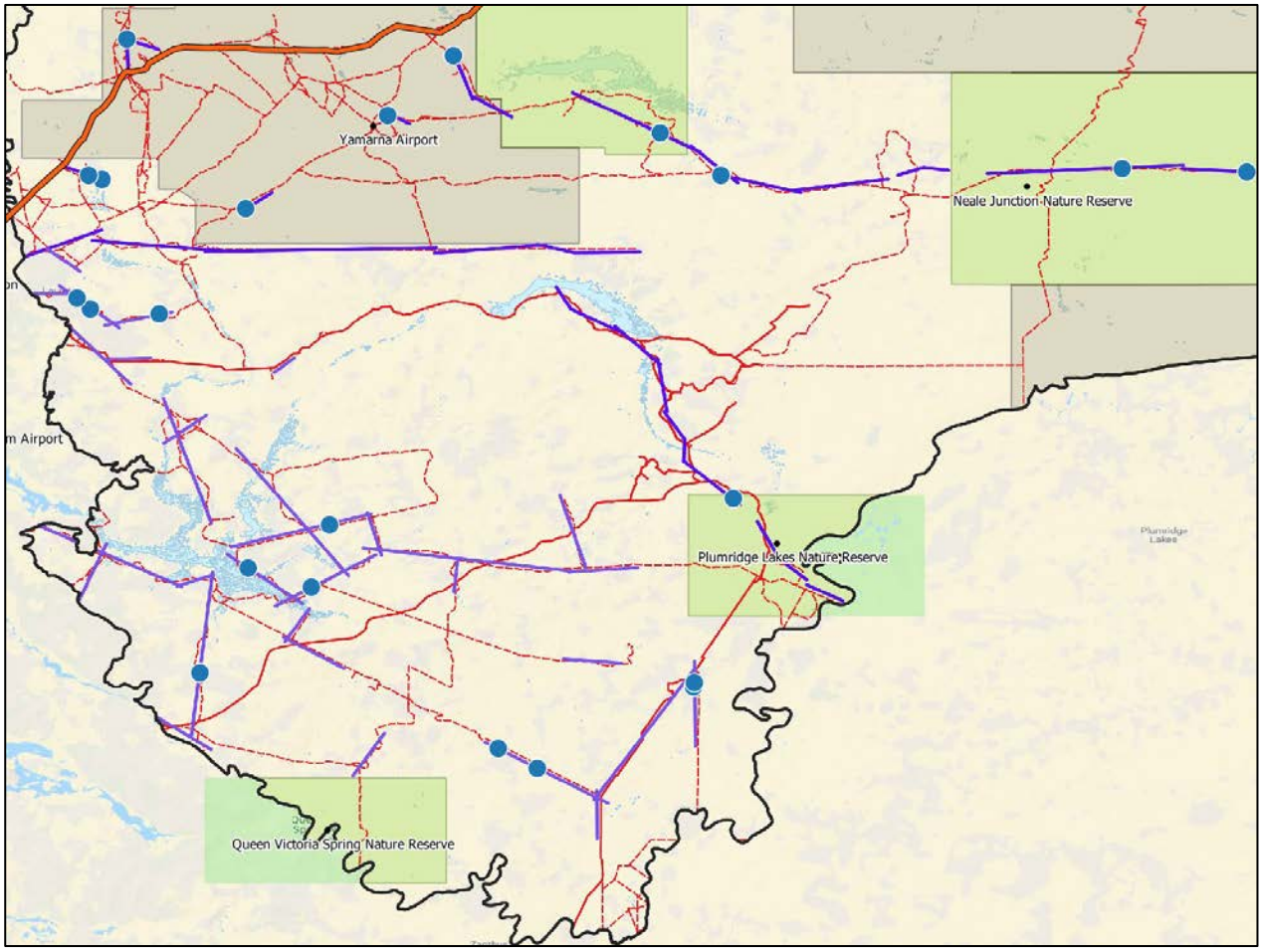
104 Class 1 matches were found with none recorded in the northern section. On verification against the orthophoto 2 Class 1 mounds were found to be vegetation. The remaining 102 Class 1 mounds are likely to be Malleefowl mounds.

Class 1 Mounds

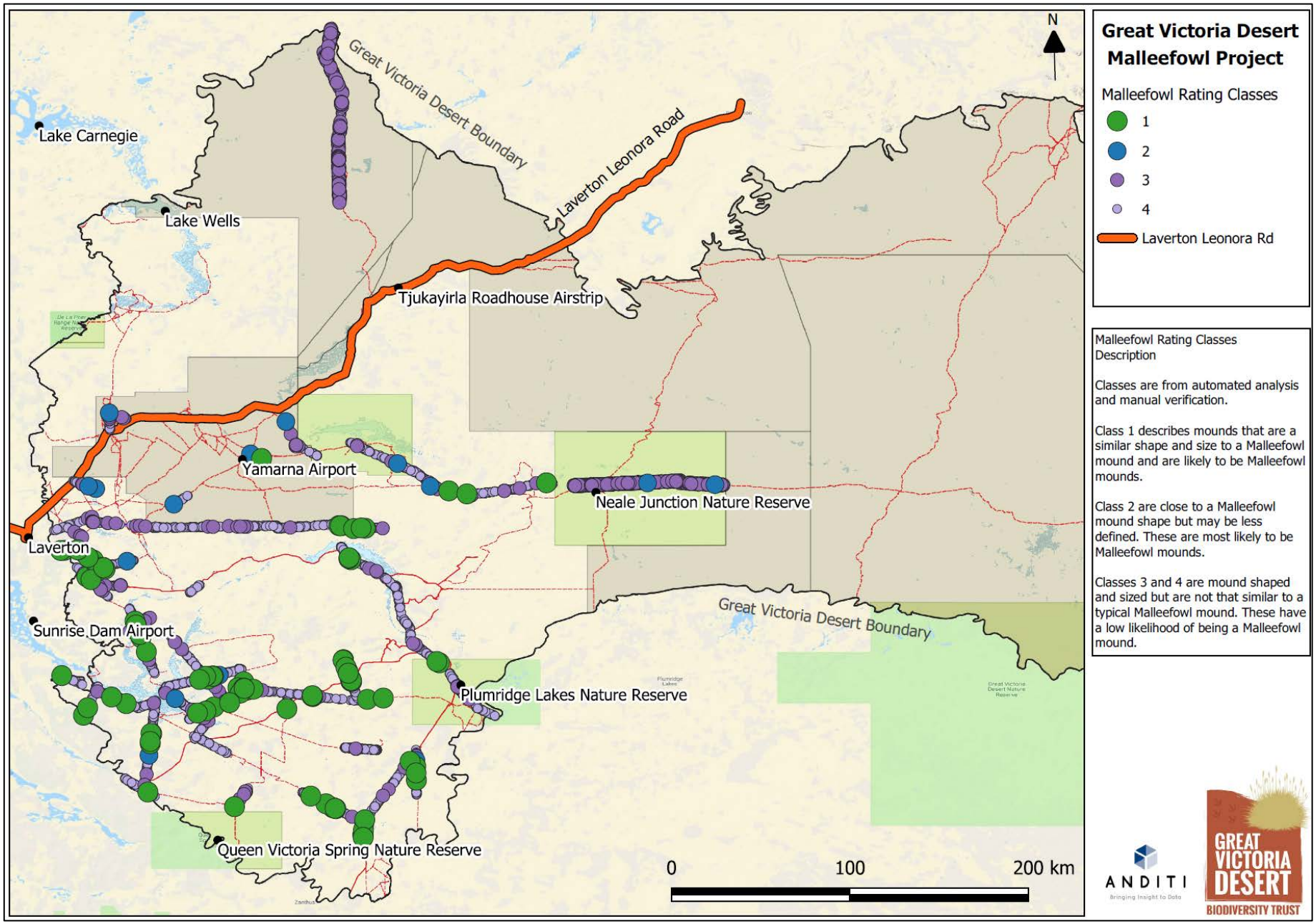


122 Class 2 matches were initially found with all 12 recorded in the northern section being false positives as on review they are spinifex or similar vegetation. A final total of 22 Class 2 mounds were verified using the orthophoto. These are not definite Malleefowl mounds but are not obviously vegetation or other features clearly identifiable as not being Malleefowl mounds.

Class 2 Mounds



1826 Class 3 mounds were discovered. These are likely to be spinifex/mound-like vegetation, natural earth mounds built up around living or dead vegetation, other mound-like features or very old Malleefowl mounds. 21,713 Class 4 mounds were found. These are likely to be vegetation or other mound-like features. It is not expected that there will be many, if any, Malleefowl mounds. These could be reviewed using a GIS and the orthophoto.


Great Victoria Desert Boundary
Laverton Leonora Road
Lake Carnegie
Lake Wells
Tjukayirla Roadhouse Airstrip
Yamarna Airport
Neale Junction Nature Reserve
Laverton
Sunrise Dam Airport
Great Victoria Desert Boundary
Plumridge Lakes Nature Reserve
Queen Victoria Spring Nature Reserve
N
0
100
200 km
Great Victoria Desert Malleefowl Project
Malleefowl Rating Classes
1
2
3
4
Laverton Leonora Rd
Malleefowl Rating Classes Description
Classes are from automated analysis and manual verification.
Class 1 describes mounds that are a similar shape and size to a Malleefowl mound and are likely to be Malleefowl mounds.
Class 2 are close to a Malleefowl mound shape but may be less defined. These are most likely to be Malleefowl mounds.
Classes 3 and 4 are mound shaped and sized but are not that similar to a typical Malleefowl mound. These have a low likelihood of being a Malleefowl mound.
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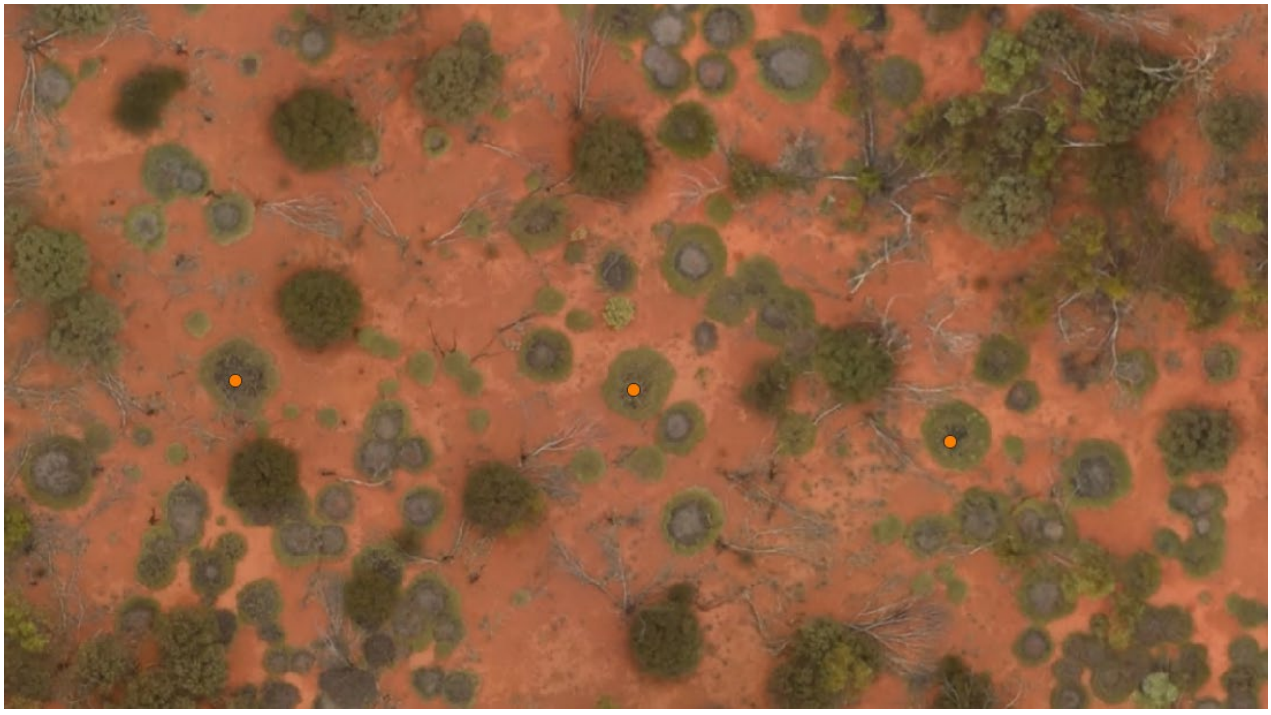
15.0 Data analysis issues

Due to the dense low spinifex in this area a large number of false positives were recorded. These can likely be filtered automatically or reviewed manually in a GIS against the supplied orthophoto to reduce the false positives and select candidates for field inspection.

Spinifex is low to the ground, very dense so the LiDAR usually only returns a last return and the spinifex often dies from the centre leaving a feature that correlates very well with a typical Malleefowl mound shape.

Spinifex forming a classic mound shape



Earthworks forming a mound shape

16.0 Data clean-up

With significant variation in lightness/darkness in the orthophoto, MNG Survey are looking at further colour balancing of the orthophoto to improve overall consistency. With many false positives Anditi have completed a check of the Class 1 and Class 2 analysed Malleefowl mound points against the MNG supplied orthophoto. Any points that are obviously not Malleefowl mound-like features have been removed to Classes 3 and 4 depending on the certainty of identification.

Class 3 – Hummocky ground but no obvious Malleefowl mounds

17.0 Conclusion

This was a large survey project in very remote terrain in Western Australia 700 km ENE of Perth and immediately east of Laverton and during very hot weather conditions. The aerial survey encountered a few challenges that included obtaining permission to overfly a military restricted zone, keeping equipment and aircraft functioning in over 40-degree temperatures and re-tasking around fires. The survey obtained good quality LiDAR but due to operating early in the cooler part of the day, the aerial imagery was at times taken in less than optimal lighting. The poorer lighting made image processing slower and the delivery of the orthophoto was later than expected. This caused a delay in completing visual checking. In summary 1675 km of 600 m wide corridors were surveyed from the air, totalling over 1000 km² in survey area. The resultant point cloud totalled 40GB of data.

Analysis of the data found 103 class 1 mounds of which many on visual inspection appear to be likely to be Malleefowl mounds. Due to the spinifex in the area having a very Malleefowl mound-like shape and size, many of the automated class 2 mounds were found to be Spinifex clumps and moved to class 4. Of the 122 class 2 mounds detected automatically only 22 sites were found to be potential Malleefowl mound candidates. It should be understood that in all classes these are mound shapes that appear to be or could be Malleefowl mounds, these are not guaranteed to be Malleefowl mounds and the GVDBT should review these sites and rank them for ground inspection.

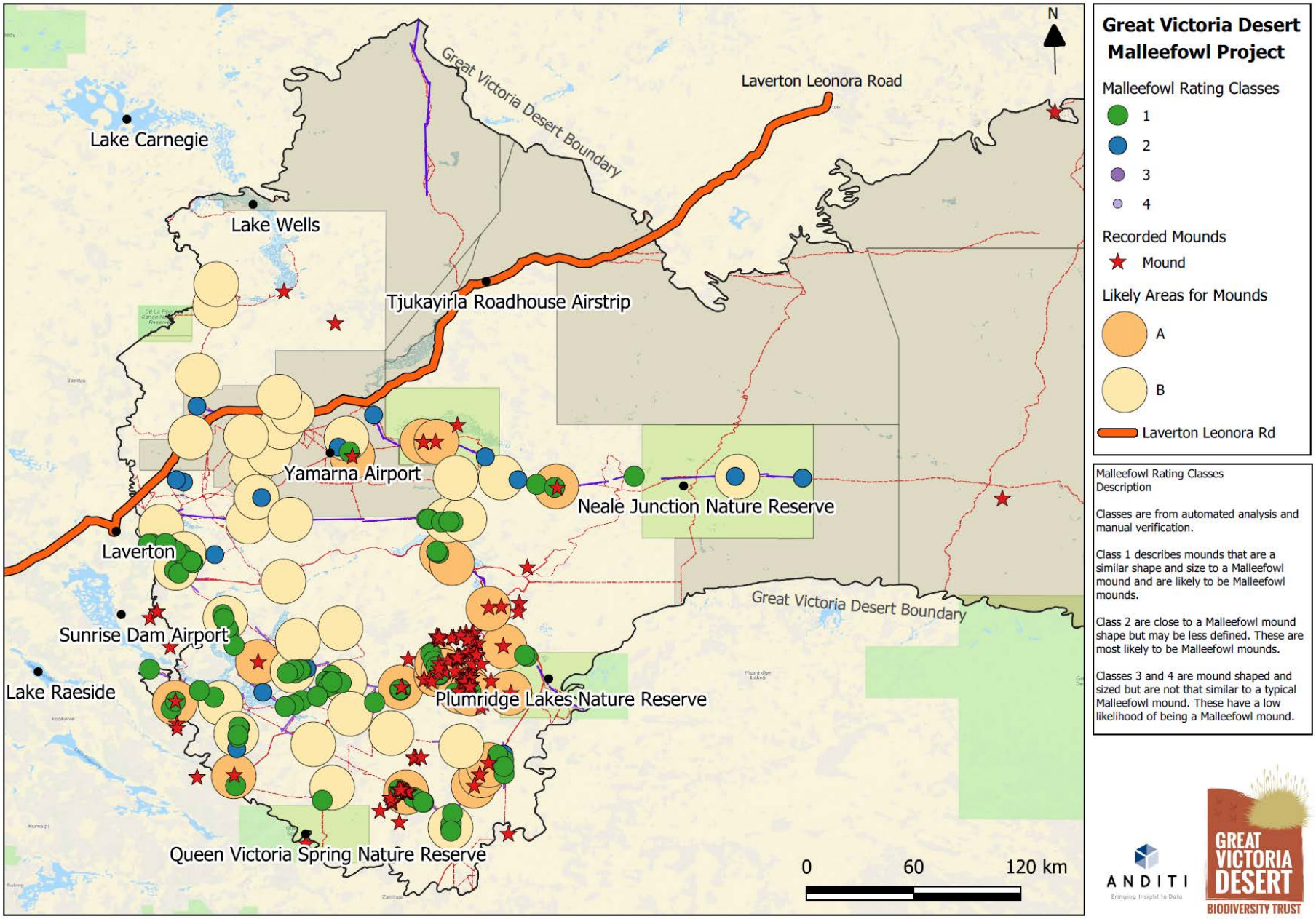
Inspection of the sites using the orthophoto does highlight that many class 1 and some class 2 mounds appear to be Malleefowl mounds with others being less obvious or obscured by overhanging vegetation. Class 3 and 4 may include some old or poorly formed Malleefowl mounds but will include many more mounds that are formed by vegetation, erosion or accretion. No class 1 or 2 mounds were discovered in the northern section of the survey. In the southern section of the survey area, class 1 and 2 mounds are relatively well distributed across the area.

Malleefowl mounds were discovered within burned areas, many of which were recent burns that occurred during the aerial survey.

It is interesting to note that within the reserve areas on the map in this area, there were very few class 1 and 2 mounds with quite large concentrations of mounds found outside the reserves.

The Great Victoria Desert Biodiversity Trust supplied 'MF_GVDBT_map' and 'Final_Random_Site_Selection_centroids_20170726' with the description: *'The first are the Malleefowl records on the state database and the second are 100 sites selected via a desktop study which were high likelihood through to low likelihood of finding mounds. Not all of these on the second shapefile are mounds but if you categorise them the 'A – Known sites' are known mounds.'*

Reviewing the areas most likely to have Malleefowl (Categories A and B from 'Final_Random_Site_Selection_centroids_20170726') there appears to be good correlation with the Anditi analysis in some areas and poor in others – i.e. there are not necessarily any mounds found in these predictor areas. Where there are 'known' mounds from 'MF_GVDBT_map' in the few instances where these correlate with the survey corridors, there is nothing evident in the orthophoto to indicate a mound at the locations provided. It is not known how accurate the sites from 'MF_GVDBT_map' are so there may be a search radius required around the site shown.


N
Great Victoria Desert Boundary
Laverton Leonora Road
Lake Carnegie
Lake Wells
Tjukayirla Roadhouse Airstrip
Yamarna Airport
Neale Junction Nature Reserve
Laverton
Great Victoria Desert Boundary
Sunrise Dam Airport
Lake Raeside
Plumridge Lakes Nature Reserve
Queen Victoria Spring Nature Reserve
0
60
120 km
Great Victoria Desert Malleefowl Project
Malleefowl Rating Classes
1
2
3
4
Recorded Mounds
Mound
Likely Areas for Mounds
A
B
Laverton Leonora Rd
Malleefowl Rating Classes Description
Classes are from automated analysis and manual verification.
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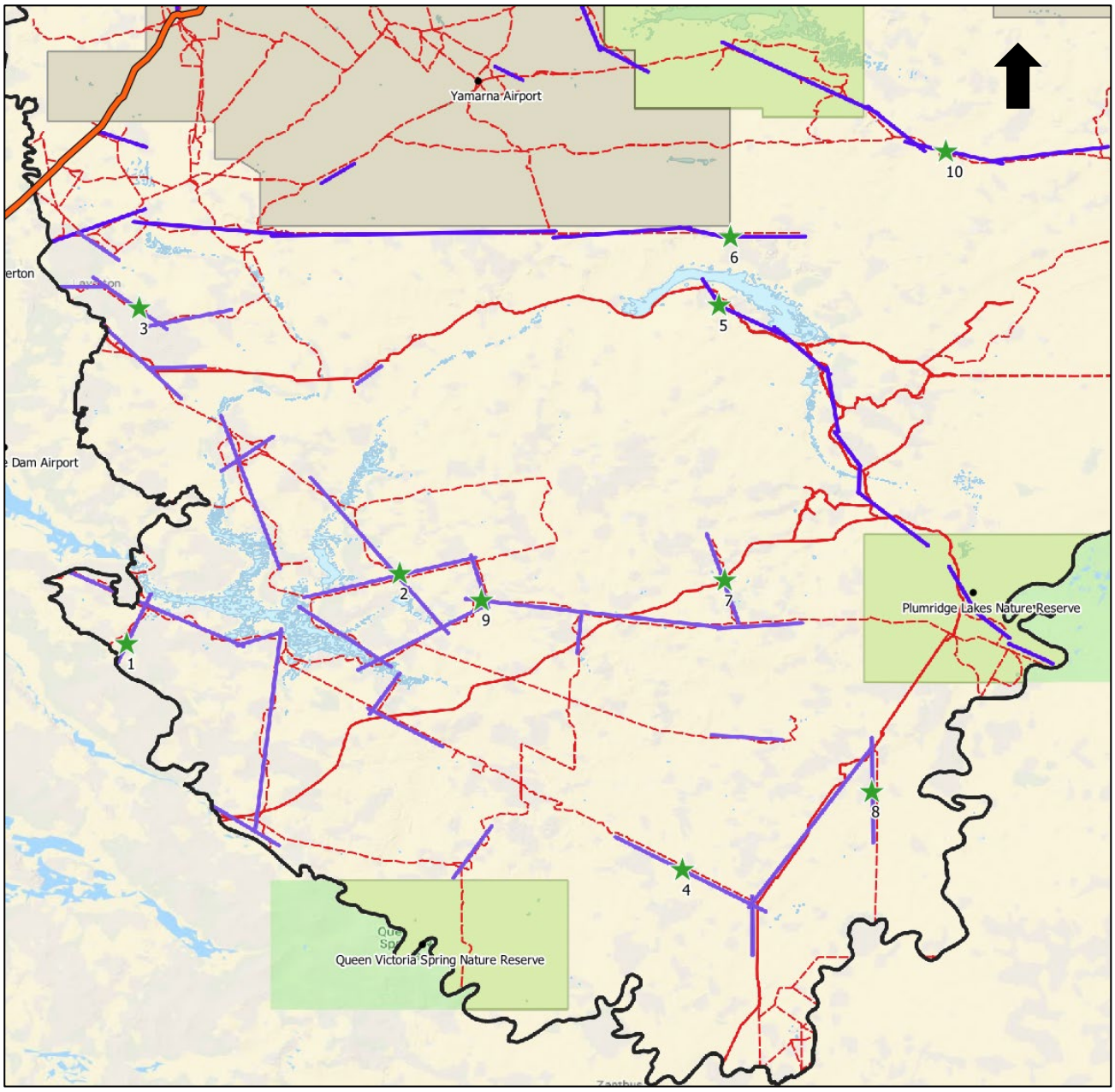
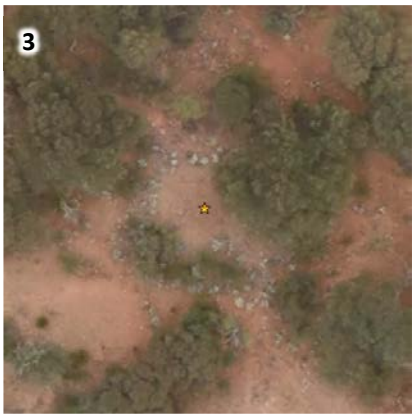
APPENDIX I

Malleefowl Mound Examples

Class 1 Mound Examples



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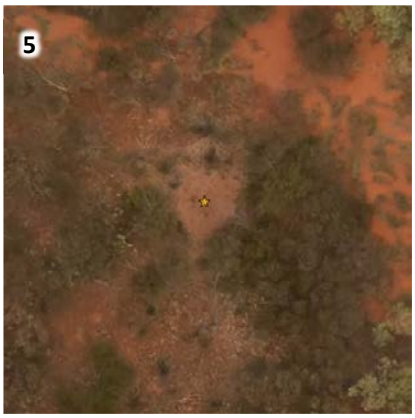
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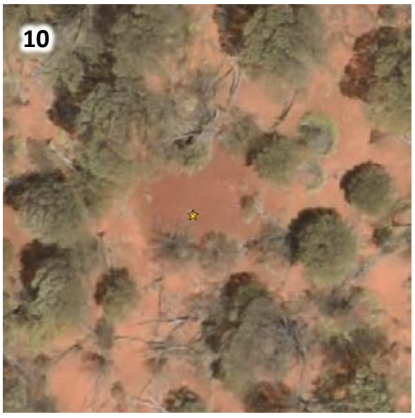
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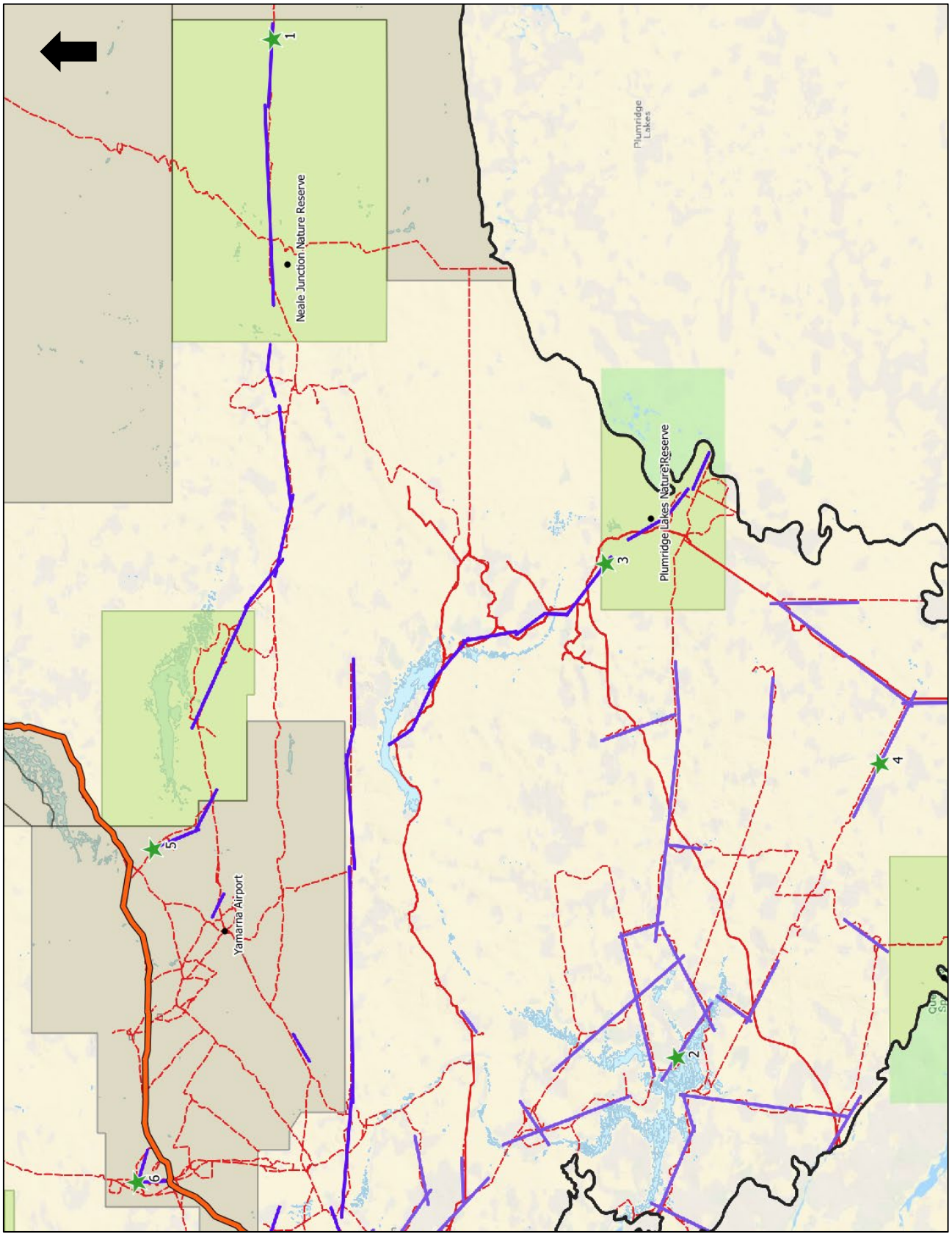
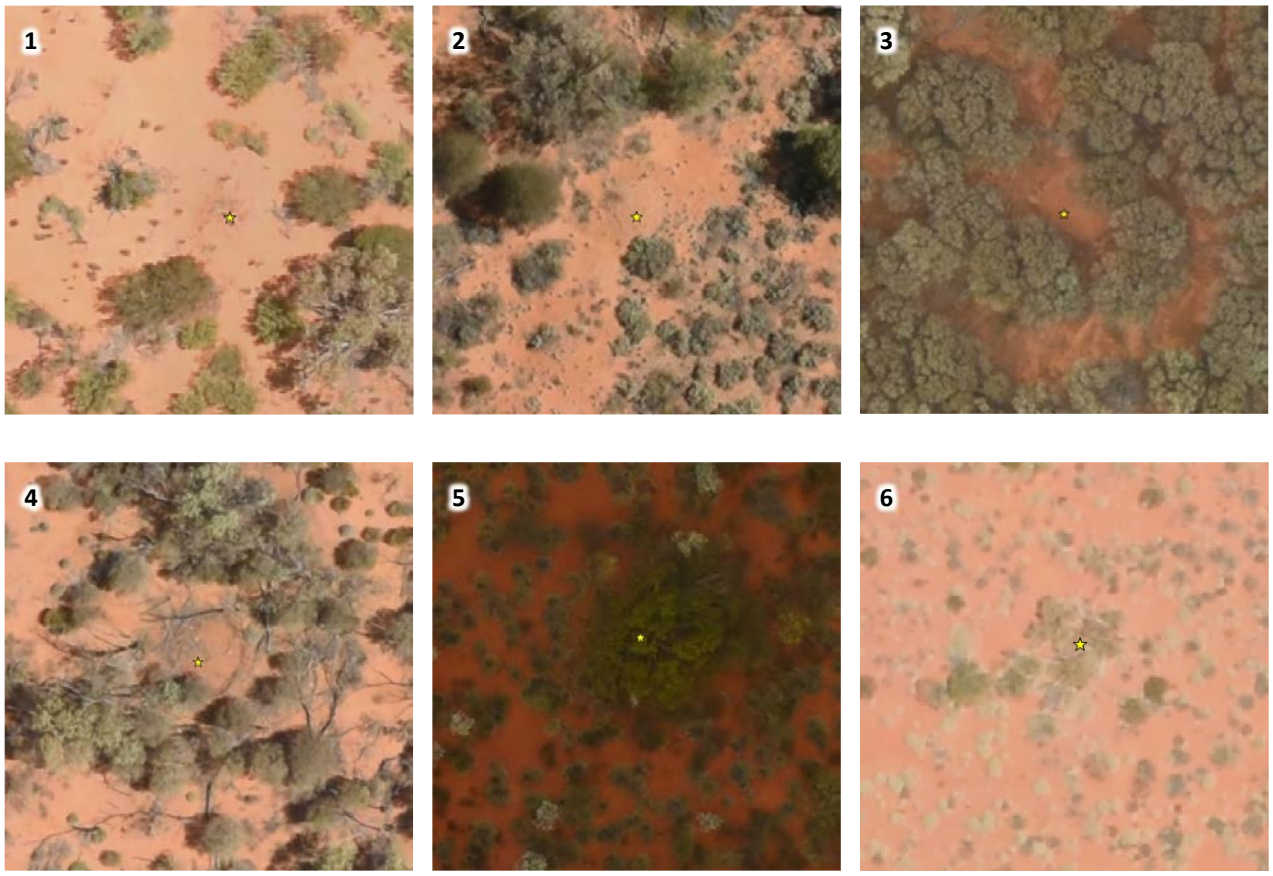
Class 2 Mound Examples

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