NORFOLK METALS LTD PREPARED ANNUAL REPORT FOR 100% OWNED SUBSIDUARY

ROGER RIVER RESOURCES PTY LTD EL20/2020 YEAR 1 ANNIVERSARY

PERIOD 15TH AUGUST 2021 TO 15TH AUGUST 2022

PREPARED BY

BEN PHILLIPS, LEO PILAPIL & PHIL MUIR

INCLUDED DATA

Atlas Geophysics raw data from Gravity and Aeromagnetic Survey(s)

ASEG-GDF2

COMPANY DETAILS

NORFOLK METALS LTD (ACN 652438385)
ROEGR RIVER RESURCES PTY LTD (ACN 644016053)
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Phone: +61 8 6555 2950

ABSRACT / EXECUTIVE SUMMARY

Norfolk Metals Ltd acquired 100% of this issued capital in Roger River Resources Pty Ltd upon the successful raising of AUD$5,500,000 and successful listing on the Australian Stock Exchange (ASX). Roger River Resources Pty Ltd hold the project known as The Roger River Gold Project.

The Roger River Gold Project comprises one granted exploration licence, EL20/2020, and one exploration licence application EL17/2021, which together cover 261km^2, located 410km northwest of the capital city of Hobart, Tasmania.

The Project is prospective for gold as indicated by the intense silicification, argillisation and diatreme breccias in close proximity to the RRF along with carbonate-rich host rocks.

The Project covers over 90% of the regional Roger River Fault (RRF) which is traced over ~50km strike. This fault is a NNE trending major structure transecting Neoproterozoic rocks at the eastern margin of the Smithton Basin/Smithton Synclinorium.

By comparison with other major basin bounding faults in western Tasmania it is likely that the Roger River Fault has been through at least two major orogenic deformation events during the Paleozoic and it may have been reactivated again during the regional Cenozoic rifting and volcanism associated with the development of the Bass Basin (Morrison, 2014).

The region has minor registered gold and copper occurrences in the Tasmanian geological survey data. The minor copper occurrences have not been identified in the field by Sahara. The copper is considered to be associated with the basalt units in the region.

The Roger River project is primarily prospective for gold as indicated by the intense silicification, argillisation and diatreme breccias in the hanging wall of the steeply east-dipping, reverse Roger River Fault along with carbonate-rich host rocks which can result in emplacement of hot spring related epithermal mineralisation.

The rocks hosting the silicification zone comprise well bedded and banded dolomites, calcareous and dolomitic siltstones, grits, black shales and some cherts on the east or hanging wall side of the RRF, capped on topographic highs in places by basalt. The west or footwall side of the RRF contains dolomites, dolomitic siltstones and other carbonate-rich rocks.

This report outlines the exploration work completed in the first year of EL20/2020 from 15th August 2021 to 15th August 2022.

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SUMMARY OF ACTIVITIES VIA MAPS

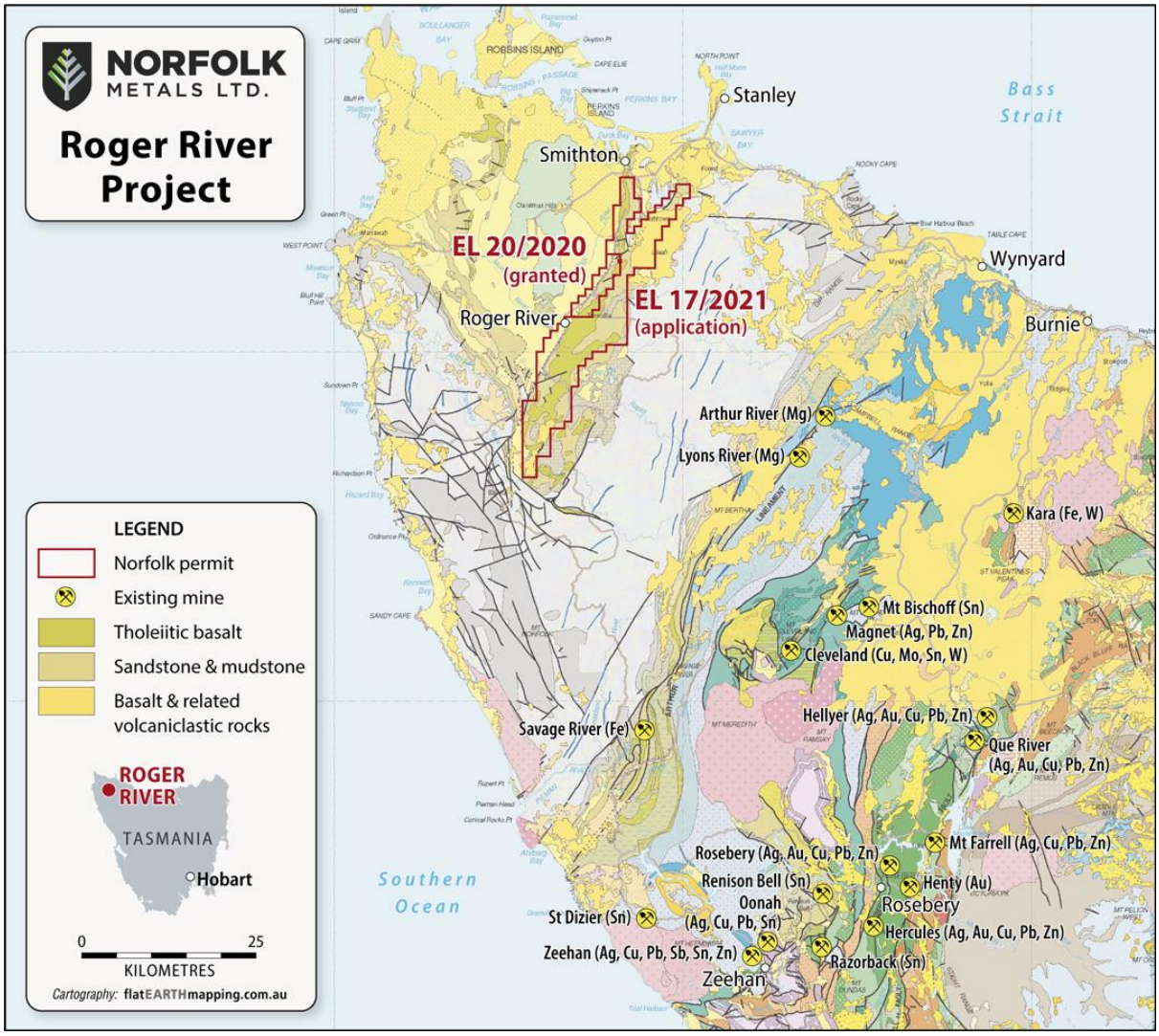
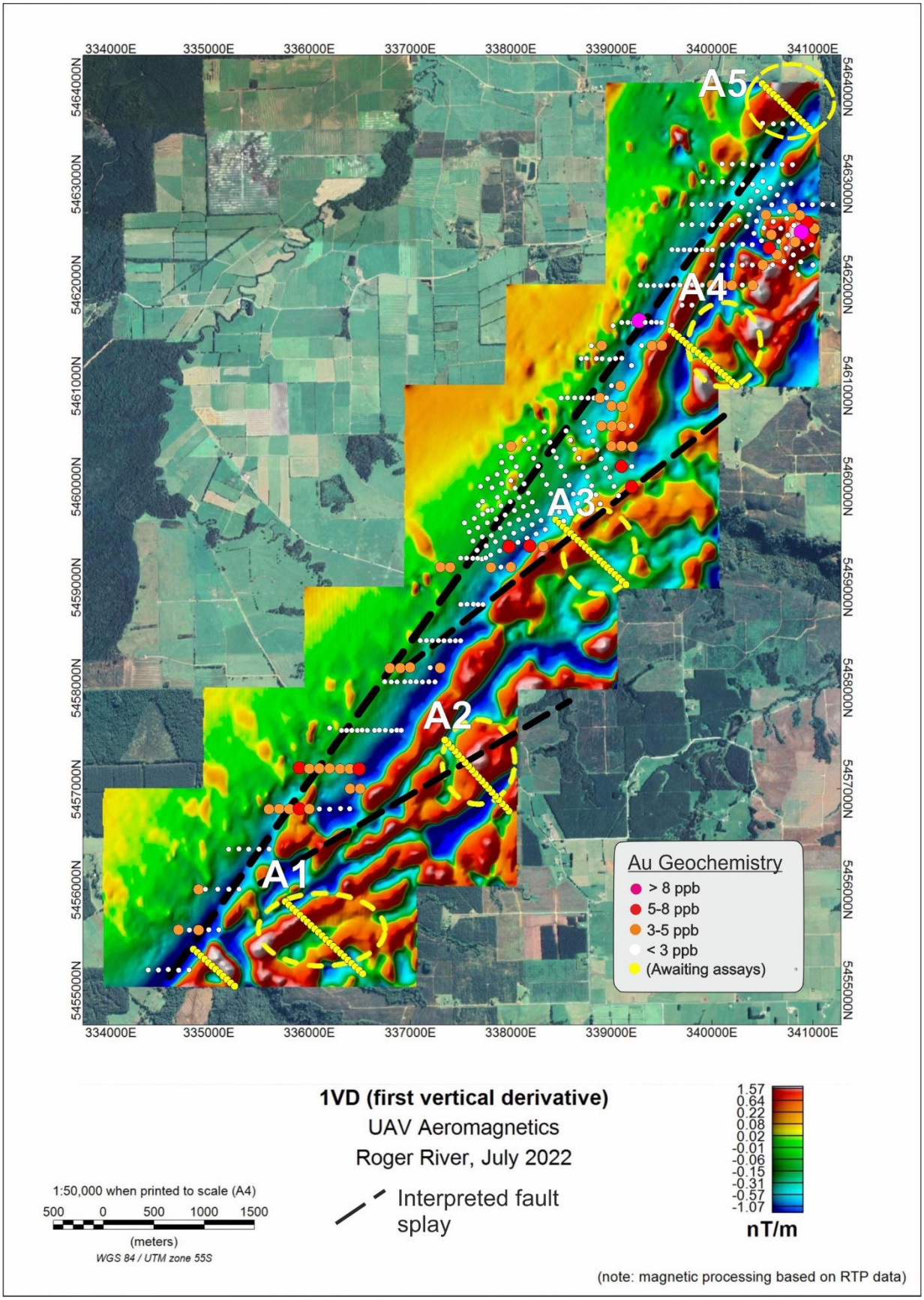


Figure 1.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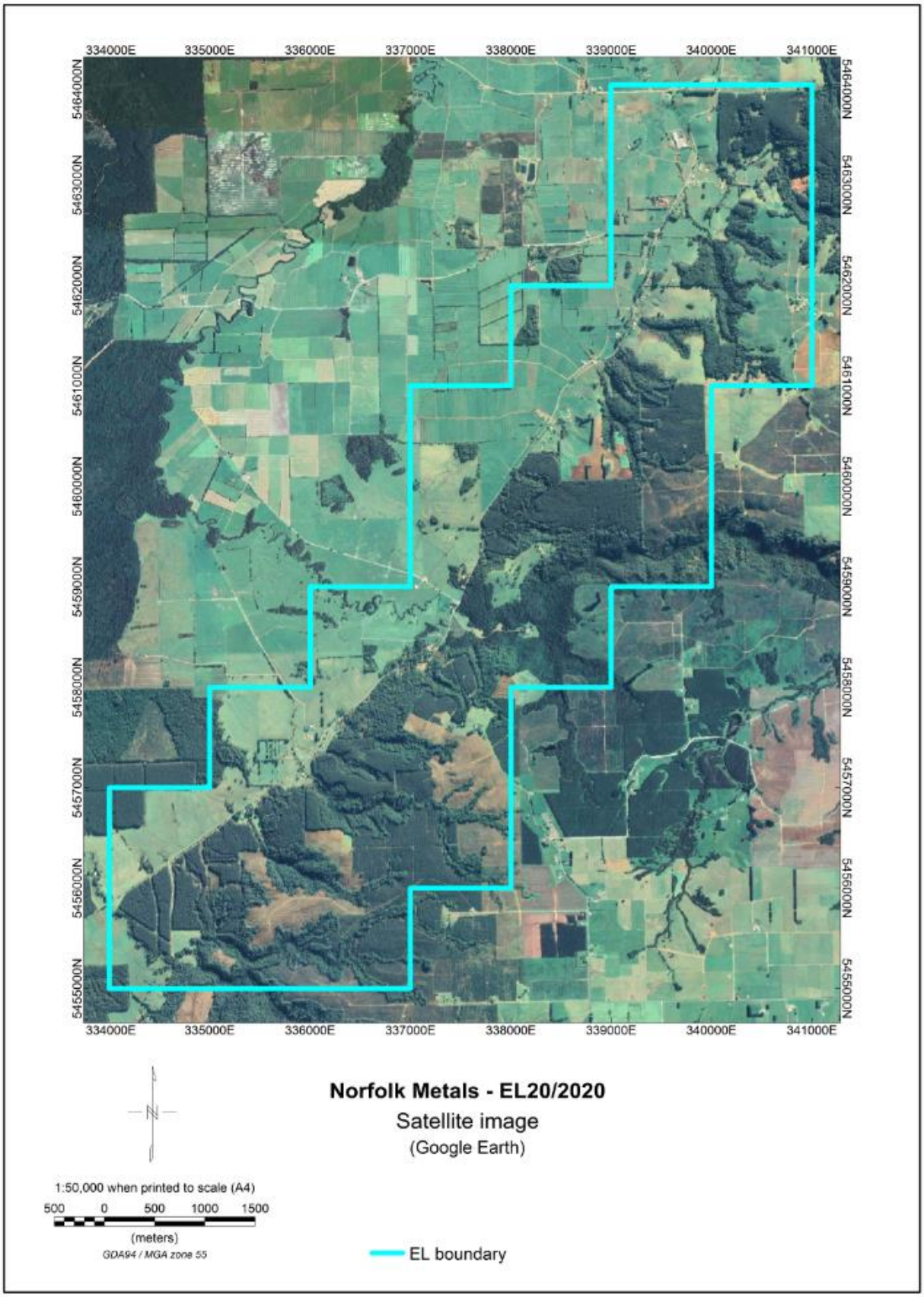
5460000N
5459000N
5458000N
5457000N
5456000N
5455000N
A5
A4
A3
A2
A1
Au Geochemistry
> 8 ppb
5-8 ppb
3-5 ppb
< 3 ppb
(Awaiting assays)
1VD (first vertical derivative)
UAV Aeromagnetics
Roger River, July 2022
Interpreted fault splay
1.57
0.64
0.22
0.08
0.02
-0.01
-0.06
-0.15
-0.31
-0.57
-1.07
nT/m
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
WGS 84 / UTM zone 55S
(note: magnetic processing based on RTP data)

Figure 2.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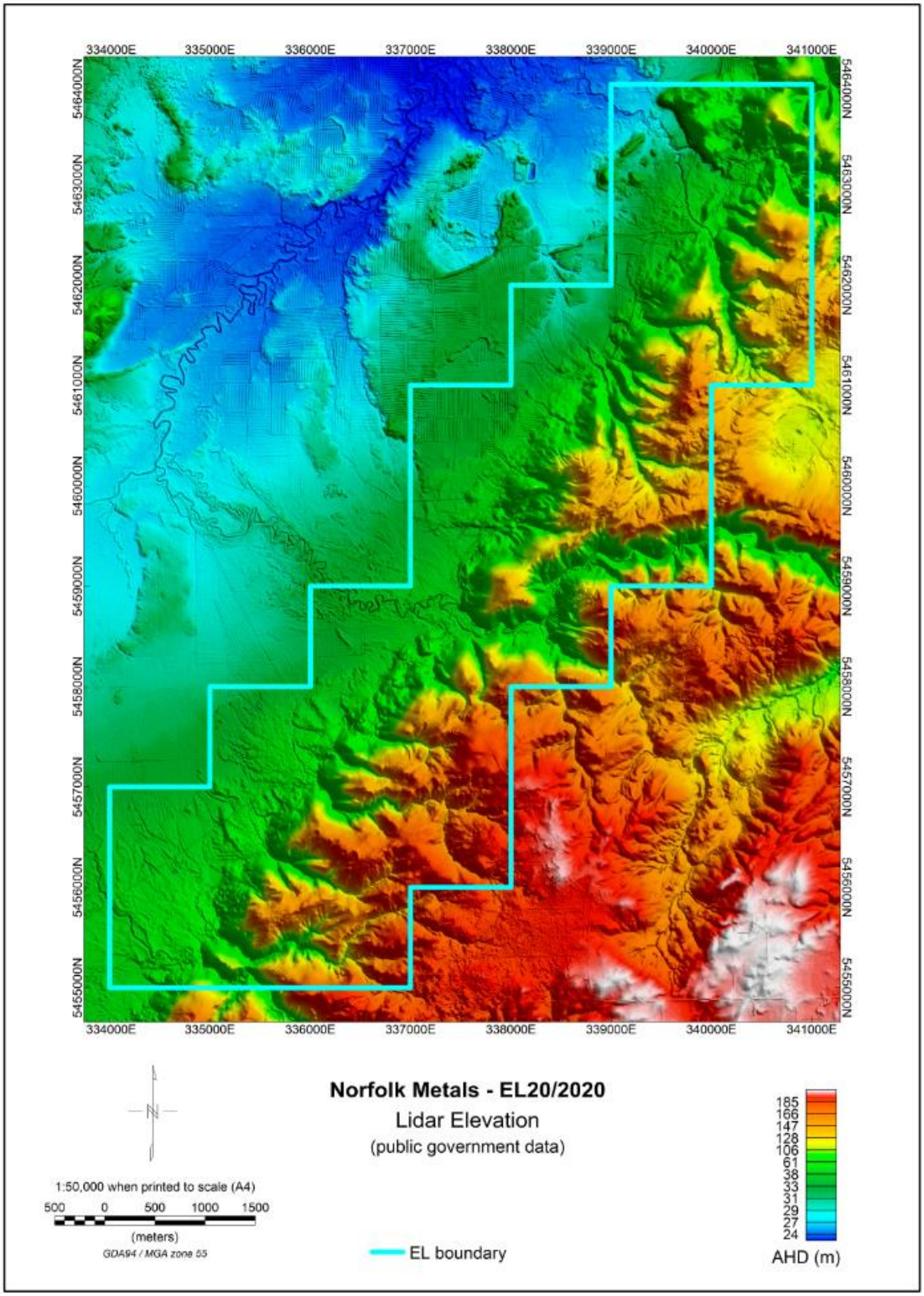
5459000N
5458000N
5457000N
5456000N
5455000N
Norfolk Metals - EL20/2020
Satellite image
(Google Earth)
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
EL boundary

Figure 3.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5459000N
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5457000N
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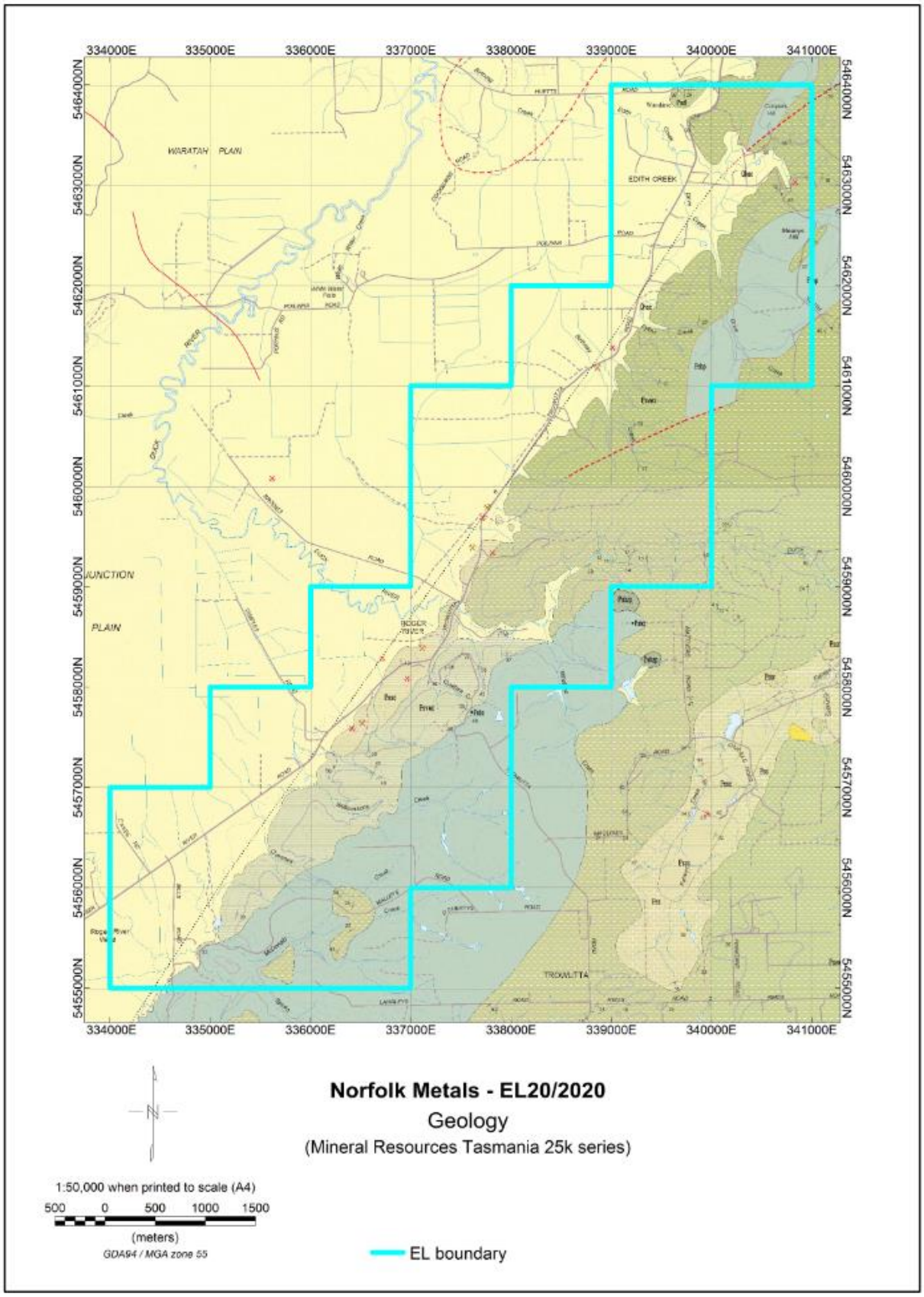
5455000N
Norfolk Metals - EL20/2020
Lidar Elevation
(public government data)
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
EL boundary
185
166
147
128
106
61
38
33
31
29
27
24
AHD (m)

Figure 4.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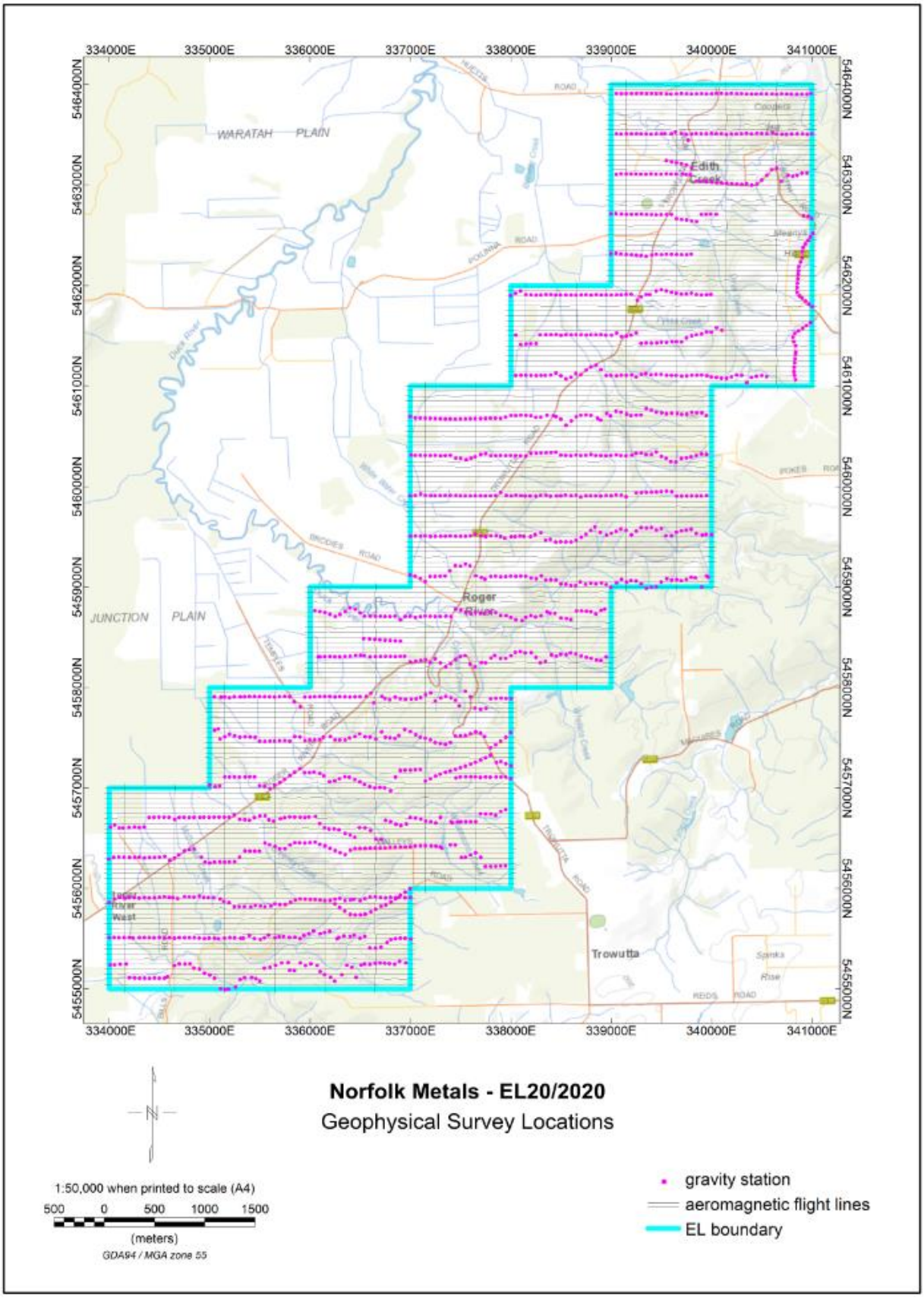
5464000N
5463000N
5462000N
5461000N
5460000N
5459000N
5458000N
5457000N
5456000N
5455000N
WARATAH PLAIN
EDITH CREEK
JUNCTION PLAIN
ROGER RIVER
TROWUTTA
Norfolk Metals - EL20/2020
Geology
(Mineral Resources Tasmania 25k series)
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
EL boundary

Figure 5.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5459000N
5458000N
5457000N
5456000N
5455000N
WARATAH PLAIN
JUNCTION PLAIN
Edith Creek
Roger River
Trowutta
Norfolk Metals - EL20/2020
Geophysical Survey Locations
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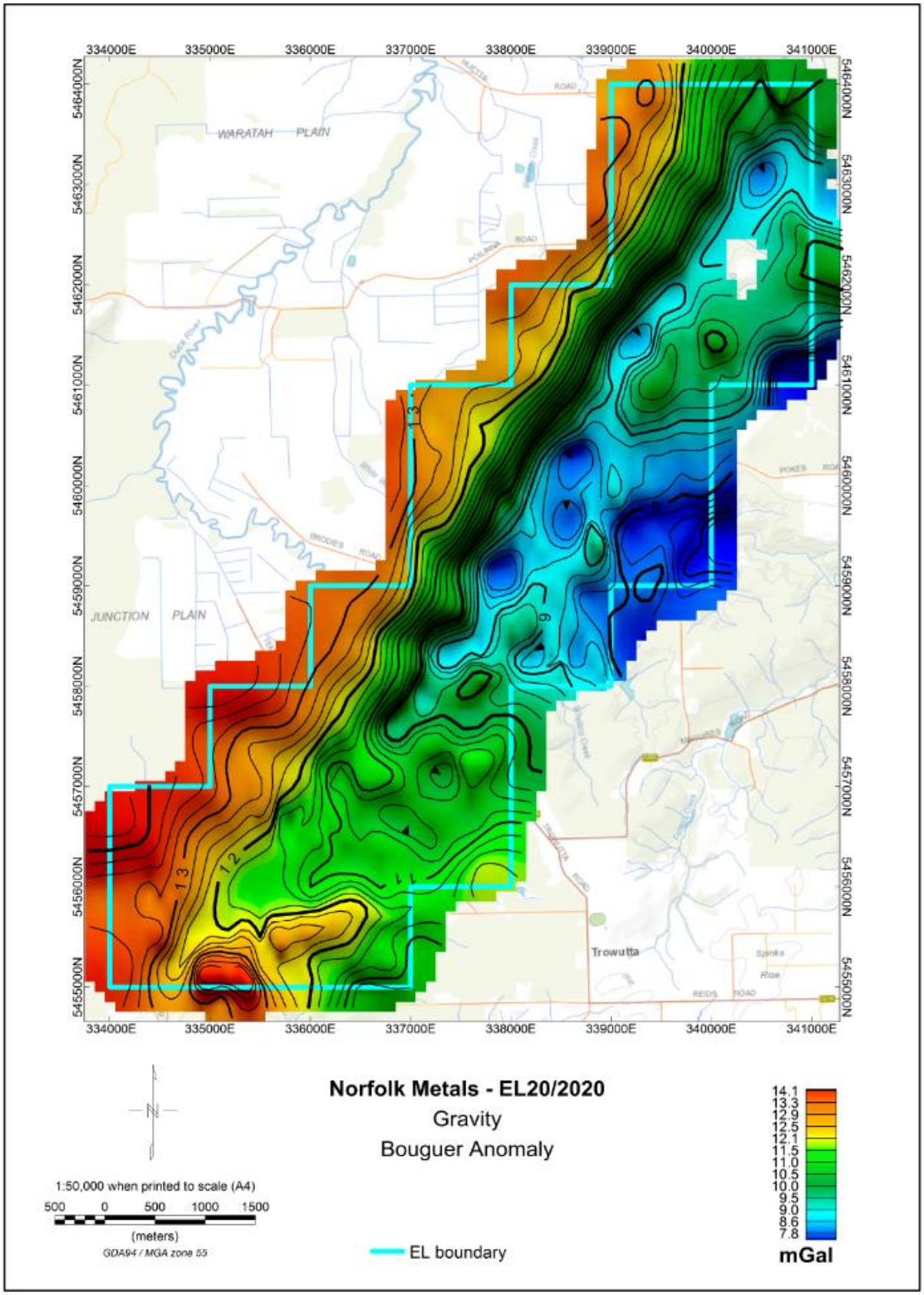
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
gravity station
aeromagnetic flight lines
EL boundary

Figure 6.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341000E
5464000N
5463000N
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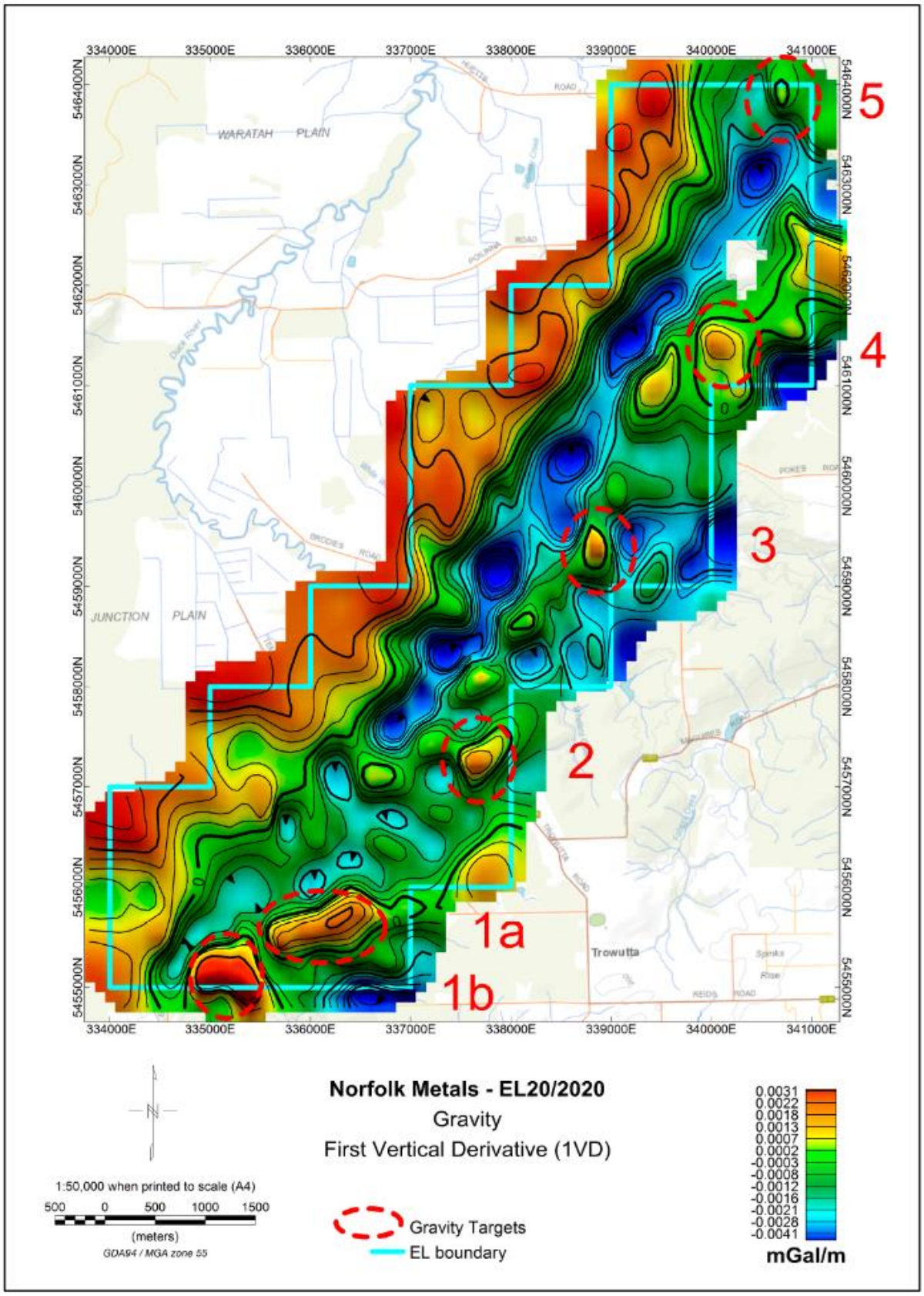
5461000N
5460000N
5459000N
5458000N
5457000N
5456000N
5455000N
WARATAH PLAIN
JUNCTION PLAIN
Trowutta
Norfolk Metals - EL20/2020
Gravity
Bouguer Anomaly
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
EL boundary
14.1
13.3
12.9
12.5
12.1
11.5
11.0
10.5
10.0
9.5
9.0
8.6
7.8
mGal

Figure 7.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5464000N
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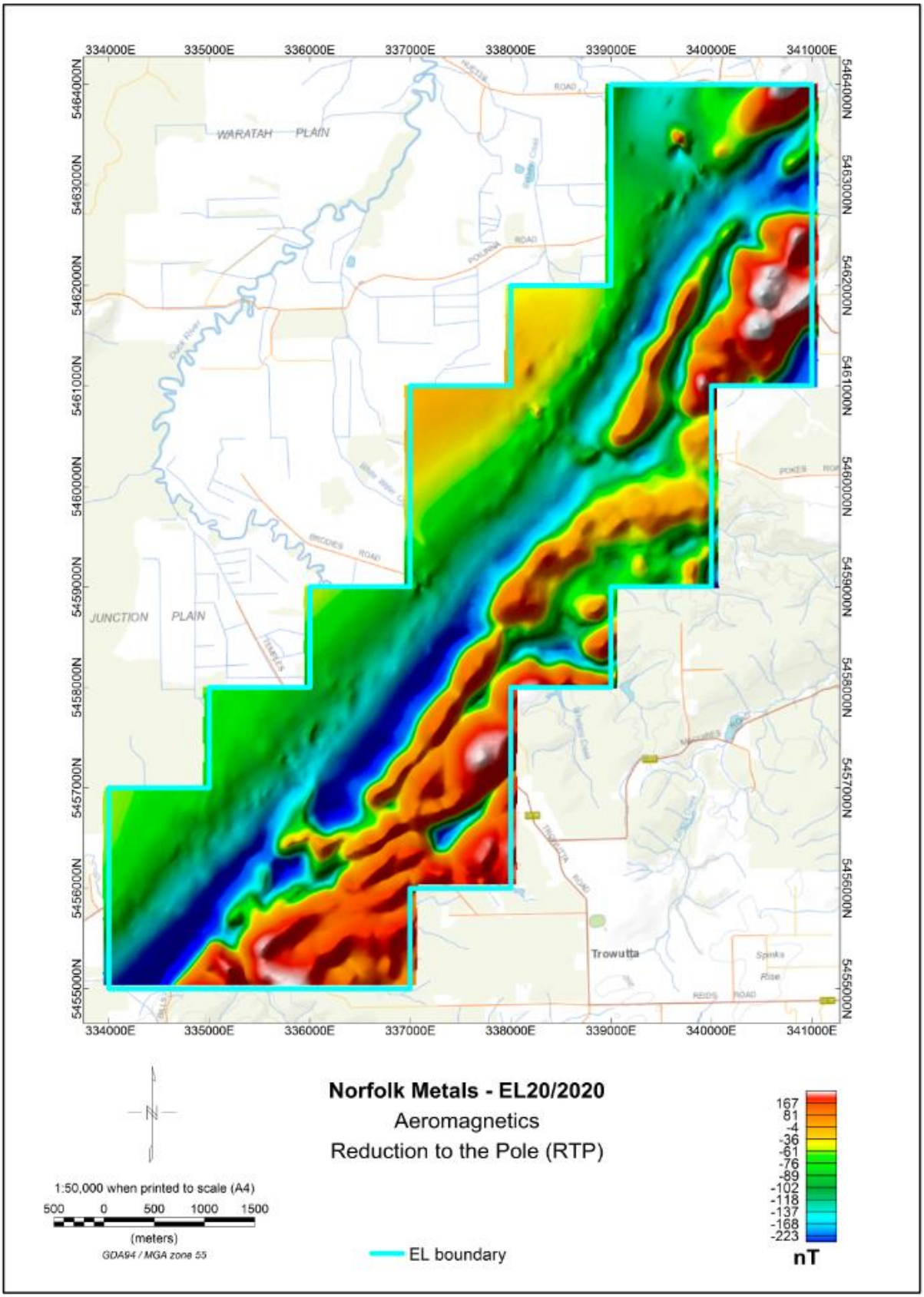
5462000N
5461000N
5460000N
5459000N
5458000N
5457000N
5456000N
5455000N
WARATAH PLAIN
JUNCTION PLAIN
Trowutta
5
4
3
2
1a
1b
Norfolk Metals - EL20/2020
Gravity
First Vertical Derivative (1VD)
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
Gravity Targets
EL boundary
0.0031
0.0022
0.0018
0.0013
0.0007
0.0002
-0.0003
-0.0008
-0.0012
-0.0016
-0.0021
-0.0028
-0.0041
mGal/m

Figure 8.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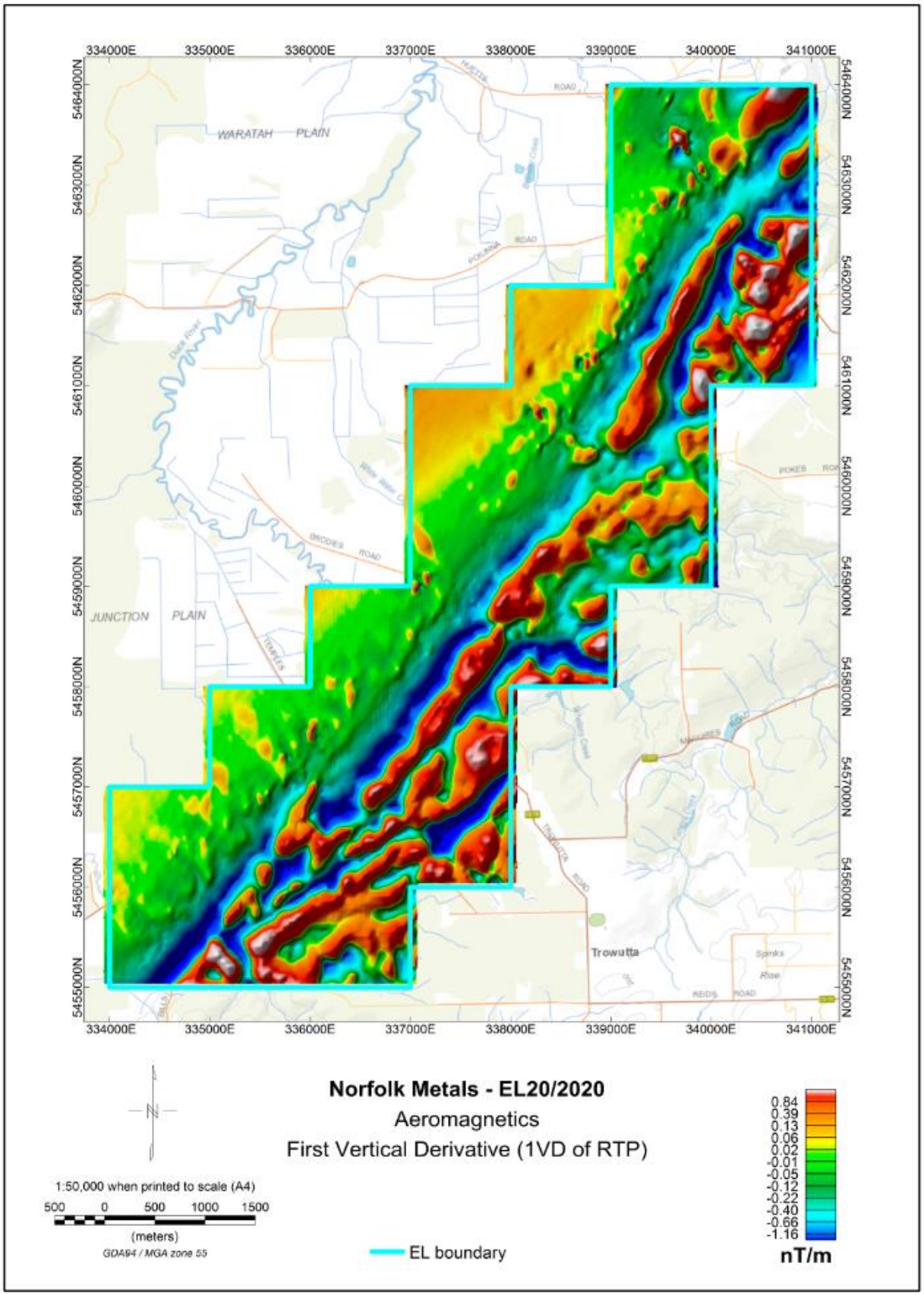
5459000N
5458000N
5457000N
5456000N
5455000N
WARATAH PLAIN
JUNCTION PLAIN
Trowutta
Norfolk Metals - EL20/2020
Aeromagnetics
Reduction to the Pole (RTP)
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
EL boundary
167
81
-4
-36
-61
-76
-89
-102
-118
-137
-168
-223
nT

Figure 9.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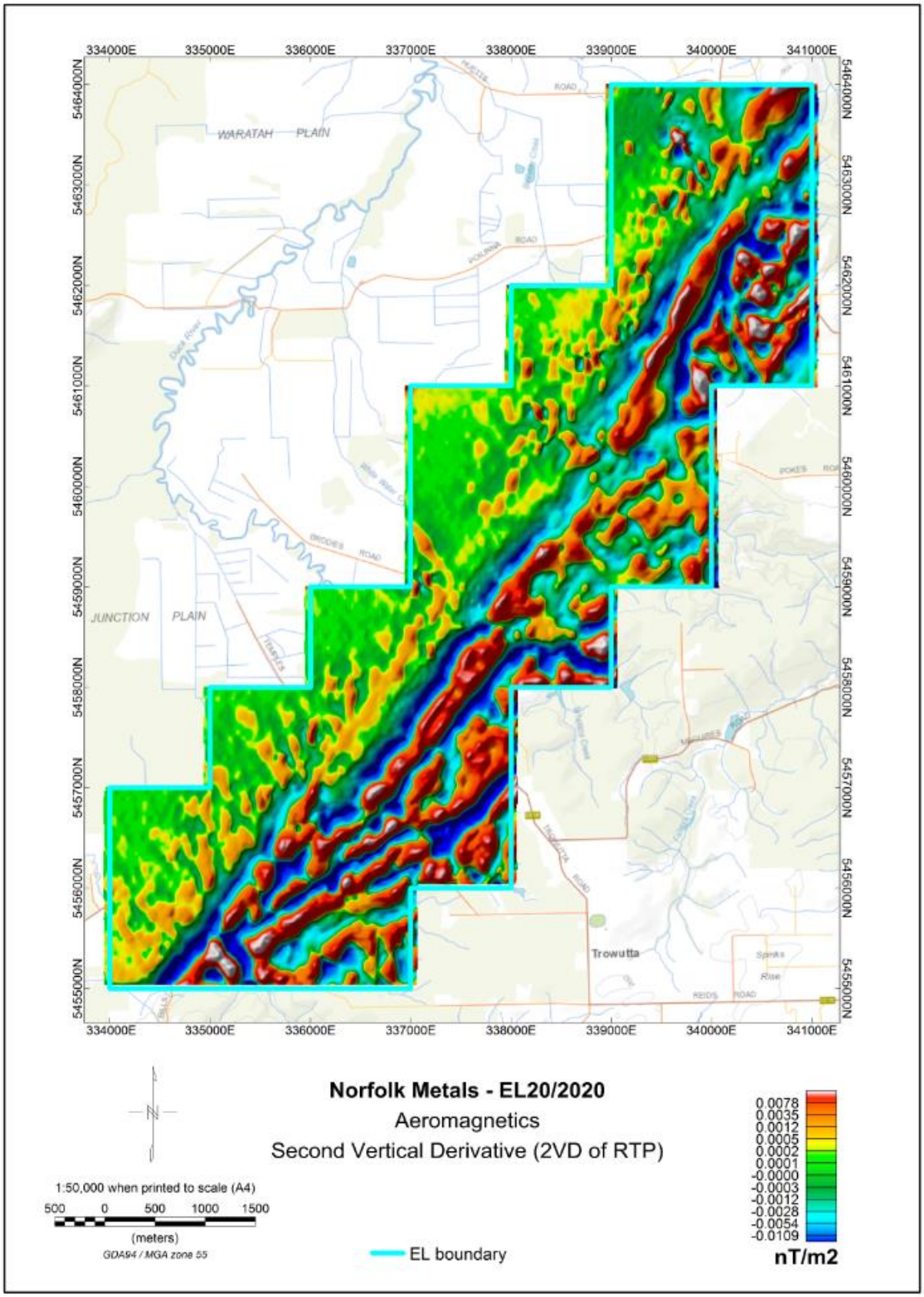
5460000N
5459000N
5458000N
5457000N
5456000N
5455000N
WARATAH PLAIN
JUNCTION PLAIN
Trowutta
Norfolk Metals - EL20/2020
Aeromagnetics
First Vertical Derivative (1VD of RTP)
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
EL boundary
0.84
0.39
0.13
0.06
0.02
-0.01
-0.05
-0.12
-0.22
-0.40
-0.66
-1.16
nT/m

Figure 10.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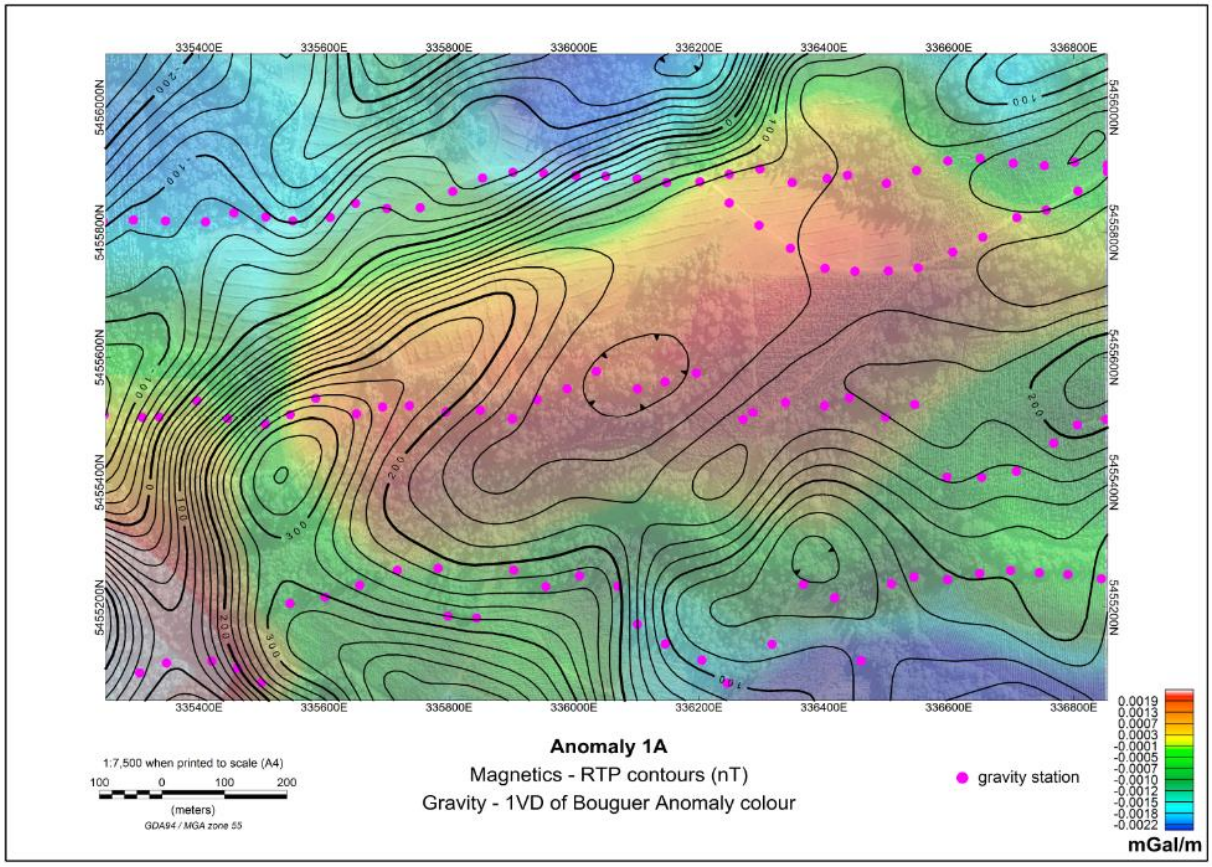
5460000N
5459000N
5458000N
5457000N
5456000N
5455000N
WARATAH PLAIN
JUNCTION PLAIN
Trowutta
Norfolk Metals - EL20/2020
Aeromagnetics
Second Vertical Derivative (2VD of RTP)
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
GDA94 / MGA zone 55
EL boundary
0.0078
0.0035
0.0012
0.0005
0.0002
0.0001
-0.0000
-0.0003
-0.0012
-0.0028
-0.0054
-0.0109
nT/m2

Figure 11.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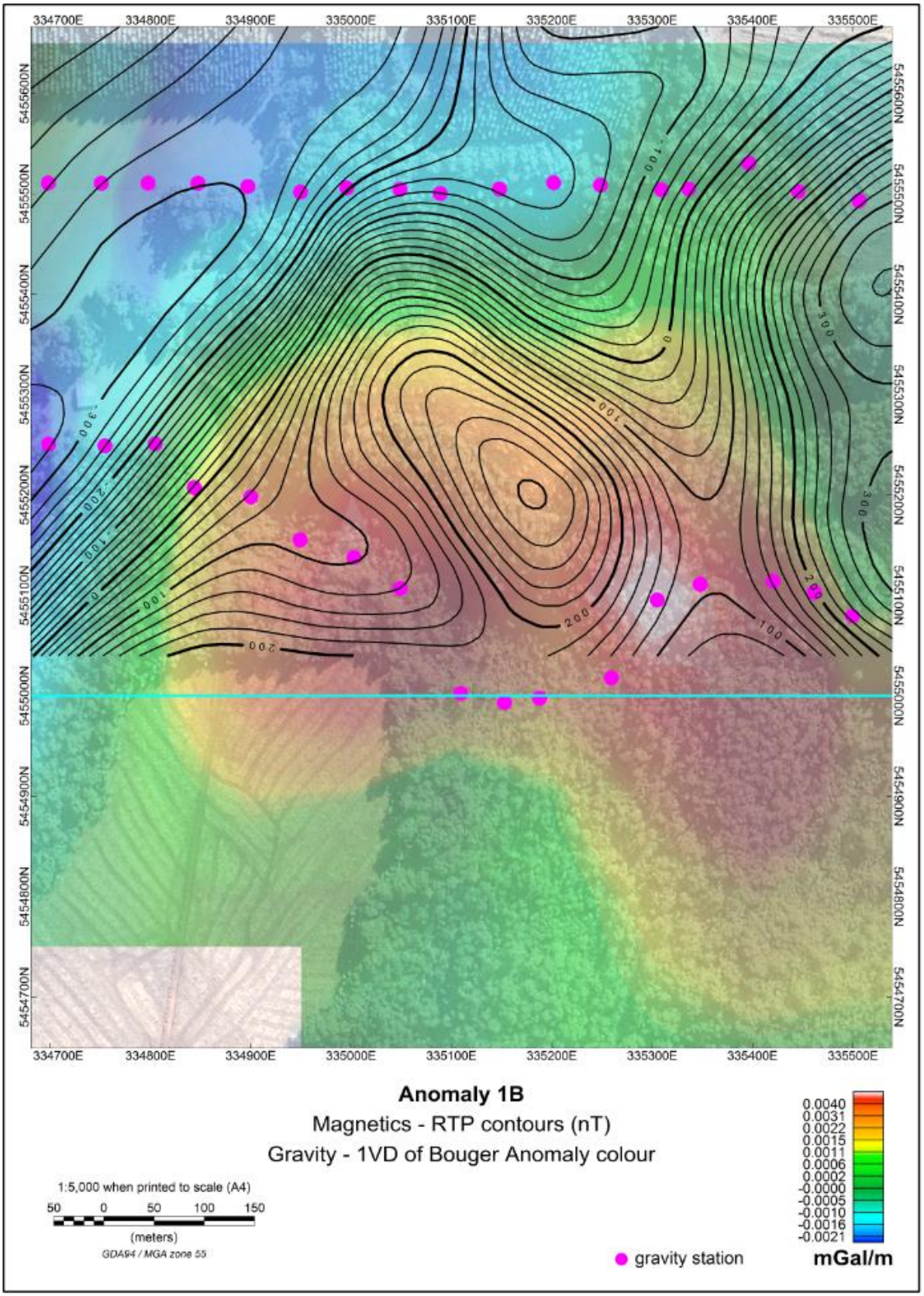
335800E
336000E
336200E
336400E
336600E
336800E
5456000N
5455800N
5455600N
5455400N
5455200N
Anomaly 1A
Magnetics - RTP contours (nT)
Gravity - 1VD of Bouguer Anomaly colour
gravity station
1:7,500 when printed to scale (A4)
100 0 100 200
(meters)
GDA94 / MGA zone 55
0.0019
0.0013
0.0007
0.0003
-0.0001
-0.0005
-0.0007
-0.0010
-0.0012
-0.0015
-0.0018
-0.0022
mGal/m

Figure 12.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335200E
335300E
335400E
335500E
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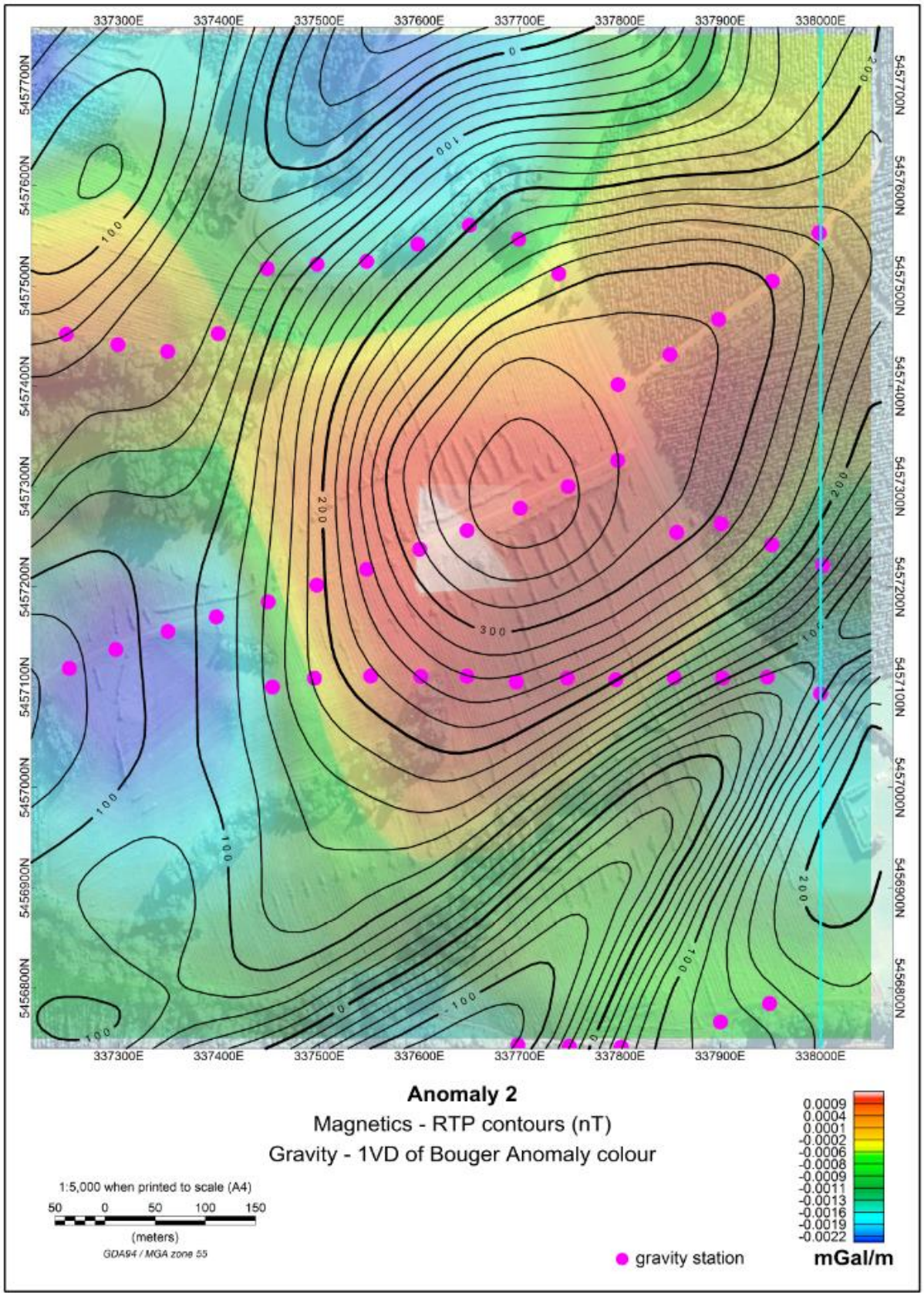
5455400N
5455300N
5455200N
5455100N
5455000N
5454900N
5454800N
5454700N
Anomaly 1B
Magnetics - RTP contours (nT)
Gravity - 1VD of Bouger Anomaly colour
1:5,000 when printed to scale (A4)
50 0 50 100 150
(meters)
GDA94 / MGA zone 55
gravity station
0.0040
0.0031
0.0022
0.0015
0.0011
0.0006
0.0002
-0.0000
-0.0005
-0.0010
-0.0016
-0.0021
mGal/m

Figure 13.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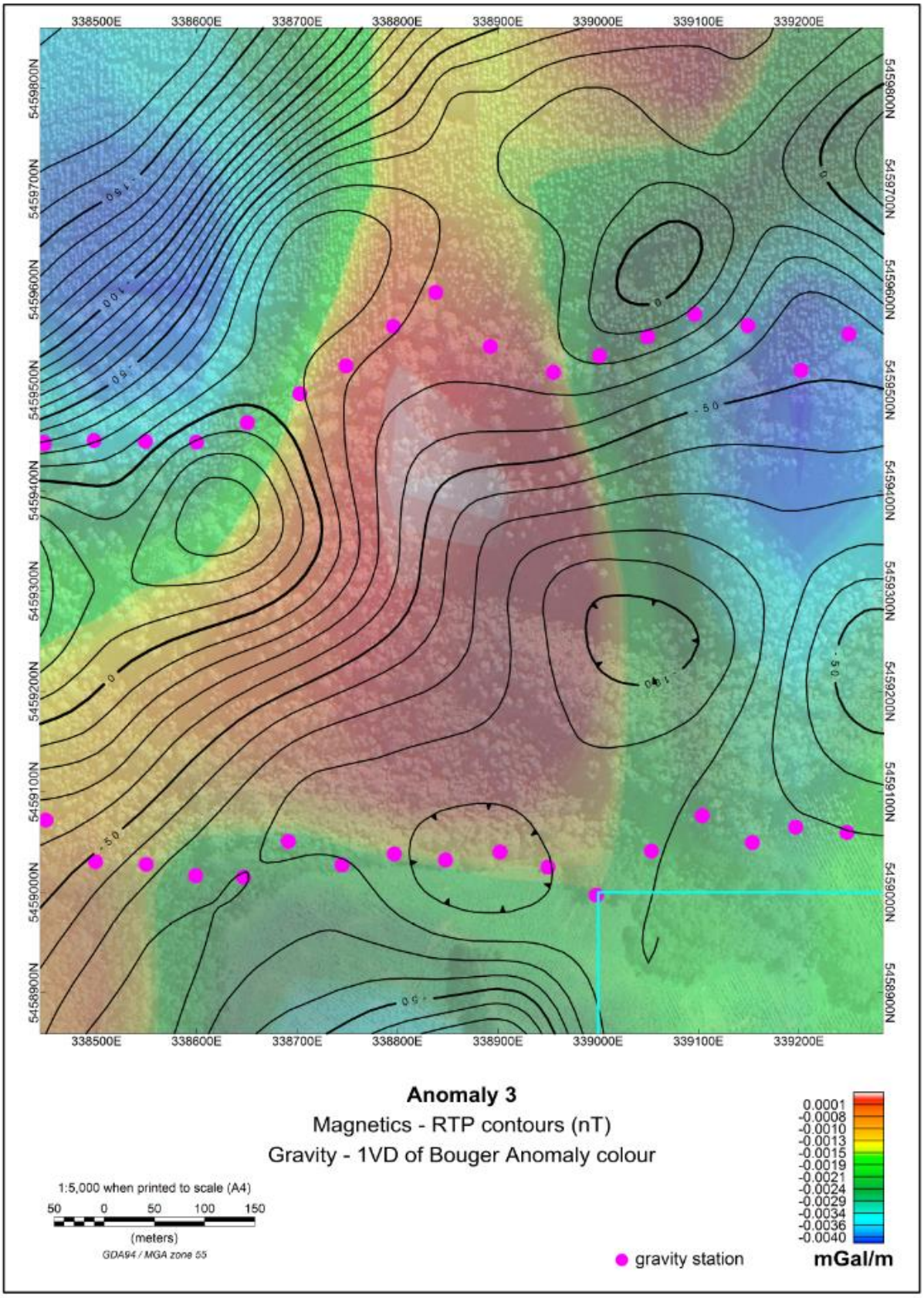
5457600N
5457500N
5457400N
5457300N
5457200N
5457100N
5457000N
5456900N
5456800N
Anomaly 2
Magnetics - RTP contours (nT)
Gravity - 1VD of Bouger Anomaly colour
1:5,000 when printed to scale (A4)
50 0 50 100 150
(meters)
GDA94 / MGA zone 55
0.0009
0.0004
0.0001
-0.0002
-0.0006
-0.0008
-0.0009
-0.0011
-0.0013
-0.0016
-0.0019
-0.0022
mGal/m
gravity station

Figure 14.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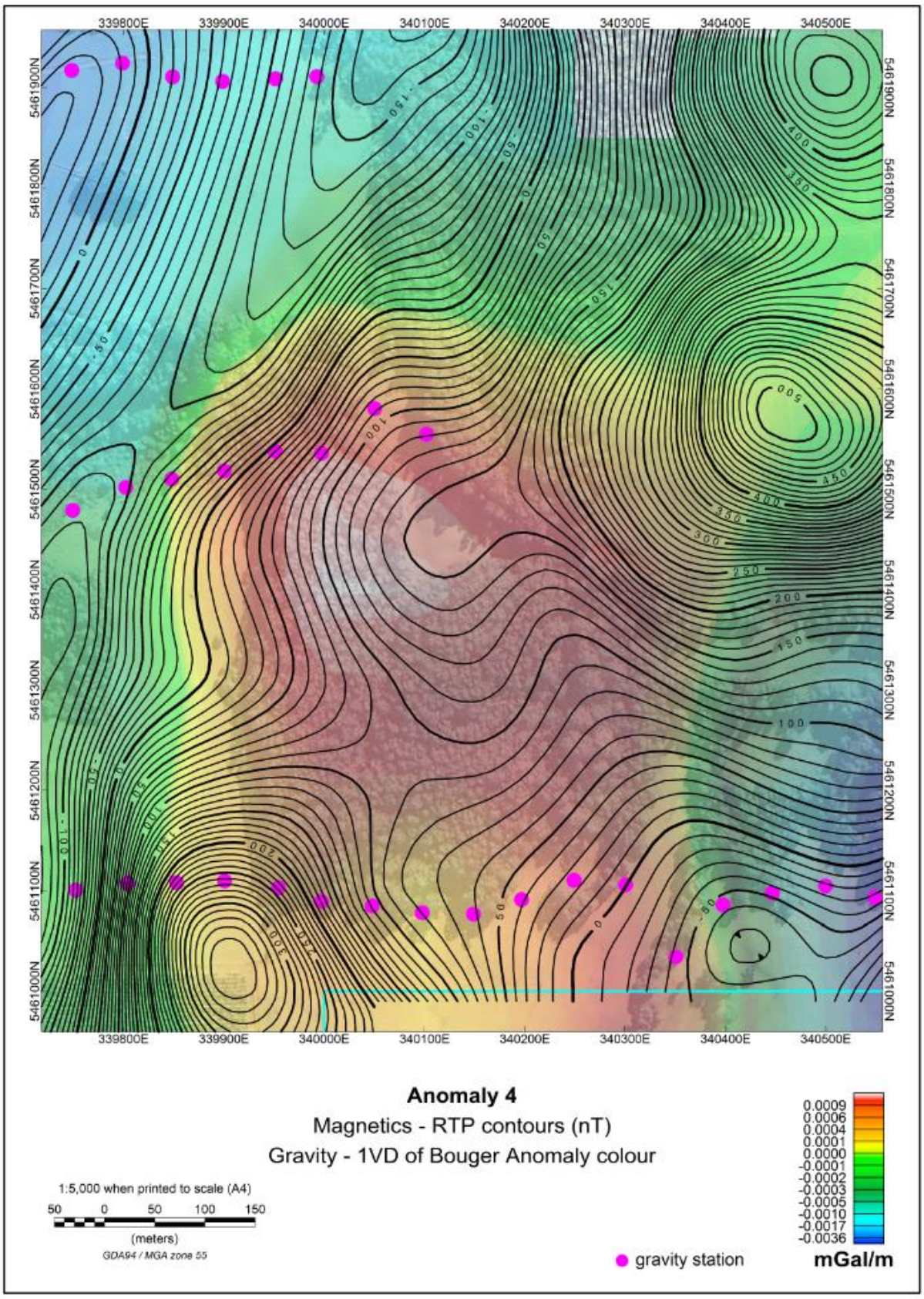
5459400N
5459300N
5459200N
5459100N
5459000N
5458900N
Anomaly 3
Magnetics - RTP contours (nT)
Gravity - 1VD of Bouger Anomaly colour
1:5,000 when printed to scale (A4)
50 0 50 100 150
(meters)
GDA94 / MGA zone 55
gravity station
0.0001
-0.0008
-0.0010
-0.0013
-0.0015
-0.0019
-0.0021
-0.0024
-0.0029
-0.0034
-0.0036
-0.0040
mGal/m

Figure 15.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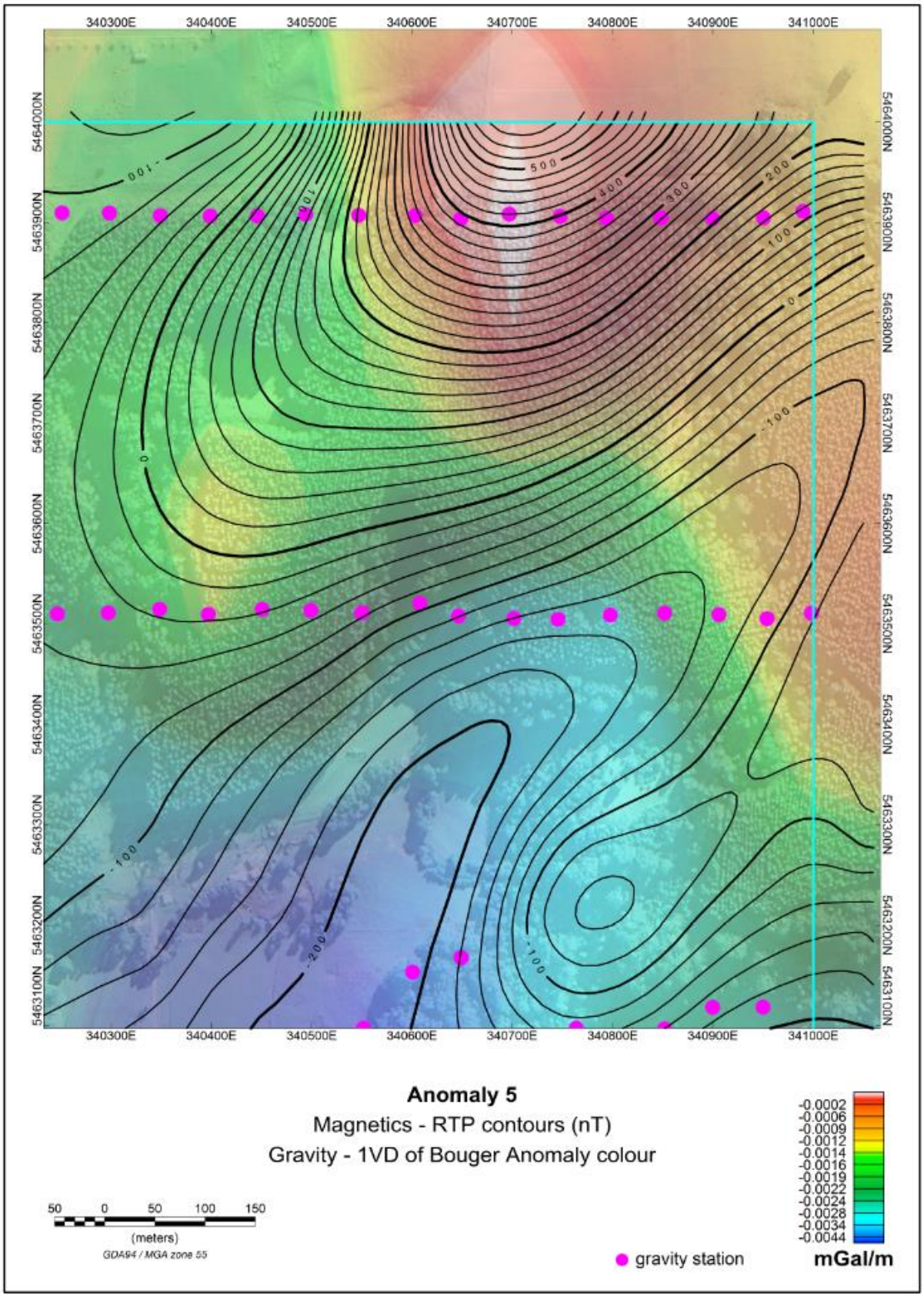
5461500N
5461400N
5461300N
5461200N
5461100N
5461000N
Anomaly 4
Magnetics - RTP contours (nT)
Gravity - 1VD of Bouger Anomaly colour
1:5,000 when printed to scale (A4)
50 0 50 100 150
(meters)
GDA94 / MGA zone 55
gravity station
0.0009
0.0006
0.0004
0.0001
0.0000
-0.0001
-0.0002
-0.0003
-0.0005
-0.0010
-0.0017
-0.0036
mGal/m

Figure 16.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340900E
341000E
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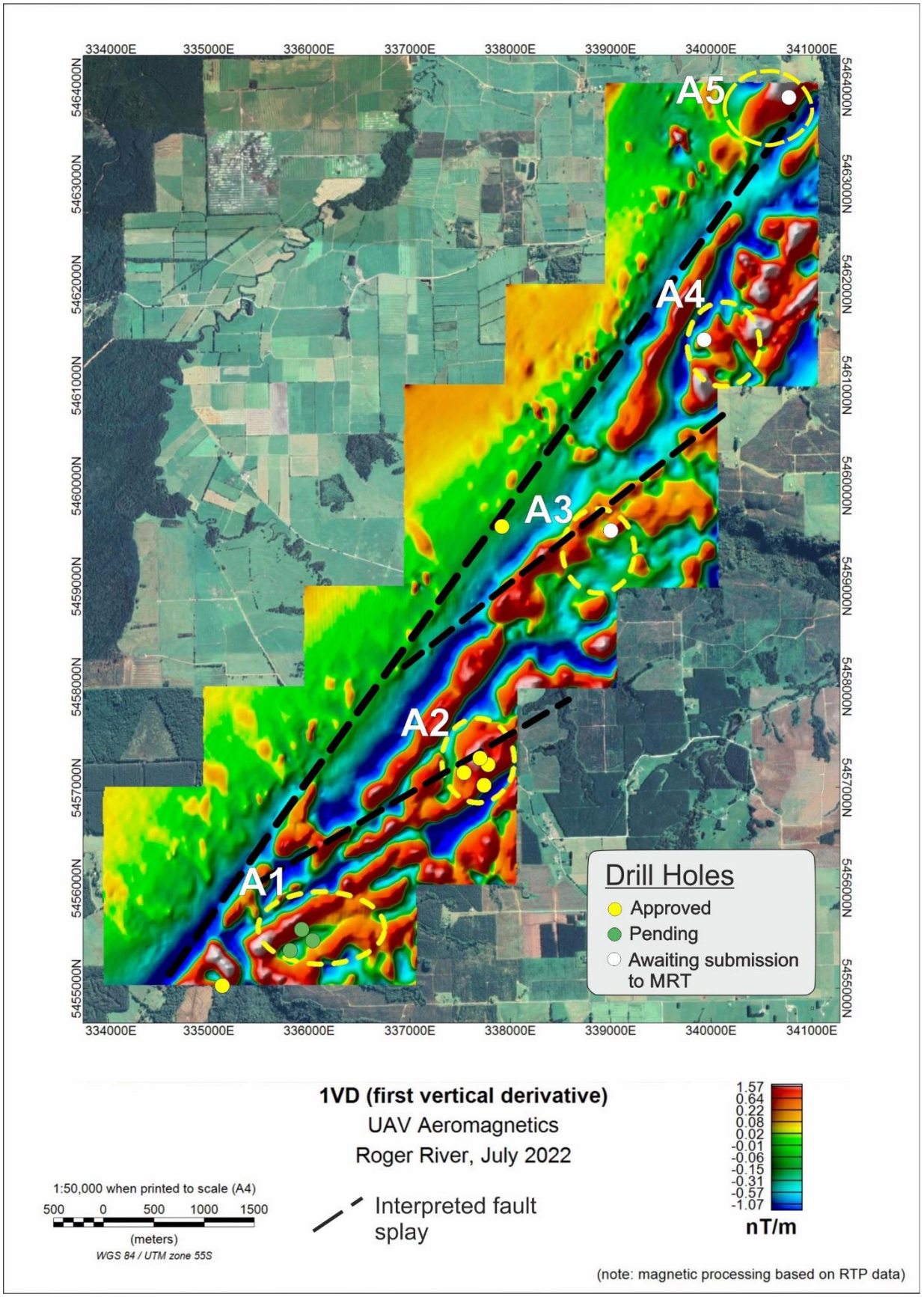
5463700N
5463600N
5463500N
5463400N
5463300N
5463200N
5463100N
Anomaly 5
Magnetics - RTP contours (nT)
Gravity - 1VD of Bouger Anomaly colour
-0.0002
-0.0006
-0.0009
-0.0012
-0.0014
-0.0016
-0.0019
-0.0022
-0.0024
-0.0028
-0.0034
-0.0044
mGal/m
50 0 50 100 150
(meters)
GDA94 / MGA zone 55
gravity station

Figure 17.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5459000N
5458000N
5457000N
5456000N
5455000N
A1
A2
A3
A4
A5
Drill Holes
Approved
Pending
Awaiting submission to MRT
1VD (first vertical derivative)
UAV Aeromagnetics
Roger River, July 2022
Interpreted fault splay
1.57
0.64
0.22
0.08
0.02
-0.01
-0.06
-0.15
-0.31
-0.57
-1.07
nT/m
1:50,000 when printed to scale (A4)
500 0 500 1000 1500
(meters)
WGS 84 / UTM zone 55S
(note: magnetic processing based on RTP data)

Figure 18.

EXPLORATION RATIONALE

Prospectivity of EL20/2020 for epithermal style gold mineralisation at depth beneath the outcropping silica has been established by previous mapping and exploration geochemistry (Turner, 2001, 2003, 2009) and the exploration rationale is based on the concept that the outcropping silica represents heavily leached, high-level capping to an epithermal system analogous to some established gold epithermal provinces elsewhere (eg. Radtke and Davis, 1990). The presence of geologically-juvenile mounds and warm water springs along the eastern margin of the Smithton Basin supports the model.

During the reporting period, Norfolk Metals Ltd (NFL) conducted the following exploration activities:

- Ground Gravity Survey
- Airborne (UAV) Magnetics Survey
- Soil Orientation Survey over identified Targets

The aim of the gravity survey was to identify anomalous zones that may possibly represent sulphide mineralization related with epithermal style gold deposits. The ‘bulls-eye’ anomalies identified, suggested to be located near or on fault structures, were considered as priority targets.

The aim of the airborne magnetic survey was to refine or improve the resolution of the existing airborne magnetics data (public domain from MRT), by conducting a drone survey at a closer space (50m) line spacing over the entire EL20/2020 tenement. The acquired data were to be processed to define structures (fault) that may host the gold and sulphide mineralization.

Once the priority targets were identified, a line soil orientation program was conducted over the anomalous zones to assist as a vector for the drilling program. It was also aimed at increasing the understanding the possible relationship between the soil geochemistry and the gravity anomalies.

LEASE INFORMATION

ROGER RIVER RESOURCES PTY LTD EL20/2020 YEAR 1 ANNIVERSARY

REPORTING PERIOD 15TH AUGUST 2021 TO 15TH AUGUST 2022

ROGER RIVER RESOURCES PTY LTD ANNUAL REPORT PREPARED FOR NORFOLK METALS LTD OWNER OF 100% OF ISSUED CAPITAL IN ROGER RIVER RESOURCES PTY LTD

COMPANY DETAILS

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Phone: +61 8 6555 2950

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REVIEW OF PREVIOUS WORK

EL 19/2012, located due south of Smithton in NW Tasmania, covers a large area of uneroded hot spring related silicification, argillic alteration and associated diatreme breccias with a strike length of at least 7 kilometres in a classic basin and range setting, similar to Carlin-style deposits in Nevada USA. The range front has protected the silicification and argillisation zone from erosion as it occurs at the base of the range. Un-eroded hot spring systems physically and chemically cannot carry economic values of precious metals to or near surface as the required pressure, temperature and fluid composition conditions are not present close to surface. Boiling zones intimately associated with economic mineralisation occur at a depth where the required pressures, temperatures and fluid compositions are present.

Comparison with other systems, such as in Nevada, and the circum-Pacific region suggest that mineralisation can be expected below the surface manifestations and up to 1km from the major structure along subsidiary structures. Surface exploration targets within the alteration zone are expected to be defined by anomalous (one or more elements) As, Sb, Hg and Ba, and detectable gold values should be considered a bonus. These can vary from very subtle to intense anomalies. At Roger River, As is the pathfinder element with the anomalous gold values.

The +7 kilometre long zone of generally intense silicification, argillisation and three diatreme breccia bodies sit primarily in the hanging wall of the steeply east-dipping, reverse Roger River Fault (RRF), a deep crustal, regional scale structure which appears to have a long history of movement. The predominantly carbonate-rich host rocks are ideal for the emplacement of hot spring related epithermal mineralisation, either as disseminated mineralisation or as structurally controlled mineralised zones. The rocks hosting the silicification zone comprise well bedded and banded dolomites, calcareous and dolomitic siltstones, grits, black shales and some cherts

on the east or hanging wall side of the RRF, capped on topographic highs in places by basalt. The west or footwall side of the RRF contains dolomites, dolomitic siltstones and other carbonate-rich rocks.

A 2002 soil sampling programme identified detectable gold anomalies to 6ppb gold and arsenic values to 100ppm, and exceptionally in rock chip samples of iron-rich rocks to over 1,000ppm As, particularly at the North Whitewater zone near the projected intersection of a splay fault. Zinc shows a degree of anomalism around and in the silicification zones, and rare samples have provided slightly anomalous antimony and anomalous barium and mercury results. One occurrence of visible exotic barite has been located at surface, and possible manganese oxides intersected in a drill hole.

An IP programme in 2013 along 4 lines across the silicification has identified the silicified RRF as clearly dipping steeply resistivity zone to the east, and also demonstrated that the lithologies of the rock sequences either side of the RRF are different.

Three diamond drill holes totalling 595.30 metres were completed as a first pass test of the system to test the IP chargeability anomalies, clarify the geology, test the intensity of silicification below surface and its variations, and to intersect and understand the RRF. Assays from the 2 shallow drill holes within the silicified zone have confirmed detectable gold values, anomalous arsenic and zinc values in silicified rocks. Significantly, in hole RRD02 these are closely associated with the RRF hanging wall rocks, and in hole RRD03 which was abandoned well short of the target depth, values are in silicified dolomitic rocks below anomalous soil geochemistry.

EXPLORATION COMPLETED DURING THE REPORTING PERIOD

The location of geophysical surveys completed during the reporting period is shown in Figure 6. For information, additional plots are also included on the same map-base showing a Google Earth satellite image, Lidar elevation, and Mineral Resources Tasmania geology (Figures 3, 4 and 5 respectively).

Airborne Magnetics

In May 2022 Pegasus Airborne Systems conducted a low-level UAV magnetic survey covering the whole of EL20/2020. Data acquisition commenced on the 9th of May 2022 and was completed on the 12th of May.

A specialised unmanned rotary wing geophysical survey aircraft was equipped with a Pegasus autonomous flight control and terrain following system. This aircraft was used to tow a Pegasus designed and built magnetometer bird which housed the geophysical sensors and Pegasus data acquisition system.

Basic survey parameters were

Line Spacing	50m
Line Direction	090-270
Tie-Line Spacing	500m
Tie-Line Direction	000-180
Sensor Height	75m
Total Line km	595

Full details are given in the contractor's report - see Appendix

Gravity

In December 2021 Atlas Geophysics conducted a semi-detailed ground-based gravity survey covering the whole of EL20/2020. Acquisition commenced on the 1st of December 2021 and finished on the 15th of December 2021.

Gravity stations were acquired using a 400m x 50m spacing, with survey lines oriented east-west. A total of 1,317 gravity stations were acquired. In the far northeast of EL20/2020 coverage at that spacing was not fully completes due to issues with land access.

Full details are given in the contractor's reports - see Appendix

DISSCUSSION OF RESULTS

Airborne Magnetics

The measured TMI (Total Magnetic Intensity) data was gridded and processed into three different images; RTP (Reduced to the Pole), 1VD and 2VD (First and Second Vertical Derivatives). RTP processing converts the data into what it would look like if the earth's magnetic field were vertical, so removing the "distortion" of anomalies caused by the earth's actual dipping magnetic field. Derivatives tend to sharpen the edges of anomalies and enhance shallow features.

The vertical derivative is much more responsive to local influences than to broad or regional effects. Relatively smaller anomalies are more readily apparent in areas of strong regional features. The derivatives tend to enhance anomalies, and consequently structures, that are more within the typical range of depth of interest for exploration.

The RTP, 1VD and 2VD data (Figures 9,10 and 11 respectively) from the 2022 Pegasus Airborne Systems survey have delivered significantly improved resolution of magnetic features and structure when compared to older surveys flown in 2001 (a 200m spaced government survey) and 1998 (a 150m spaced company survey).

The new data has allowed a better understanding of trends and structure within the prospective lithologies east of the Roger River Fault. This includes added evidence for a NE structural trend, an orientation that aligns with previously interpreted splays off the Roger River Fault. Cross-structures in other directions are also quite evident in the new magnetic data.

Gravity

Gravity data was read at a nominal 400m line spacing and stations at 50m intervals. Maintaining a uniform station spacing was made difficult in some areas due to rugged and steep terrain, and an area in the northeast could not be surveyed due to the inability to conclude an access agreement with one landowner by the time of the survey.

The gravity survey contractor provided fully reduced Bouguer Anomaly data (Appendix). The Bouguer anomaly data was imaged (Figure 7.) and processed to generate a 1VD image (Figure 8). Guided by the 1VD data's enhancement of anomalies (see the above comments for magnetics), six exploration targets (1a, 1b, 2, 3, 4, 5) were defined.

Targeting

Coincident magnetic and gravity anomalies were the targets of primary interest, however the semi-detailed nature of the gravity survey, combined with the difficult access in some locations, meant that the gravity anomalies were not always fully defined and closed off. Therefore each target can be said to have a "spatially close" relationship between magnetic and gravity anomalies, but at this stage it is uncertain if that relationship is truly "coincident". Drilling these magnetic/gravity targets will provide a better understanding of the true relationship between the magnetic and gravity anomalism.

Figures 12. to Figure 17. show each of the six targets in detail. Contours of magnetic data (RTP) are shown with a transparent gravity image (1VD) overlain on a satellite image backdrop. It is important to note the actual locations of the gravity stations when looking at the coloured gravity image because in some cases the true gravity peak location may not have been fully defined by the gravity station locations. Anomaly 3 (Figure 15.) is an example; the northern traverse line shows that a gravity anomaly is present but the data interpolation producing the coloured gravity image placed the coloured gravity high some 150m to 200m to the south of the traverse line. Such uncertainty surrounding a gravity anomaly's exact peak location should be allowed for during any subsequent drill planning to test the target.

CONCLUSION

During the reporting period, NFL conducted ground gravity and airborne surveys and were able to identify anomalous areas that may be possibly associated with

epithermal style gold deposits. The ground gravity data identified 'bulls-eye' anomalies and together with anomalous magnetic 'highs' along fault structures, the zones were considered as high priority drill targets. All of the geophysics data were processed and modelled to assist in the construction of drill holes to target the anomalies at depth using diamond drilling. The diamond drilling programmes were constructed in 2 stages and have been submitted to MRT for approval.

Subsequently, orientation line soil geochemistry programme was conducted over the anomalous zones to assist with the vector of the drill holes and improve the understanding between the soil geochemistry and geophysics data. The results were unavailable during the reporting period.

FUTURE EXPLORATION

During the reporting period several drill holes were submitted to MRT for approval. The drill holes were proposed based on the interpretation of the gravity and magnetics data, identifying anomalous zones. The status of the drilling application to MRT and landowner approvals has been illustrated in Figure 18. The diamond drilling campaign designed to test the 'priority' targets will commence in September 2022. It is envisaged that the drilling order of the anomalous targets will depend largely on the results of the first 2 drill holes and the soil orientation program (Figure 2.)

ENVIRONMENTAL MANAGEMENT

As the soil sampling program was non-disturbing there were no environmental issues to address. Future drill sites and any associated earthworks will be created and rehabilitated according to the Mineral Exploration Code of Practice as a minimum.

EXPENDITURE

ROGER RIVER EXPENDITURE - YEAR 1	
GEOLOGY	
Accommodation / Rentals	$14,209.34
Contract Geologists and Field Assistants	$69,343.68
Satellite Communications	$1,208.59
GEOPHYSICS	
Aeromagnetic	$37,125.00
Gravity	$46,095.00
Data Processing and Analysis	$21,304.30

REMOTE SENSING

Mapping and Imagery	$2,182.50

OTHER

Ford Ranger (1-year of 5-year costs)	$7,600.00

ADMINISTRATION

Company Secretary and Legal	$20,000.00

TOTAL	$219,068.41

APPENDIX

ATLAS Geophysics Gravity Survey and Aeromagnetic reports at rear of document

Atlas Geophysics Memorandum M2021138

EL20/2020 Gravity Survey

NORFOLK METALS LIMITED

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22nd December 2021

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1.0 Project Brief

Project P2021138 involved the acquisition and processing of **1,317** new gravity stations for Norfolk Metals Limited over an area approximately 18km south of Smithton in Northern Tasmania (Figure 1).

Gravity stations were acquired using a 400m x 50m grid configuration. Atlas Geophysics completed the acquisition of the dataset with one crew utilising foot-borne gravity methods.

Acquisition for the project commenced on the 1st of December 2021 and finished on the 15th of December 2021. Final data were delivered shortly after project completion.

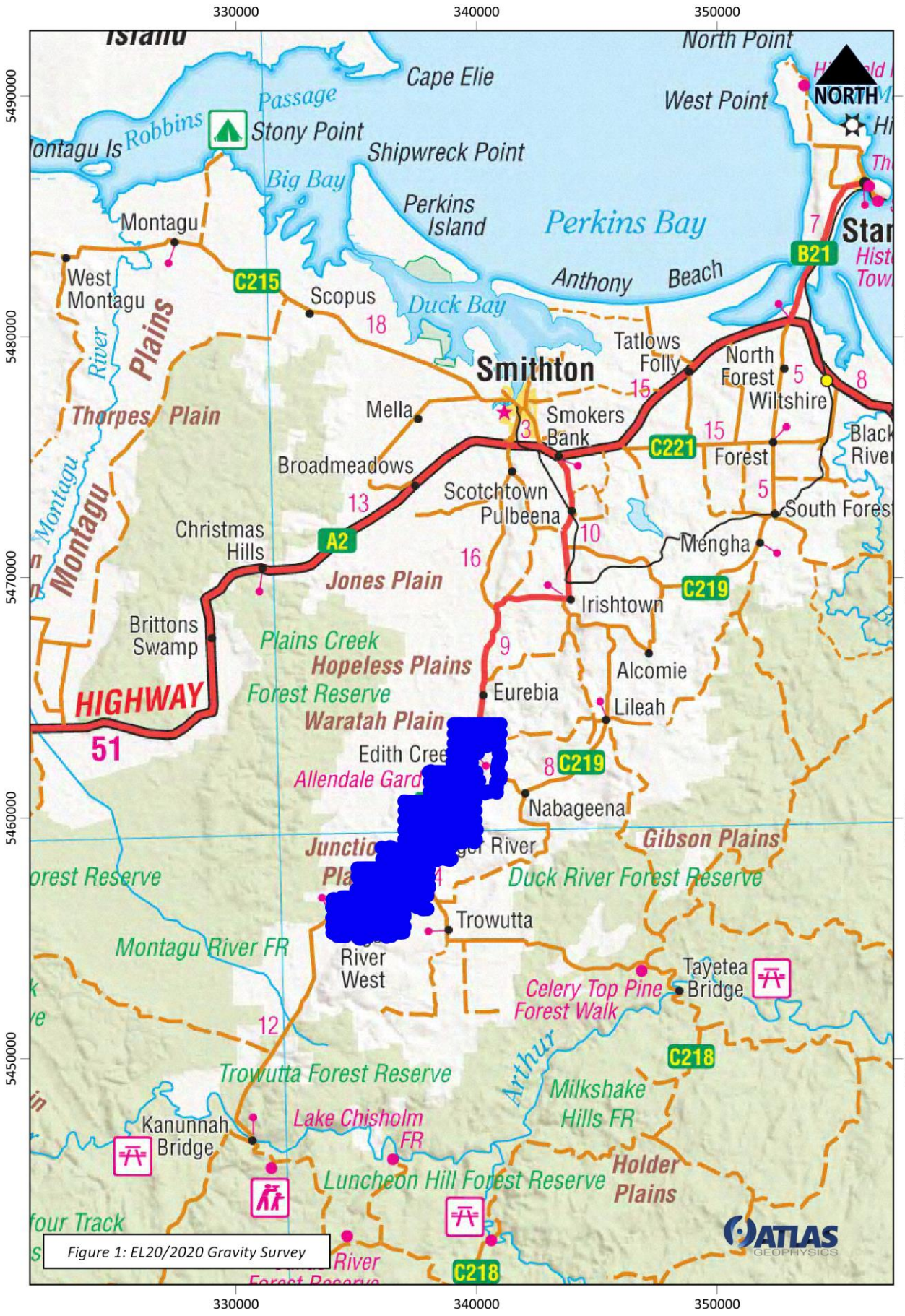


Figure 1: EL20/2020 Gravity Survey

2.0 Equipment and Instrumentation

The following instrumentation was used for acquisition of the gravity data:

- One CG-6 Autograv Gravity Meter
  - (Serial Number: 21020321, SF: 1.0000)
- One CHCi70+ GNSS Rover Receiver
- One CHCi70+ GNSS Base Receiver

Ancillary equipment included:

- Laptop computers for data download and processing
- Garmin autonomous GPS receivers for navigation
- InReach personal satellite tracking units
- Iridium satellite phones for long distance communications
- Personal Protective Equipment for all personnel
- Batteries, battery chargers, solar cells, UPS System
- Survey consumables
- Tools, engineering, and maintenance equipment for vehicle servicing
- First aid and survival kits
- Tyres and recovery equipment

3.0 Calibration and Control

The gravity meter used for the survey had been recently calibrated on the Guildford Cemetery – Helena Valley Primary School calibration range (2010990117 - 2010990217) in Western Australia. The calibration process validated the gravity meter's scale factor to ensure reduction of the survey data produces correct Observed Gravities from measured dial reading values.

One new gravity control station 202113800001 "Dutch Mill Dairy" and one new GNSS control station 202113800101 "Dutch Mill Dairy GNSS only" were used to control all field observations throughout the project.

GNSS control was established at 202113800101 by submitting three 10-hour sessions of static data to Geoscience Australia's AUSPOS processing system, producing first-order geodetic coordinates. These coordinates are accurate to better than 10mm for the x, y, and z observables.

Gravity control was established at station 202113800001 via two ABA ties to existing Atlas Geophysics control station 201300100001 "Grace's Cottage". Standard deviation of the gravity ties is 0.001mGal.

4.0 GNSS-Gravity Acquisition

Gravity data were acquired concurrently with GNSS data using a Scintrex CG-6 gravity meter. Data were acquired in single shifts of up to 12 hours duration, with each shift consisting of a single loop controlled by observations at the gravity control station. Each loop contained a minimum of two repeated readings so that an interlocking network of closed loops was formed. A total of **40** repeat readings representing **3.04%** of the survey were acquired for quality control purposes. Repeat readings were evenly distributed, where possible, on a time-basis throughout each of the gravity loops.

GNSS data were acquired with the rover receiver operating in post-process kinematic (PPK) mode with a GNSS rover sensor attached to a 2.00m walking pole. Static data were logged at the control station with a base receiver operating in post-process static (PPS) mode with the GNSS sensor mounted on a fixed tripod.

5.0 GNSS Processing and QC

The acquired GNSS raw data were processed daily using Novatel Waypoint GrafNav v8.90 post-processing software.

GrafNav was used to transform the GNSS-derived WGS84 coordinates to GDA94 coordinates for each gravity station location. MGA coordinates were then derived by projecting the GDA94 geodetic coordinates with a Universal Transverse Mercator (UTM) transform using the appropriate zone. It should be noted that WGS84 and GDA94 coordinates (x, y, and z) are no longer roughly equivalent, with a difference in horizontal coordinates of greater than 1.0m and a difference in elevation of 90-100mm. GrafNav produced GDA94 ellipsoidal heights for each gravity station location; and elevations above the Australian Height Datum (AHD) were modelled using the AUSGEOID09 geoid model, with separations (N values) added to GDA94 ellipsoidal heights.

The resulting GrafNav data (output in Atlas Geophysics standard format) were then imported into Atlas Geophysics Reduction and Interpretation Software (AGRIS) for QC and used in the reduction of the gravity data. A module built into AGRIS allows the user to examine data quality factors such as station repeatability between multiple control stations, coordinate velocity, dilution of precision, coordinate quality factor and standard error for each gravity station location. The procedure is carried out before merging the positional data with gravity data for final reduction to Bouguer Anomaly. Comprehensive statistics, repeatability analysis and histogram plotting are also performed.

QC procedures were applied to the GNSS data daily and any gravity stations not conforming to the quoted specifications were repeated by the company at no cost to the client.

6.0 Gravity Processing and QC

The acquired gravity data were processed using the company's in-house gravity pre-processing and reduction software, AGRIS. This software allows for full data pre-processing, reduction to Bouguer Anomaly, repeatability, and statistical analysis, as well as full quality control of the output dataset.

Once downloaded from the gravity meters, the data were analysed for consistency and preliminary QC was performed to confirm that observations meet specification for standard deviation, reading rejection, temperature, and tilt values. Once the data were verified the software averaged the multiple gravity readings and performed a merge with the previously QC-passed GNSS data. The software then applies a linear drift correction and earth tide correction. Any gravity stations not conforming to the quoted specifications were repeated by the company at no cost to the client.

The following corrections were further applied to the dataset to produce Spherical Cap Bouguer Anomalies on the GDA94 transform of the GRS80 ellipsoid and AAGD07 gravity datum. For legacy reasons, Geoidal Bouguer Anomalies on the Australian Height Datum (AHD) and ISOGAL84 gravity datum have also been calculated.

The formulae below produce data in μms^{-2} or gravity units (GU). To convert to mGal, divide by a factor of 10.

***Instrument scale factor*:** This correction is used to correct a gravity reading (in dial units) to a relative gravity unit value based on the meter calibration.

$$r_c = 10 \cdot (r \cdot S(r))$$

where,

r_c corrected reading in gravity units
r gravity meter reading in dial units
$S(r)$ scale factor (dial units/milliGal)

Earth Tide Correction: The earth is subject to variations in gravity due to the gravitational attraction of the Sun and the Moon. These background variations can be corrected for using a predictive formula which utilises the gravity observation position and time of observation. The Scintrex CG-5 & CG-6 gravity meters automatically calculate ETC but use only an approximate position for the gravity observation so is not entirely accurate. For this reason, the Scintrex ETC is subtracted from the reading and a new correction calculated within AGRIS software.

$$r_t = r_c + g_{tide}$$

where,

r_t tide corrected reading in gravity units
r_c scale factor corrected reading in gravity units
g_{tide} Earth Tide Correction (ETC) in gravity units

Instrument Drift Correction: Since all gravity meters are mechanical, they are all prone to instrument drift. Drift can be caused by mechanical stresses and strains in the spring mechanism as the meter is moved, knocked, reset, subjected to temperature extremes, subjected to vibration, unclamped etc. The most common cause of instrument drift is due to extension of the sensor spring with changes in temperature (obeying Hooke's law). To calculate and correct for daily instrument drift, the difference between the gravity control station readings (closure error) is used to assume the drift and a linear correction is applied.

$$ID = \frac{r_{cs2} - r_{cs1}}{t_{cs2} - t_{cs1}}$$

where,

ID	Instrument Drift in gu/hour
r_{cs2}	control station 2nd reading in gravity units
r_{cs1}	control station 1st reading in gravity units
t_{cs2}	control station 2 time
t_{cs1}	control station 1 time

Observed Gravity: The preceding corrections are applied to the raw gravity reading to calculate the earth's absolute gravitational attraction at each gravity station. The corrections produced Observed Gravities on the AAGD07 and ISOGAL84 datums.

$$G_o = g_{cs1} + (r_t - r_{cs1}) - (t - t_{cs1}) \cdot ID$$

where,

G_o	Observed Gravity in gravity units (ISOGAL84 or AAGD07)
g_{cs1}	control station 1 known Observed Gravity in gravity units
r_t	tide corrected reading in gravity units
r_{cs1}	control station 1 reading in gravity units
t	reading time
t_{cs1}	control station 1 time
ID	instrument drift in gravity units/hour

Theoretical Gravity 1980: The theoretical (or normal) gravity value at each gravity station is calculated based on the assumption that the Earth is a homogeneous ellipsoid. The closed form of the 1980 International Gravity Formula is used to approximate the theoretical gravity at each station location and essentially produce a latitude correction. Gravity values vary with latitude as the earth is not a perfect sphere and the polar radius is much smaller than the equatorial radius. The effect of centrifugal acceleration is also different at the poles versus the equator.

$$G_{t80} = 9780326.7715((1 + 0.001931851353(sin^2 l)/(SQRT(1 - 0.0066943800229(sin^2 l)))$$

where,

G_{t80}	Theoretical Gravity 1980 in gravity units
l	GDA94 latitude at the gravity station in decimal degrees

Theoretical Gravity 1967: The theoretical (or normal) gravity value at each gravity station is calculated based on the assumption that the Earth is a homogeneous ellipsoid. The 1967 variant of the International Gravity Formula is used to approximate the theoretical gravity at each station location and essentially produce a latitude correction. Gravity values vary with latitude as the earth is not a perfect sphere and the polar radius is much smaller than the equatorial radius. The effect of centrifugal acceleration is also different at the poles versus the equator.

$$G_{t67} = (9780318.456 \cdot (1 + 0.005278895 \cdot sin^2(l) + 0.000023462 \cdot sin^4(l)))$$

where,

G_{t67} Theoretical Gravity 1967 in gravity units
l GDA94 latitude at the gravity station in decimal degrees

Atmospheric Correction: The gravity effect of the atmosphere above the ellipsoid can be calculated with an atmospheric model and is subtracted from the theoretical gravity.

$$AC = 8.74 - 0.00099 \cdot h + 0.0000000356 \cdot h^2$$

where,

AC Atmospheric Correction in gravity units
h elevation above the GDA94 transformed GRS80 ellipsoid in metres

Ellipsoidal Free Air Correction: Since the gravity field varies inversely with the square of distance, it is necessary to correct for elevation changes from the reference ellipsoid (GDA94 transformed GRS80). Gravitational attraction decreases as the elevation above the reference ellipsoid increases.

$$EFAC = -(3.087691 - 0.004398\, sin^2 l) \cdot h + 7.2125 \cdot 10^{-7} \cdot h^2$$

where,

$EFAC$ Ellipsoidal Free Air Correction in gravity units
l GDA94 latitude at the gravity station in decimal degrees
h elevation above the GDA94 transformed GRS80 ellipsoid in metres

Geoidal Free Air Correction: Since the gravity field varies inversely with the square of distance, it is necessary to correct for elevation changes from the reference geoid (AHD). Gravitational attraction decreases as the elevation above the reference geoid increases.

$$GFAC = (3.08768 - 0.00440 sin^2(l)) \cdot h - 0.000001442 \cdot h^2$$

where,

$GFAC$ Free Air Correction in gravity units
l GDA94 latitude at the gravity station in decimal degrees
h elevation above the reference geoid (AHD) in metres

Spherical Cap Bouguer Correction: If a gravity observation is made above the reference ellipsoid, the effect of rock material between the observation and the ellipsoid must be considered. The mass of rock makes a positive contribution to the gravity value. The correction is calculated using the closed form equation for the gravity effect of a spherical cap of radius 166.7km, based on a spherical Earth with a mean radius of 6,371.0087714km, height relative the ellipsoid and rock densities of 2.67, 2.40 and 2.20 tm^{-3} (gm/cc).

$$SCBC = 2\pi G\rho((1+\mu)\cdot h - \lambda R)$$

where,

$SCBC$	Spherical Cap Bouguer Correction in gravity units
G	gravitational constant = $6.67428{\cdot}10^{-11} m^3 kg^{-1} s^{-2}$
ρ	rock density (2.67, 2.40 and 2.20 tm^{-3})
h	elevation above the GDA94 transformed GRS80 ellipsoid in metres
R	$(R_o + h)$ the radius of the earth at the station
R_o	mean radius of the earth = 6,371.0087714 km (on the GDA94 transformed GRS80 ellipsoid)
μ & λ	are dimensionless coefficients defined by:

$$\mu = ((1/3)\cdot \eta^2 - \eta)$$

where,

η	h/R

$$\lambda = (1/3)\{(d + f\delta + \delta^2)[(f-\delta)^2 + k]^{\frac{1}{2}} + p + m\cdot ln(n/(f - \delta + [(f-\delta)^2 + k]^{\frac{1}{2}})\}$$

where,

d	$3\cdot cos^2\alpha - 2$
f	$cos\alpha$
k	$sin^2\alpha$
p	$-6\cdot cos^2\alpha\cdot \sin(\alpha/2) + 4\cdot sin^3(\alpha/2)$
δ	(R_o/R)
m	$-3\cdot k\cdot f$
n	$2\cdot[sin\,(\alpha/2) - sin^2(\alpha/2)]$
α	S/R_o with S = Bullard B Surface radius = 166.735 km

Geoidal Bouguer Correction: If a gravity observation is made above the reference geoid, the effect of rock material between the observation and the ellipsoid must be considered. The mass of rock makes a positive contribution to the gravity value. The slab of rock makes a positive contribution to the gravity value. Rock densities of 2.67, 2.40 and 2.20 t/m^{-3} (gm/cc) were used in the correction.

$$GBC = 0.4191\cdot\rho\cdot h$$

where,

GBC	Geoidal Bouguer Correction in gravity units
ρ	rock density (2.67, 2.40 and 2.20 tm^{-3})
h	elevation above the reference geoid (AHD) in m

Ellipsoidal Free Air Anomaly: The Ellipsoidal Free Air Anomaly is the difference between the observed gravity and theoretical gravity that has been computed for latitude and corrected for the elevation of the gravity station above or below the reference ellipsoid.

$$EFAA = G_{oAAGD07} - (G_{t80} - AC) - EFAC$$

where,

$EFAA$ Ellipsoidal Free Air Anomaly in gravity units
G_o Observed Gravity on the AAGD07 datum in gravity units
G_{t80} Theoretical Gravity 1980 in gravity units
AC Atmospheric Correction in gravity units
$EFAC$ Ellipsoidal Free Air Correction in gravity units

Geoidal Free Air Anomaly: The Geoidal Free Air Anomaly is the difference between the observed gravity and theoretical gravity that has been computed for latitude and corrected for the elevation of the gravity station above or below the reference geoid.

$$GFAA = G_{oISOGAL84} - G_{t67} + GFAC$$

where,

$GFAA$ Free Air Anomaly in gravity units
G_o Observed Gravity on the ISOGAL84 datum in gravity units
G_{t67} Theoretical Gravity 1967 in gravity units
$GFAC$ Geoidal Free Air Correction in gravity units

Spherical Cap Bouguer Anomaly: The Spherical Cap Bouguer Anomaly is computed from the Ellipsoidal Free Air Anomaly above by removing the attraction of the spherical cap calculated by the Spherical Cap Bouguer Correction.

$$SCBA = EFAA - SCBC$$

where,

$SCBA$ Spherical Cap Bouguer Anomaly in gravity units
$EFAA$ Ellipsoidal Free Air Anomaly in gravity units
$SCBC$ Bouguer Correction in gravity units

Geoidal Bouguer Anomaly: The Geoidal Bouguer Anomaly is computed from the Geoidal Free Air Anomaly above by removing the attraction of the slab calculated by the Geoidal Bouguer Correction.

$$GBA = GFAA - GBC$$

where,

GBA Geoidal Bouguer Anomaly in gravity units
$GFAA$ Geoidal Free Air Anomaly in gravity units
GBC Geoidal Bouguer Correction in gravity units

7.0 Gravity Results

The gravity survey was completed in **15** days of acquisition. An average acquisition rate of around **88** stations per day of production was achieved for the survey. The survey progressed well with no major delays.

Final data have met and exceeded quoted project specifications. Repeatability of the data was excellent, with the standard deviation of the elevation repeats at **0.025m** and the standard deviation of the gravity repeats at **0.005mGal**. The production report contains summary statistics and histograms for repeatability.

8.0 Data Formats and Deliverables

Final reduced ASCII data for the project have been delivered in ASEG-GDF2 and standard Atlas format. Table 2 overleaf details the format of the final gravity database supplied. All fields are comma delimited.

Appendix B contains a plot of final station locations, images of GNSS Derived Elevation (GDA94 transformed GRS80), Spherical Cap Bouguer Anomaly and first vertical derivative of Spherical Cap Bouguer Anomaly.

All data, both raw and processed, have been supplied with this memorandum using a cloud-based service. Table 1 below summarises the deliverables. Should the reader require further copies of the deliverables, please contact Atlas Perth Operations.

Final Delivered Data	Format	Data
Gravity Database	Comma Space Delimited .csv	•
Gravity Database	Point located data ASEG-GDF2	•
Raw Positional Data	AGRIS format, comma delimited	•
Raw Gravity Data	Scintrex CG-5 format	•
Final Grids	ER Mapper Grids .ers	•
Final Images	GIS compatible Geotiff .tif	•
Acquisition Memo	PDF .pdf	•

Table 1: Final Deliverables

Field Header	Field Description	Format	Units
PROJECT	Atlas Geophysics Project Number	A9	None
STATION	Unique Station ID	I8	None
STATIONCODE	Unique Station Code	A13	None
LINE	Line ID	I8	None
TYPE	Observation Type : Base, Field or Repeat	A8	None
EASTING	Coordinate Easting UTM projection of the Geographic coordinates	F11.3	M
NORTHING	Coordinate Northing UTM projection of the Geographic coordinates	F12.3	M
ZONE	UTM Zone Number	F8.0	NA
LATITUDE	Coordinate Latitude (Refer DATUM column for Geographic Datum)	F15.10	DD
LONGITUDE	Coordinate Longitude (Refer DATUM column for Geographic Datum)	F15.10	DD
ORTHOHTM	Coordinate Elevation Orthometric (Refer GEOID column for Geoid used)	F9.3	M
ELLIPHTM	Coordinate Elevation Ellipsoidal	F9.3	M
N	Geoid Separation (Refer GEOID column for Geoid used)	F8.3	M
DATE	Observation Date	I8	None
TIME	Observation Time	I8	None
DIALMGAL	Gravity Dial Reading	F9.3	mGal
ETCMGAL	Earth Tide Correction (Longman)	F8.3	mGal
SCALE	Scale Factor Applied to Dial Reading	F9.6	None
OBSG84MGAL	Observed Gravity ISOGAL84	F11.3	mGal
OBSG84GU	Observed Gravity ISOGAL84	F11.2	Gu
OBSGAAGD07GU	Observed Gravity AAGD07	F13.2	Gu
OBSGAAGD07MGAL	Observed Gravity AAGD07	F16.3	mGal
DRIFTMGAL	Drift Applied to Dial Readings	F10.3	mGal
TGRAV67GU	Theoretical Gravity 1967	F11.2	Gu
TGRAV67MGAL	Theoretical Gravity 1967	F12.3	mGal
TGRAV80GU	Theoretical Gravity 1980	F11.2	Gu
GFACGU	Geoidal Free Air Correction	F8.2	Gu
GFACMGAL	Geoidal Free Air Correction	F9.3	mGal
GFAAGU	Geoidal Free Air Anomaly	F8.2	Gu
GFAAMGAL	Geoidal Free Air Anomaly	F9.3	mGal
GBC267GU	Geoidal Bouguer Correction 2.67 tm^-3	F9.2	Gu
GBC240GU	Geoidal Bouguer Correction 2.40 tm^-3	F9.2	Gu
GBC220GU	Geoidal Bouguer Correction 2.20 tm^-3	F9.2	Gu
GBC267MGAL	Geoidal Bouguer Correction 2.67 tm^-3	F11.3	mGal
GBC240MGAL	Geoidal Bouguer Correction 2.40 tm^-3	F11.3	mGal
GBC220MGAL	Geoidal Bouguer Correction 2.20 tm^-3	F11.3	mGal
GBA267GU	Geoidal Bouguer Anomaly 2.67 tm^-3	F9.2	gu
GBA240GU	Geoidal Bouguer Anomaly 2.40 tm^-3	F9.2	gu
GBA220GU	Geoidal Bouguer Anomaly 2.20 tm^-3	F9.2	gu
GBA267MGAL	Geoidal Bouguer Anomaly 2.67 tm^-3	F11.3	mGal
GBA240MGAL	Geoidal Bouguer Anomaly 2.40 tm^-3	F11.3	mGal
GBA160MGAL	Geoidal Bouguer Anomaly 1.60 tm^-3	F11.3	mGal
TGRAV80ACGU	Theoretical Gravity 1980 Atmospheric Corrected	F11.2	gu
EFACGU	Ellipsoidal Free Air Correction	F9.2	gu
EFAAGU	Ellipsoidal Free Air Anomaly	F8.2	gu
SCBC267GU	Spherical Cap Bouguer Correction 2.67 tm^-3	F10.2	gu
SCBC240GU	Spherical Cap Bouguer Correction 2.40 tm^-3	F10.2	gu
SCBC220GU	Spherical Cap Bouguer Correction 2.20 tm^-3	F10.2	gu
SCBA267GU	Spherical Cap Bouguer Anomaly 2.67 tm^-3	F10.2	gu
SCBA240GU	Spherical Cap Bouguer Anomaly 2.40 tm^-3	F10.2	gu
SCBA160GU	Spherical Cap Bouguer Anomaly 1.60 tm^-3	F10.2	gu
SCBA267MGAL	Spherical Cap Bouguer Anomaly 2.67 tm^-3	F12.3	mGal
SCBA240MGAL	Spherical Cap Bouguer Anomaly 2.40 tm^-3	F12.3	mGal
SCBA160MGAL	Spherical Cap Bouguer Anomaly 1.60 tm^-3	F12.3	mGal
TCINNERGU	Inner Terrain Correction	F8.2	gu
TCINNERMGAL	Inner Terrain Correction	F8.3	mGal
QFINNER	Quality Factor Inner TC	I2	None
TCOUTERGU	Outer Terrain Correction	F8.2	gu
TCOUTERMGAL	Outer Terrain Correction	F8.3	mGal
QFOUTER	Quality Factor Outer TC	F2	None
TCTOTALGU	Total Terrain Correction	F8.2	gu
TCTOTALMGAL	Total Terrain Correction	F8.3	mGal
CGBA267GU	Complete Geoidal Bouguer Anomaly 2.67 tm^-3	F11.3	gu
CGBA267MGAL	Complete Geoidal Bouguer Anomaly 2.67 tm^-3	F11.3	mGal
CSCBA267GU	Complete Spherical Cap Bouguer Anomaly 2.67 tm^-3	F12.2	gu
CSCBA267MGAL	Complete Spherical Cap Bouguer Anomaly 2.67 tm^-3	F12.2	mGal
DIFFEASTM	Repeat Error for Easting Observation	F8.3	m
DIFFNORTHM	Repeat Error for Northing Observation	F8.3	m
DIFFHTM	Repeat Error for Elevation Observation	F8.3	m
DIFFOBSGMGAL	Repeat Error for Observed Gravity	F8.3	mGal
DIFFOBSGGU	Repeat Error for Observed Gravity	F8.2	gu
METERSN	Serial Number of Gravity Instrument	I8	None
CLOSUREGU	Loop Closure in gu	F8.2	gu
CLOSUREMGAL	Loop Closure in mGal	F8.3	mGal
HDIFF	Horizontal Difference between Acquired and Proposed Station	F7.3	m
GRVBASE	Gravity Base	A11	None
GNSSBASE	GNSS Base	A11	None
DATUM	Geographic Datum	A10	None
GEOID	Geoid Model	A10	None
GRAVDATUM	Gravity Datum	A10	None

Table 2: Final Gravity Database Format

9.0 Project Safety

Prior to survey commencement, a Hazard Identification and Risk Assessment (HIRA) was carried out for all new tasks not covered under Atlas Geophysics Standard Operating Procedures (SOP's) or the company's Health Safety Environment (HSE) field manual.

APPENDIX A
Control Station Descriptions

202113800001 – Dutch Mill Dairy

GEODETIC COORDS GDA94		GRID COORDINATES MGA Z55	
Latitude (DD MM SS)	40° 57' 51.92640"S	***Easting***	339,768.297
Longitude (DD MM SS)	145° 05' 45.08160"E	***Northing***	5,463,446.320
Ellipsoidal Height	N/A	***Orthometric Height (AUSGEOID09)***	N/A

OBSERVED GRAVITY	Established: 01/12/2021
gu AAGD07	9802604.24

Occupation Method/Location Details

The control point is on the corner of a concrete path on the right side of a building at the front of the Dutch Mill Tasmanian Dairy.

Gravity Control was established via two ABA ties to existing Atlas Geophysics control station 201300100001 “Grace's Cottage”. Standard deviation of the gravity ties is 0.001mGal.

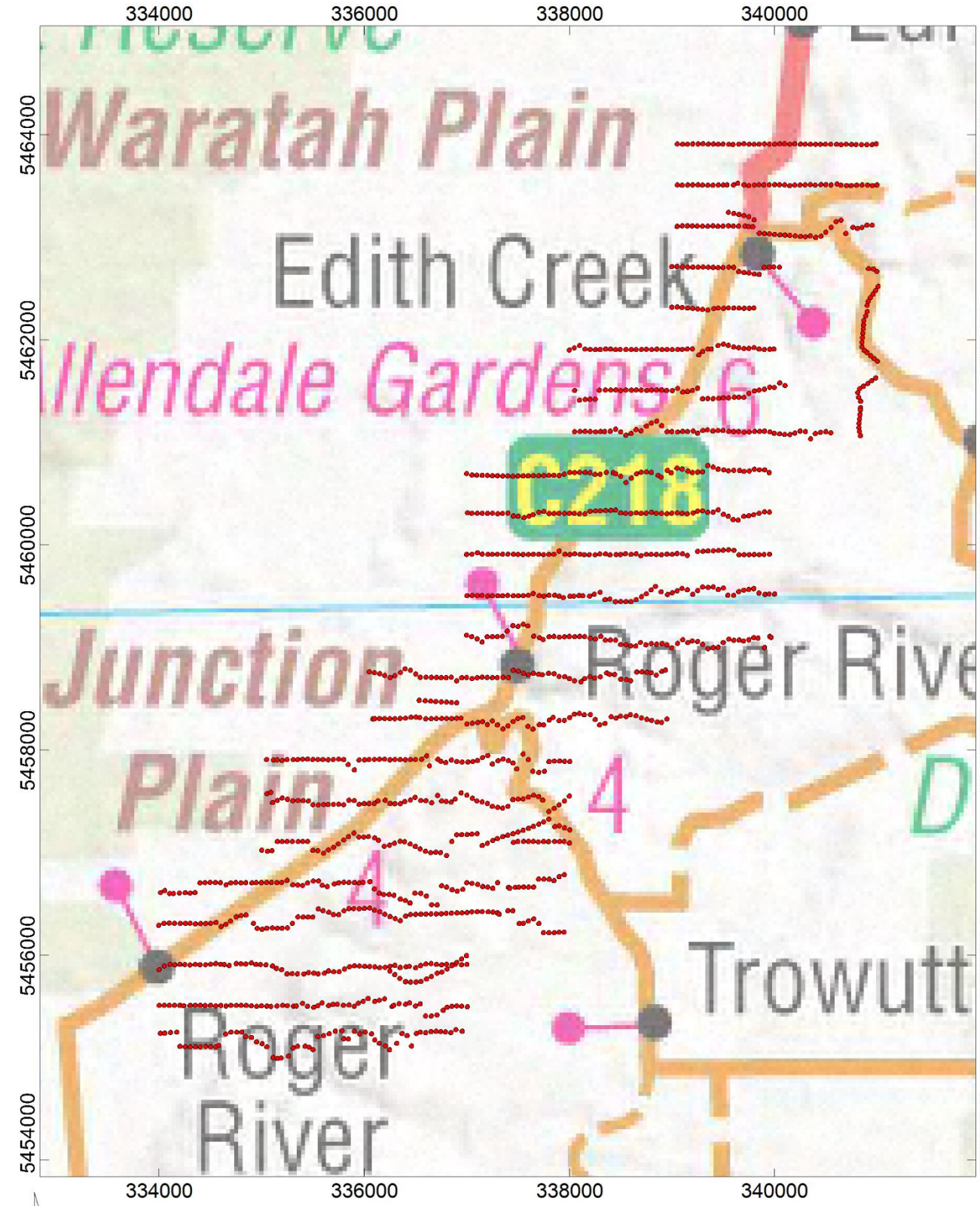
GNSS Control was not established at this location.

This control station is to the right of the building at the front of the Dutch Mill Tasmanian Dairy complex on Trowutta Road, Edith Creek, Tasmania.



Photograph of Control Station 202113800001 and surrounds

APPENDIX B
Plots and Imagery



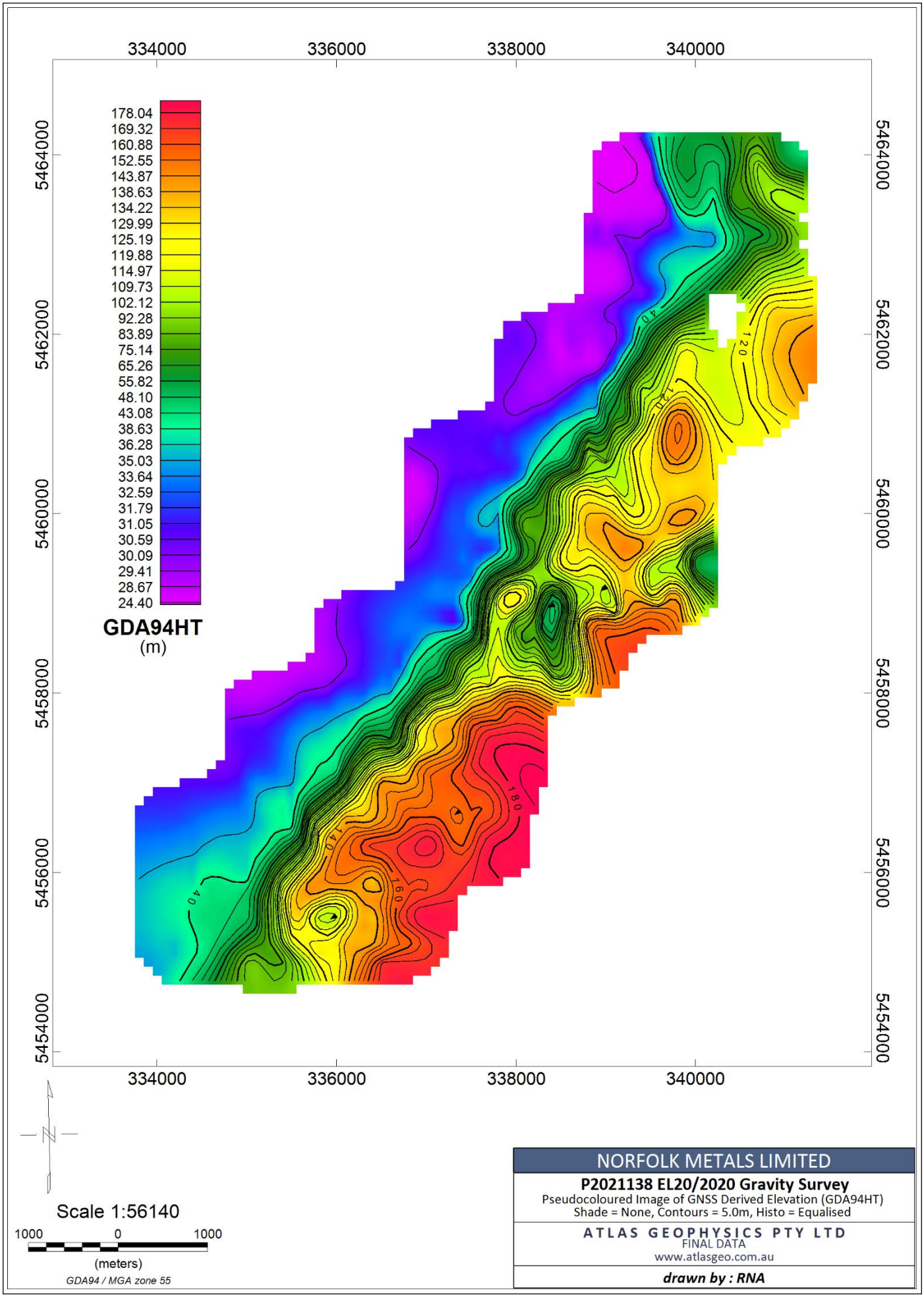
Scale 1:56140

1000 0 1000

(meters)

GDA94 / MGA zone 55

NORFOLK METALS LIMITED
P2021138 EL20/2020 Gravity Survey Plot of Gained Stations 400m x 50m Grid Configuration
ATLAS GEOPHYSICS PTY LTD FINAL DATA www.atlasgeo.com.au
drawn by : RNA



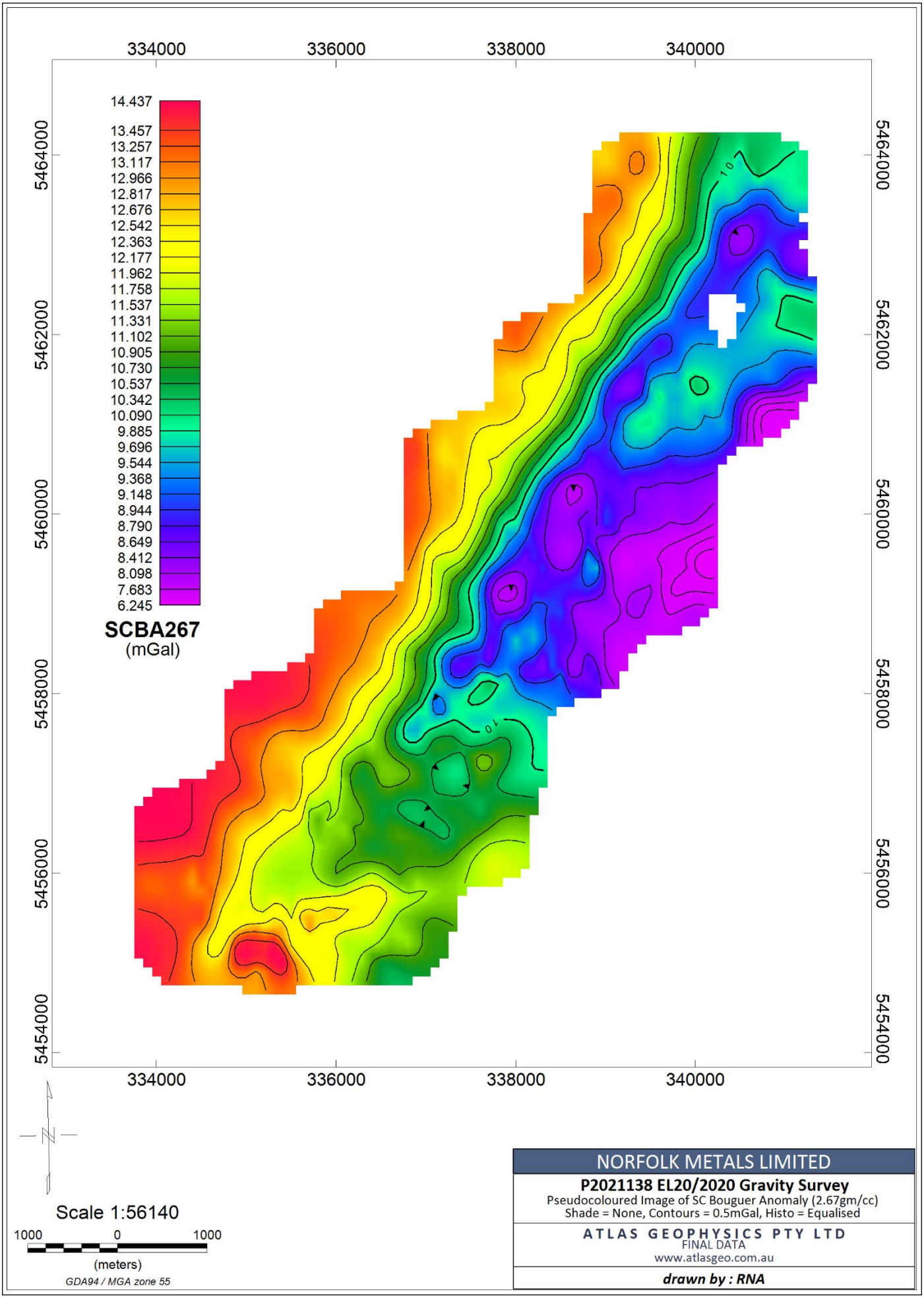
NORFOLK METALS LIMITED

P2021138 EL20/2020 Gravity Survey

Pseudocoloured Image of GNSS Derived Elevation (GDA94HT)
Shade = None, Contours = 5.0m, Histo = Equalised

ATLAS GEOPHYSICS PTY LTD
FINAL DATA
www.atlasgeo.com.au

drawn by : RNA



Scale 1:56140

1000 0 1000

(meters)

GDA94 / MGA zone 55

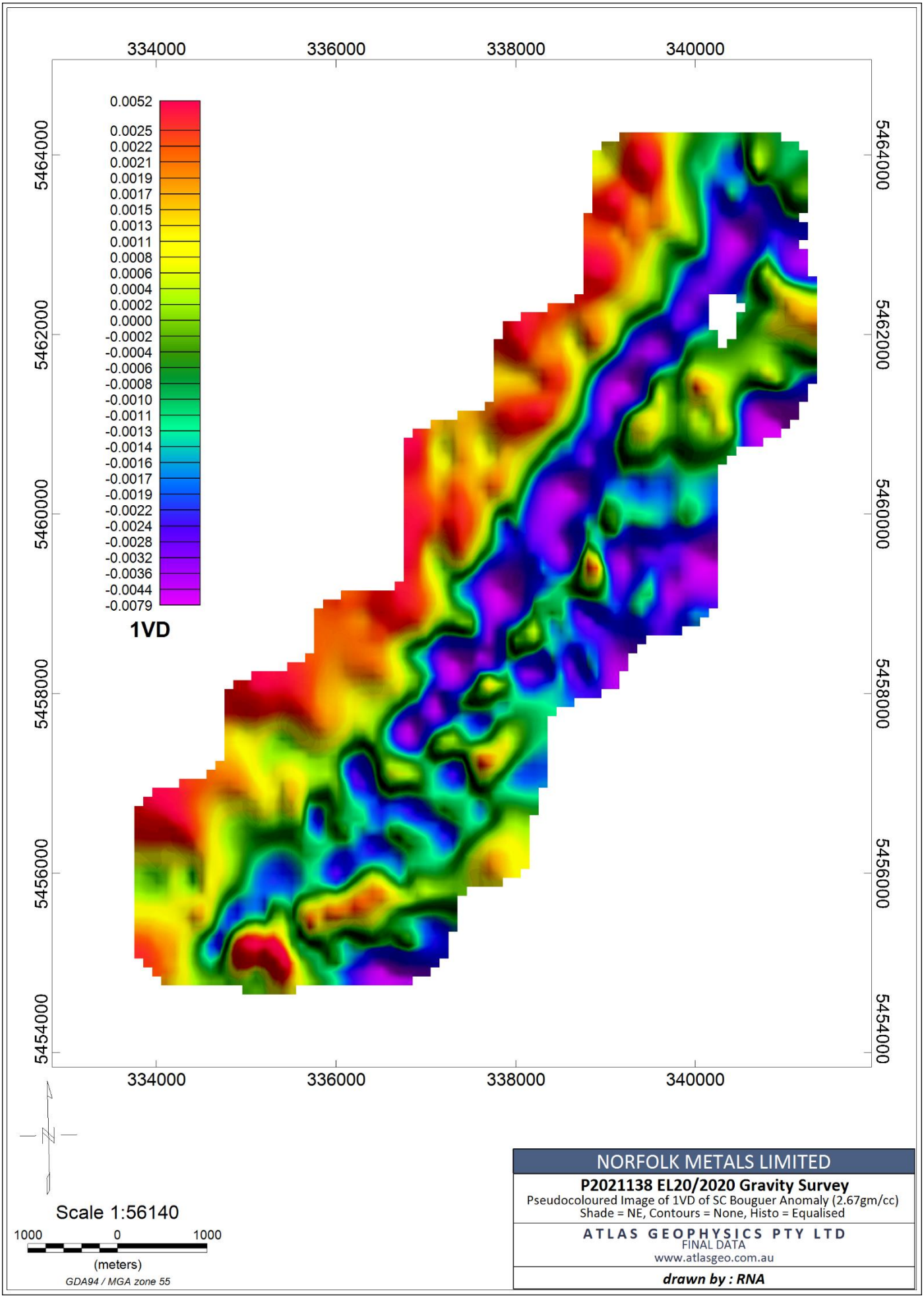
NORFOLK METALS LIMITED

P2021138 EL20/2020 Gravity Survey

Pseudocoloured Image of SC Bouguer Anomaly (2.67gm/cc)
Shade = None, Contours = 0.5mGal, Histo = Equalised

ATLAS GEOPHYSICS PTY LTD
FINAL DATA
www.atlasgeo.com.au

drawn by : RNA



Scale 1:56140

1000 0 1000

(meters)

GDA94 / MGA zone 55

NORFOLK METALS LIMITED
P2021138 EL20/2020 Gravity Survey Pseudocoloured Image of 1VD of SC Bouguer Anomaly (2.67gm/cc) Shade = NE, Contours = None, Histo = Equalised
ATLAS GEOPHYSICS PTY LTD FINAL DATA www.atlasgeo.com.au
drawn by : RNA

APPENDIX C
GNSS Control Information

202113800101 Dutch Mill Dairy GNSS only
0101 -40 57 51.46311 145 05 45.07590 35.143 37.413 GDA94
0101 -40 57 51.46297 145 05 45.07585 35.144 37.414 GDA94
0101 -40 57 51.46321 145 05 45.07572 35.141 37.411 GDA94

GDA94AVE
-40 57 51.46312
145 05 45.07580

-40.96429531
145.09585439

GDA94HT
35.143

AHDHT
37.413

N
-2.270

MGA55
339767.850
5463460.604

AMG55
339654.392
5463277.370

PEGASUS
AIRBORNE SYSTEMS

NORFOLK METALS

EL20-2020 UAV MAGNETICS

17/05/22

PREPARED BY PEGASUS AIRBORNE SYSTEMS

TABLE OF CONTENTS

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SURVEY INFORMATION & SPECIFICATIONS

In May 2022 Pegasus Airborne Systems conducted a low-level UAV magnetic survey of the EL20-2020 project for Norfolk Metals. The area surveyed was adjacent to the villages of Nabageena and Trowutta in North West Tasmania[Figure 1].

The survey was flown using the WGS84 UTM coordinate system (a Universal Transverse Mercator projection derived from the World Geodetic System of 1984) and was contained within zone 55 with a central meridian of 147 degrees. Details of the datum and projection system are provided in Appendix B of this report. Survey boundary coordinates are listed in Appendix C.

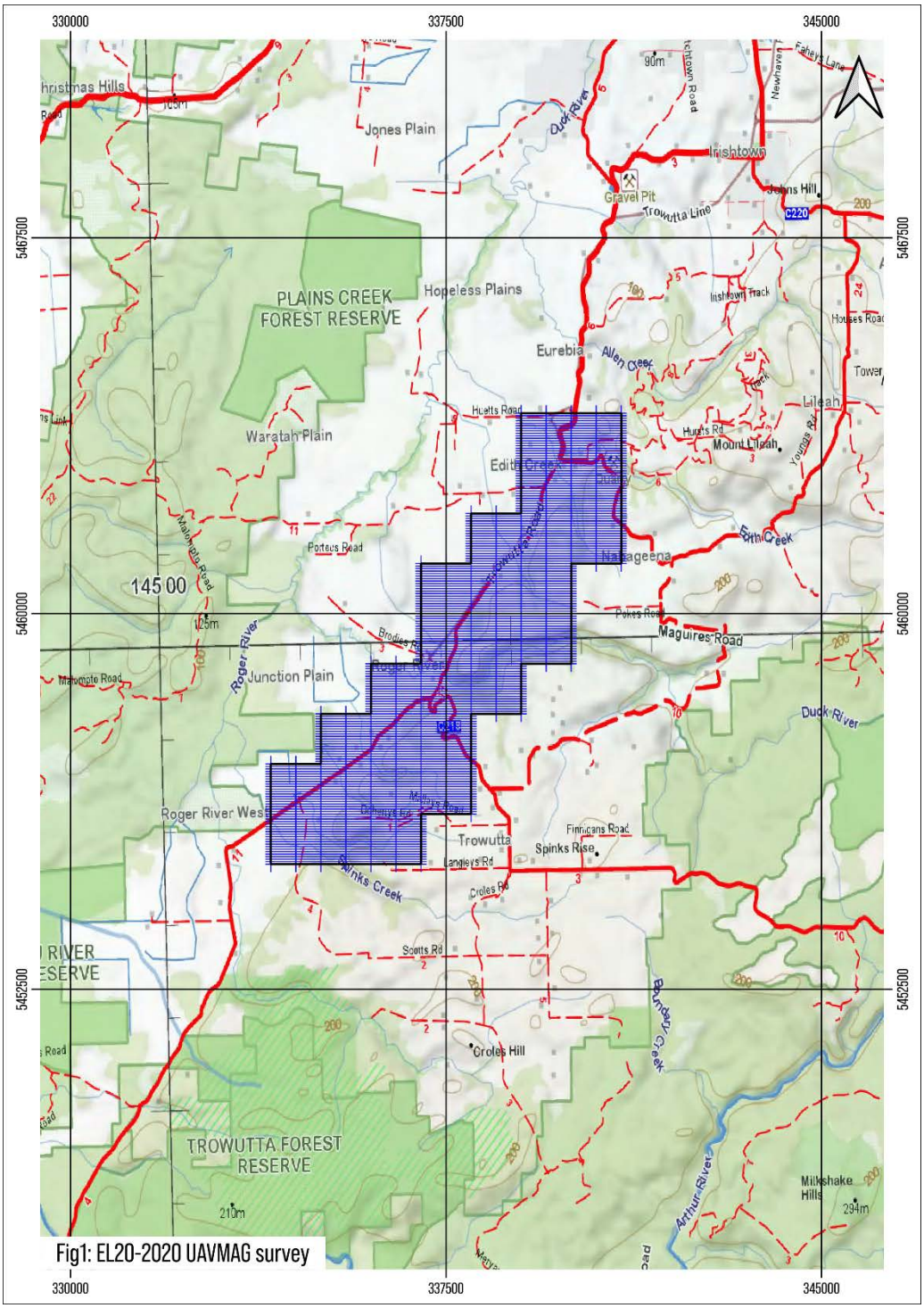
Table 1 contains acquisition specifications for each survey area. Sensor height may be varied where topographic relief or laws pertaining to built up areas do not allow this altitude to be maintained, or where the safety of the aircraft and equipment is endangered.

Grid Name	Line Spacing	Line Direction	Tie-Line Spacing	Tie-Line Direction	Sensor Height	Total Line km
EL20-2020	50	090-270	500	000-180	75m	595

Table 1

Data acquisition commenced on the 9th of May 2022 and was completed on the 12th of May with the final data delivered promptly after.

FIGURE 1 – EL20-2020 PROJECT



AIRCRAFT AND SURVEY EQUIPMENT

A specialised unmanned rotary wing geophysical survey aircraft was equipped with a Pegasus autonomous flight control and terrain following system. This aircraft was used to tow a Pegasus designed and built magnetometer bird which housed the geophysical sensors and Pegasus data acquisition system.

The list of geophysical and navigation equipment used for the survey is as follows:

Survey Aircraft

The PAS-H100 was selected for deployment to this project due to its portability, agility, and responsive handling. Due to its excellent power to weight ratio, the helicopter has exceptional climb rates making it ideal for low level geophysical surveys. Under survey, the relatively slow acquisition speed and tuning of the autopilot to make smooth transitions between climb/descent make for an extremely stable platform for the sensor payload, resulting in optimal signal to noise over the survey area.

HELICOPTER	PAS H100 Rotary Wing
ENGINE	Brushless Electric Motor
AUTOPILOT	Pegasus FC-100
FUEL TYPE	LiPo Battery
ENDURANCE	1 hours with reserve
SURVEY SPEED	15m/s
MAX LATERAL DEVIATION	5m
MAX VERTICAL DEVIATION	5m
SURVEY HEIGHT AIRCRAFT	95m AGL (Terrain drape enabled)
SURVEY HEIGHT SENSOR	75m AGL (Terrain drape enabled)

Towed Bird Assembly

- Designed by Pegasus Airborne Systems using CAD with lightweight and strong composite Kevlar construction
- 3.9kg assembled weight with battery
- Aerodynamic design with stable characteristics in cross wind
- Magnetic sensor located at distance from the electronics and GNSS receiver
- Low power consumption at < 18W
- Towed 20m below survey aircraft

Magnetic Sensor

- Scintrex CS-VL Cesium vapour magnetometer
- Sensitivity 0.0006nT sq rt RMS
- Noise envelope 0.002nT peak to peak
- Heading error ± 0.25nT
- https://scintrexltd.com/wp-content/uploads/2017/03/CS-VL-Brochure.pdf

Data Acquisition System

- Designed by Pegasus Airborne Systems to be extremely lightweight with small form factor
- Dedicated O/S for real time acquisition
- GNSS PPS time synchronised
- IEEE 802-11 Wifi module for monitoring

Magnetometer Counter

- Designed by Pegasus Airborne Systems to interface with Scintrex CS-VL square wave output
- Sample frequency 260Mhz
- Counter resolution 0.1pT

GNSS Receiver

- uBlox GNSS receiver with multi constellation tracking
- 10Hz output (20Hz capable)
- Operating in autonomous mode
- Sub metre accuracy

Laser Altimeter

- Lightweight, small form factor laser with fast, accurate measurements.
- 20g weight
- 100m range
- 1cm resolution
- 10cm accuracy
- Update rate maximum 360 readings per second
- Class 1M or class 1, eye safe.

Other Sensors

- Inertial measurement unit (IMU)
- Pitch, roll, yaw error of < 0.1 degrees

Autopilot and Ground Control Station

- Industry leading autopilot with custom Pegasus firmware for terrain draping
- Dual GNSS receivers, IMU, barometric altimeter and laser rangefinder
- Fuel consumption and level monitoring, battery monitoring, altitude, main rotor and engine RPM
- Automated alarms and fail safes
- 400Mhz radio link with Iridium satellite backup
- Display of flight path over satellite imagery or client maps
- Return to home using terrain follow mode.

Diurnal Magnetometer

- GEM Systems GSM19-F Overhauser Magnetometer
- GNSS time stamped data
- 0.01nT resolution
- 0.1nT accuracy
- 1Hz sample rate

http://www.gemsys.ca/rugged-overhauser-magnetometer/

PROJECT MANAGEMENT

Norfolk Metals	Leo Pilapil
Pegasus/PEGAIR Perth Office	Leon Mathews
Geophysicist/Data Processor	Adam Schubert
Chief UAV Pilot	Andre Lua
UAV Pilot	Reilly Williamson
UAV Pilot	Garth Thompson

DATA PROCESSING

Data Quality Control and Pre-Processing

At the end of each flight the raw data was downloaded from the acquisition system and delivered to the data processor.

Initial data quality control procedures were then implemented which included checking to ensure line navigation specifications had been met, the data was trimmed to the correct survey boundary extents, and further data quality control measures were performed, these included visual inspection of magnetic and ancillary data channel profiles and preliminary grids, measurement and analysis of magnetic noise levels, and closer inspection of various horizonal and vertical navigation parameters.

The diurnal base station data was checked to ensure survey flight coverage and for magnetic storm activity and cultural noise.

Any out of specification sections of data were flagged and marked for re-flight.

The trimmed and checked survey and diurnal data was then exported to a cumulative master processing database for further processing.

Magnetic data processing

No editing or filtering of the recorded raw TMI data is carried out. This is because the data are inherently clean due to the large separation between the bird and aircraft.

The base station diurnal data were suitably filtered to remove any high frequency content and then subtracted from the survey data using the common GNSS derived UTC time. A base datum value was applied during this process.

After diurnal subtraction, the regional magnetic gradient was removed using the IGRF for a given date and interpolated position and time. Tie line levelling was carried out using the intersection points between tie and survey lines. Where required, the tie line levelled data was selectively microlevelled to remove any residual acquisition artefacts.

Digital Terrain Model (DTM) Data Processing

A Digital Terrain Model (DTM) was calculated by subtracting the laser altimeter height from the GNSS recorded height. It should be noted that the accuracy of the DTM is governed by the accuracy of the GNSS altitude and may also be inaccurate where laser returns are recorded from dense tree canopy. The DTM should only be used as an approximation of the terrain height.

APPENDIX A – DATA FORMATS

Final located magnetic data was supplied in Geosoft .gdb and ASEG-GDF2 format, with grids of the following products in ERMapper format.

ER Mapper Grids

- TMI
- TMI 1VD 2VD
- TMI Reduced to Pole
- TMI Reduced to Pole 1VD 2VD
- TMI Reduced to Pole Tilt Derivative
- Digital Terrain Model

Located Magnetic Data Format

	FIELD FORMAT	DESCRIPTION	UNITS
1	F10.1	LINE NUMBER	
2	F7.0	FID	
3	F9.1	TIME	hhmmss.s
4	F12.3	EASTING (WGS84)	metres east
5	F13.3	NORTHING (WGS84)	metres north
6	F13.8	LATITUDE (WGS84)	degrees south
7	F13.8	LONGITUDE (WGS84)	degrees east
8	F8.1	GPS ALTITUDE	metres ASL
9	F8.2	LASER HEIGHT	metres AGL
10	F12.4	DIURNAL	nT
11	F12.4	IGRF	nT
12	F12.4	MAG RAW	nT
13	F11.4	MAG DIURNALLY CORRECTED	nT
14	F11.4	MAG DIURNALLY AND IGRF CORRECTED	nT
15	F11.4	MAG TIE LINE LEVELLED	nT
16	F11.4	MAG FINAL	nT
17	F8.2	DIGITAL TERRAIN MODEL	metres ASL

APPENDIX B – COORDINATE SYSTEMS

Locations for the survey data are provided in both geographical latitude and longitude and Universal Transverse Mercator metric projection coordinate systems.

WGS84	World Geodetic System 1994
Coordinate Type	Geographical
Semi Major Axis	6378137m
Flattening	1/298.257223563

APPENDIX C – SURVEY BOUNDARY DETAILS

SURVEY AREA COORDINATES

Project ID: 2147

Area Name: EL20-2020

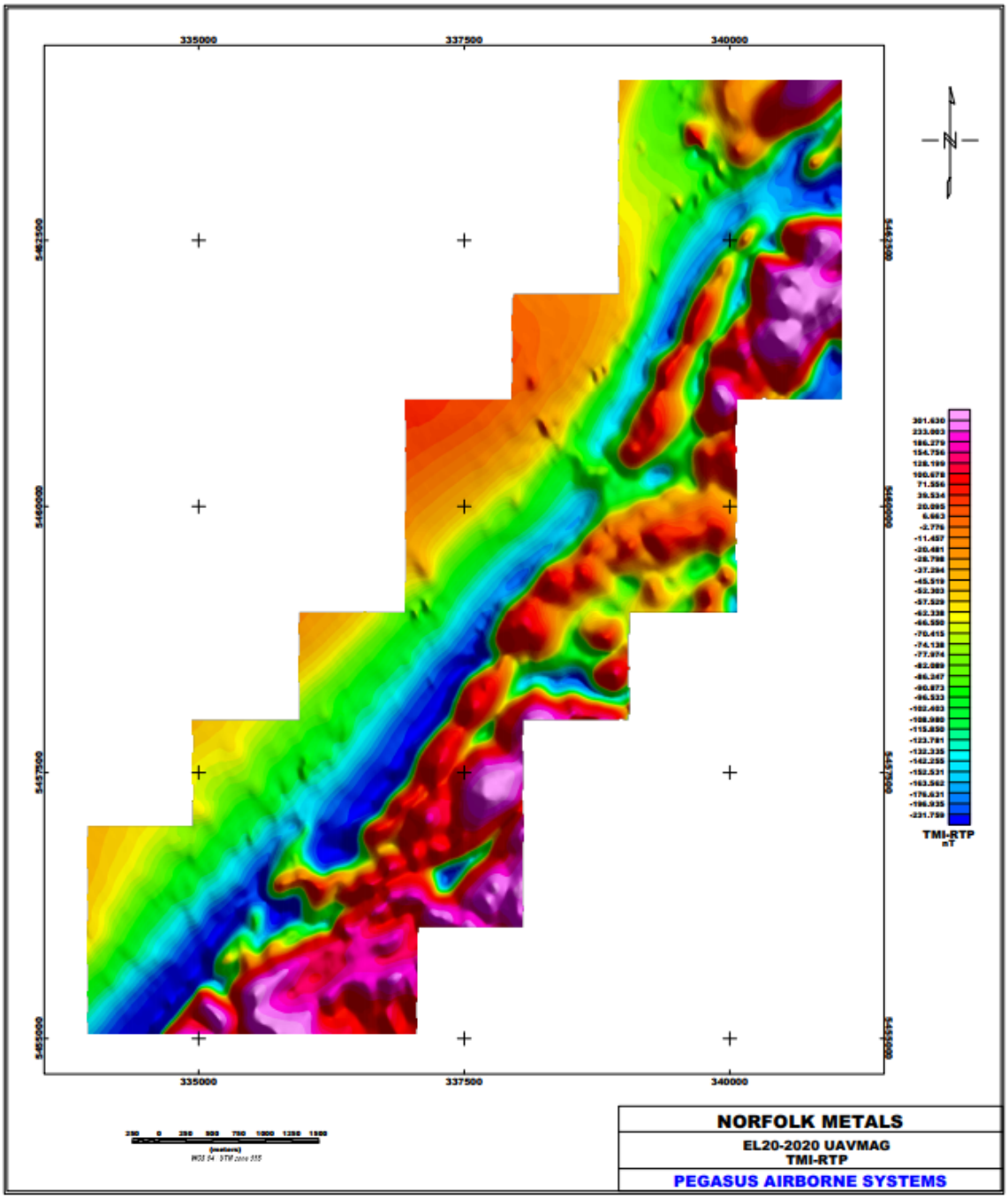
WGS84 UTM Grid Zone 55 south

341000.000	5461000.000
340000.000	5461000.000
340000.000	5459000.000
339000.000	5459000.000
339000.000	5458000.000
338000.000	5458000.000
338000.000	5456000.000
337000.000	5456000.000
337000.000	5455000.000
334000.000	5455000.000
334000.000	5457000.000
335000.000	5457000.000
335000.000	5458000.000
336000.000	5458000.000
336000.000	5459000.000
337000.000	5459000.000
337000.000	5461000.000
338000.000	5461000.000
338000.000	5462000.000
339000.000	5462000.000
339000.000	5464000.000
341000.000	5464000.000
341000.000	5461000.000

APPENDIX D – PROJECT DATA OVERVIEW

Project - EL20-2020

Total Magnetic Intensity Reduced to Pole



APPENDIX E – MAGNETIC PROCESSING PARAMETERS

IGRF Date:	IGRF 2022.335
Average Declination:	13.221 degrees
Average Inclination:	-71.419 degrees
Average IGRF Field:	61477.4503nT
Average diurnal:	61311.3874nT