MT. LINDSAY

GRAVITY SURVEY

Acquisition and Processing Report

For

Venture Minerals Pty Ltd

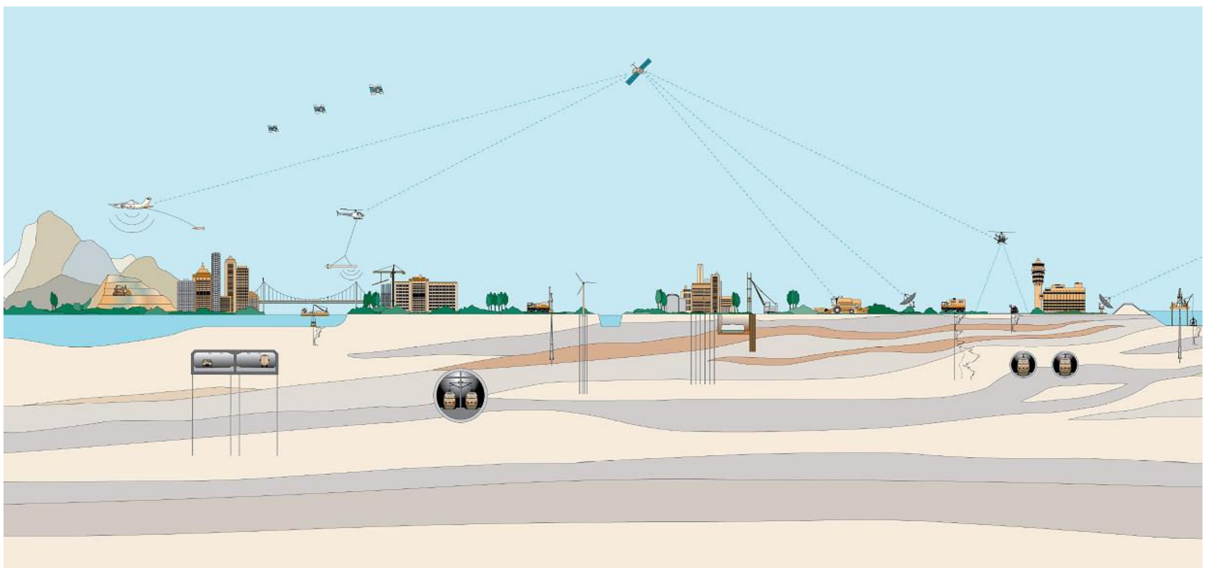
By

Fugro Ground Geophysics Pty Ltd

May 2011

G2548

This report has been authorised for release by Kathlene Oliver, Managing Director, Fugro Ground Geophysics Pty Ltd.



Introduction

This report describes the acquisition and processing of gravity data by Fugro Ground Geophysics Pty Ltd (FGG) for Venture Minerals Pty Ltd during May 2011. The survey was carried out on land at Mt. Lindsay, approximately 25 km west of Rosebery in Western Tasmania. A map of the survey area location is shown in Figure 1-1.

Figure 1-1: Map of Mt. Lindsay survey location (violet outline in NW)

1. GPS / Gravity Survey

1.1 Introduction

The gravity data was acquired from 3rd to 16th May 2011. A total of 319 observations of gravity data, positioned on stations surveyed by an independent topographic surveying company were collected over 35 lines running south-west to north-east on an elongated block running south-east to north-west to the north of Lake Pieman on the north side of Pieman Road. Line spacing was nominally 100m and the gravity station spacing was 40m and 20m on some lines. A map of the gravity survey area location and gravity stations is shown in Figure 1-2.

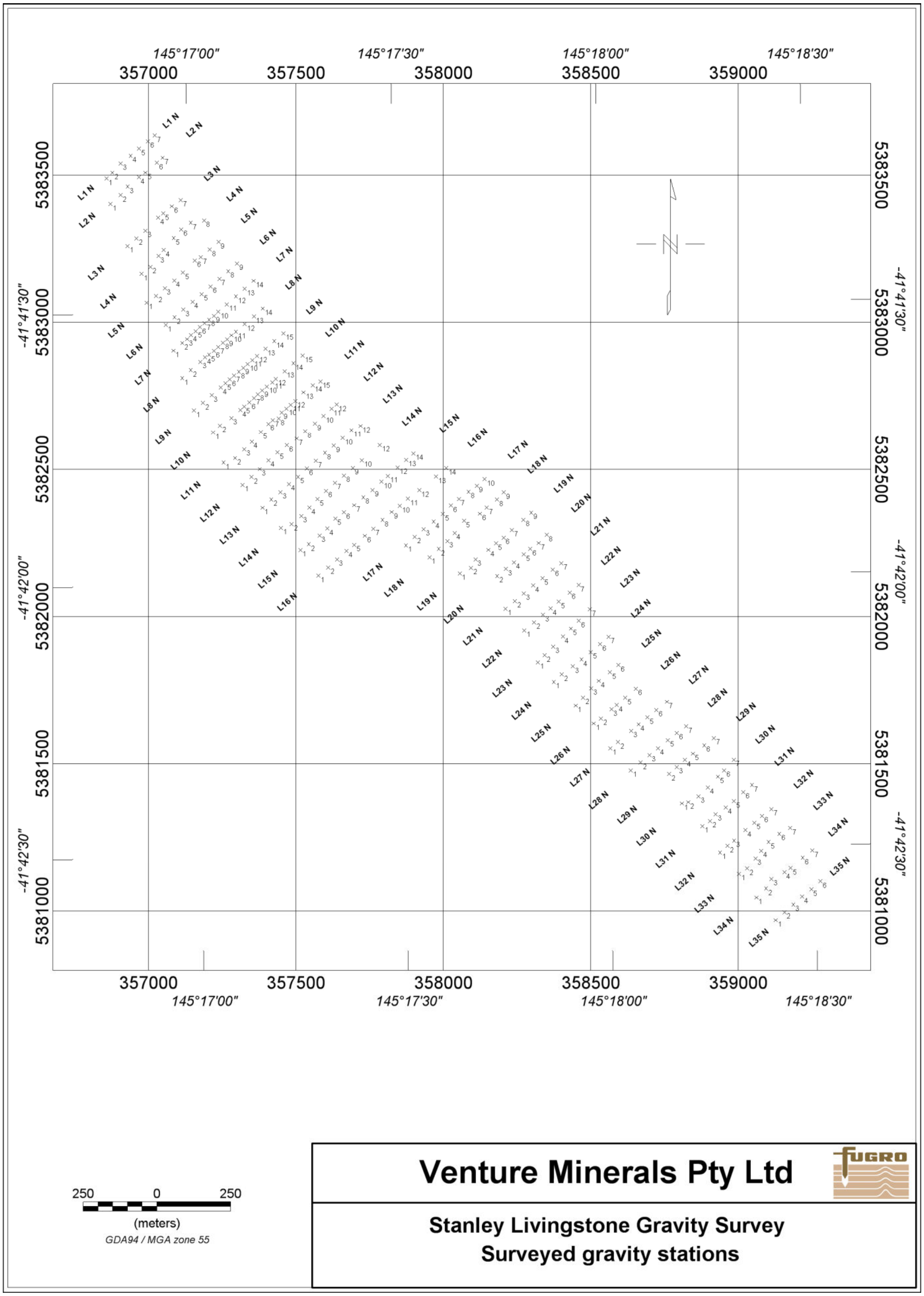


Figure 1-2: Map of all surveyed gravity station locations

1.2. Personnel

A two person crew led by Greg Kunda carried out the survey. Map coordinates and elevations were provided by the client for data processing. Acquisition of gravity readings was carried out by Greg Kunda and Sengay Dorp. Alex Shepherd of FGG was responsible for the supervision of data quality and final processing. Collin Chatley of FGG was responsible for logistical support.

Data was presented to Venture Minerals Pty Ltd representative, Mr Stuart Owen.

1.3. Equipment and Procedures

1.3.1. Equipment

Gravity data was acquired using one Scintrex CG-5 gravity-meter (serial number 060400271). The meter was calibrated at the Perth (Mundaring) gravity-meter calibration range on Geoscience Australia (GA) station numbers 1980.900317 and 1973.910217 prior to the survey.

1.3.2. Data Acquisition

This project consisted of 319 new gravity stations. Six (6) of the proposed stations had to be omitted due to safety and accessibility issues, while a few others had to be considerably offset. Repeat observations were carried out on 85 of these stations throughout the survey for quality control of the data (Table 1-1).

At least two (2) gravity readings were taken at each station, each cycling over a duration of 20 seconds. Additional readings were taken if one reading differed from the previous reading by more than 0.01 milliGal (mGal). All stations were read within independent and closed loops which started and finished on a base station established to the east of the survey area. Details are given in Appendix A.

Acquisition was carried out on foot in the thick vegetation. A 4WD vehicle was also used as a support vehicle for use in carrying out supply runs and commuting to the survey grid taking readings on the survey base on each survey loop en route.

Copies of the final production report are contained on the CD attached at the rear of this report.

1.3.3. Gravity Repeats

An operational procedure that includes regular repeat observations throughout the survey provides both quality control and confirmation of the linearity of the residual drift. All stations were marked by numbered wooden witness posts positioned by the land survey contractor so that they could be easily identified and reoccupied as repeats (Figure 1-3) as designated. A total of 85 (26.6%) stations were repeated with a standard deviation of 0.019 mGal. The error distributions for the repeat readings are shown in Figure 1-4. These error distributions are exactly the same for both the observed gravity and for the Complete Bouguer Anomaly values, as all gravity repeats for each gravity station were processed on the same topographic record for that station on the in-house gravity processing software.

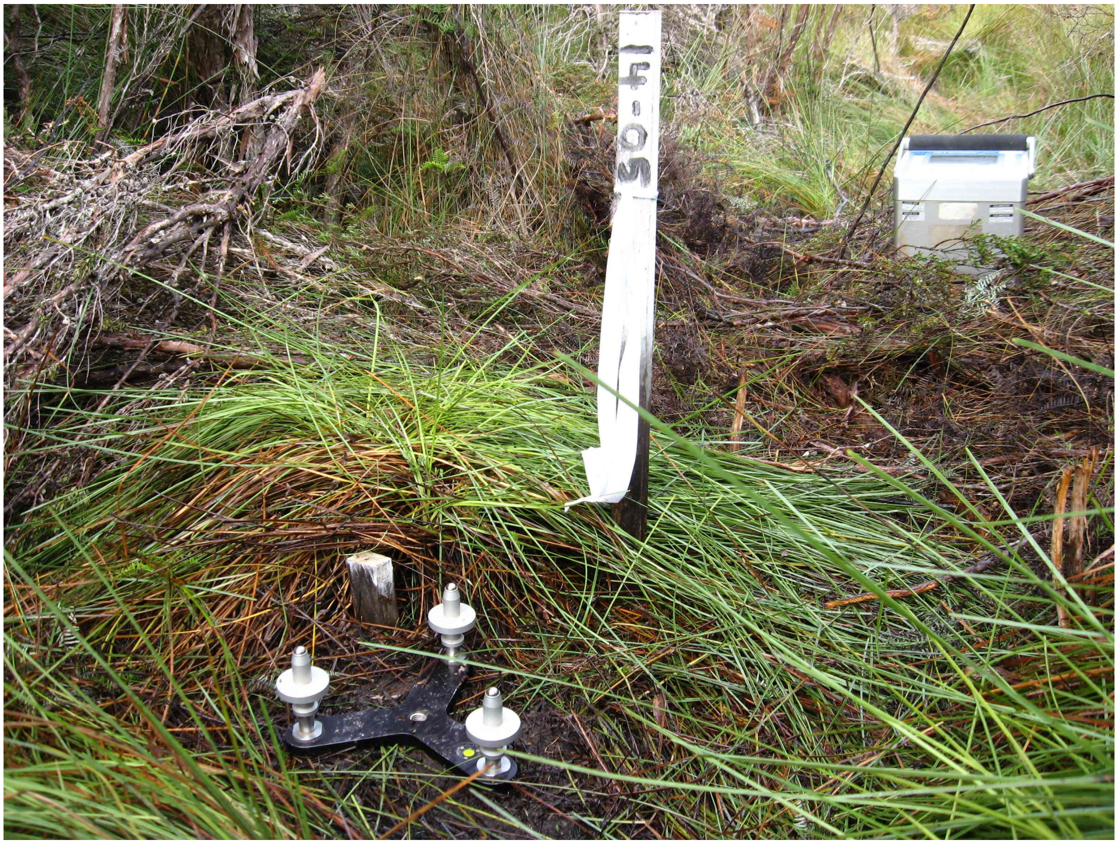


Figure 1-3: Typical gravity station setup at witness post with line and station number and Scintrex CG5 gravimeter in the background

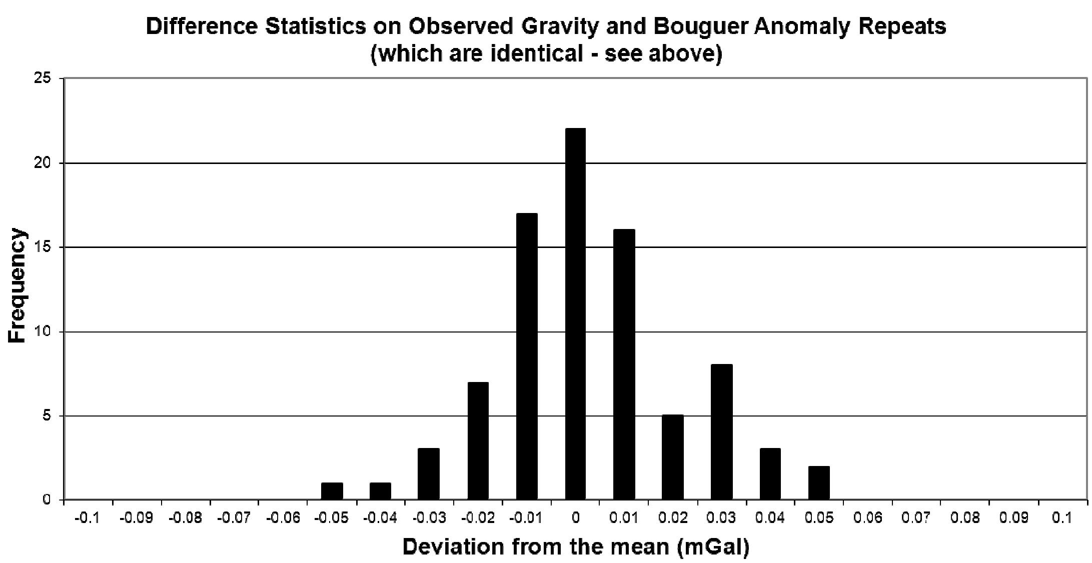


Figure 1-4: Error distribution for the gravity repeats

1.3.4. Repeat Statistics

The numerical statistics for the gravity are presented in Table 1-2. The overall precision for the Observed Gravity data set was better than the one standard deviation of ±0.05 mGal. Loops incorporating stations that, upon re-occupation, show differences in the Observed Gravity that fell outside 2 standard deviations (±0.10 mGal) were routinely re-observed or corrected by FGG.

Gravity Statistics		
Bins (milligals)	Frequency	total
-0.1	0	0
-0.09	0	0
-0.08	0	0
-0.07	0	0
-0.06	0	0
-0.05	2	-0.05
-0.04	1	-0.04
-0.03	10	-0.09
-0.02	9	-0.14
-0.01	19	-0.17
0	23	0
0.01	26	0.16
0.02	14	0.1
0.03	4	0.24
0.04	1	0.12
0.05	0	0.1
0.06	0	0
0.07	0	0
0.08	0	0
0.09	0	0
0.1	0	0
Sum of results	85	0.23
total # stations:	319	
% repeat:	26.6%	
within 1st std (0.05mg):	100%	
Standard deviation:	0.019	milliGals

Table 1-2: Statistics for Gravity and GPS repeats

1.3.5. Gravity Base Station Establishment

The gravity base station used was in within a fenced in enclosure on the roadside near the township of Tullah, where the crew were based at Lakeside Lodge in Farrell Street, about 27 km due east of the survey grid. The meter was placed on the concrete hard standing to take 2 x 120 second readings at the beginning of the commute to the grid and another 2 x 120 second readings on return from the grid. Details of this base are given in Appendix A, located at the rear of this report.

1.4. Data Processing

1.4.1. Gravity Data Processing

The following corrections are applied to the raw gravity data to obtain observed gravity.

- Tidal correction
- Mechanical drift

The following corrections are applied to the observed gravity data to obtain Bouguer gravity. Details of reduction formulae are given in Appendix B, at the rear of this report.

- Latitude Correction
- Free Air Correction
- Bouguer Correction

1.4.2. GPS data Processing

All elevation data was processed on the GDA94 datum and then converted to AHD using the Ausgeoid98 model. This was performed using in-house software. The calculation takes the form:

$$H_{orthometric} = h_{ellipsoidal} - N_{value}$$

Where	$h_{ellipsoidal}$	is the GDA94 ellipsoid elevation
	$H_{orthometric}$	is the AHD geoid elevation
	N_{value}	is the Ausgeoid98 geoid-ellipsoid separation value

1.4.3. Office Reprocessing

The following data integrity checks were made:

- All data entry of raw gravity was checked against field logs
- All gravity data was reprocessed from raw to Bouguer Anomalies
- Any gravity repeat over 0.05mgals (0.5 μms^{-2}) was checked

1.5. Deliverables

Preliminary digital data was sent to Stuart Owen at regular intervals throughout the course of the survey. All raw and final gravity data can be found on the CD attached to the end of this report.
Acquisition and logistics (this) report (MS word and pdf)
Production report (MS Excel)

Verification images can be found in Appendix C, at the rear of this report and as map images on the CD:
Bouguer (2.67gm/cc)
Bouguer with a first order regional trend removed (2.67gm/cc)
First Vertical Derivative (1VD) of the Bouguer (2.67gm/cc)
Elevation on the Australian Height Datum (AHD)

The following geo-referenced Tiff images are included on the CD for loading into mapping software (in all densities; 1.7 2.2, 2.4, 2.67 and 2.9 gm/cc unless stated otherwise):
Bouguer – blue (low), pink (high)
Bouguer with 1 mGal contours
Bouguer with a 1st regional trend removed – violet (low), red (high)
(For 2.2, 2.4 and 2.67 gm/cc only)
Bouguer with a 1st regional trend removed with 1 mGal contours
(For 2.2, 2.4 and 2.67 gm/cc only)
Bouguer 1st Vertical derivative (1VD) – red (low), blue (high)
Bouguer 2nd Vertical derivative (2VD) – red (low), blue (high)

The daily gravity (RAW) files:
1 set at 2.2, 2.4 & 2.67 gm/cc
1 set at 1.7, 2.67 & 2.9 gm/cc

ArcView MXD files covering all of the mapping as aforementioned:
G2548_TAS_MXD.mxd (grids in map surrounds for densities 2.2, 2.4 and 2.67 gm/cc only)
G2548_grids_MXD.mxd (grids only for all densities)

3D PDF file with a 3D movable image of the Bouguer Anomaly gravity grid.

The final data is supplied in Geosoft XYZ format (1967 gravity) in the following file:
G2548_final_17_22_24_267_29.xyz

This file includes an overall header detailing column assignments and information on what these column headers represent in the dataset. All gravity data are in units of milliGals (mGal), where 1mGal = 10 micrometres/sec/sec (μms^{-2}). All coordinate data is in GDA94, MGA Zone 51.

Submitted by:

Alexander M. Shepherd
Processing Geophysicist

for and on behalf of:
Fugro Ground Geophysics Pty Ltd

APPENDIX A

GRAVITY BASE STATION DESCRIPTION

Tullah EDM calibration range	
Latitude of Tullah township	-41.609 (S) decimal degrees (approx.)
Longitude of Tullah township	145.636 (E) decimal degrees (approx.)
Gravity value at survey base	Base station used as below
Gravity Tied to **Tullah EDM calibration range**	198051.9902 ISOGAL65 gravity datum
Observed Gravity	980274.89 mGal
Field Description: concrete hard standing within fenced enclosure near main power pole	

Location where gravity survey loop base readings were taken

APPENDIX B

GRAVITY REDUCTION FORMULAE

1. Gravity Drift Control

Drift has two components, a cyclic component due to the time varying gravitational effects of the sun and moon, and an approximately linear component due to instrumental drift. The tidal effects are removed using Longman's algorithm which calculates the tidal correction to a resolution of 0.01mgals (0.1 μms^{-2}). As the remaining drift is predominantly linear, gravity loop times can be extended to cover the full day.

This offers a number of advantages:

- Most loops are directly tied to primary bases reducing accumulated errors generated from tying secondary bases to other secondary bases.
- Removes the need to set up a series of temporary bases along the survey line.
- Instrument drift rate is often less than reading error, even for long duration loops.

The gravity meter, being a mechanical instrument consisting of beams, weights and springs, suffers from drift due to minute stretching of the spring mechanism. This drift can be removed provided each survey loop starts and ends at the same gravity station or at two different stations each of known value of gravity. Because the long term instrument drift of the Scintrex CG-5 gravity meter is extremely stable and linear, a correction in real time (by the gravity meter software) is made leaving only a small residual which is determined using the daily base in and out readings. Demonstration of the linearity of the drift can be seen by analysing the repeats within each loop.

2. Gravity Formulae

2.1. Observed Gravity

The following corrections are applied to the raw gravity data to obtain **observed gravity (g_o)**:

Instrument correction: Not required for Scintrex CG5 gravimeter as all necessary factors are applied internally.

Tidal correction: To correct for the differential gravitational effects of the Moon and the Sun. Longman's polynomial approximation of tidal effect is applied to the base-out and base-in readings before the loop drift rate is calculated and is also applied to each station within the loop. The Longman's formulae are published in the Journal of Geophysical Research, Vol 64, No 12 (1959).

Mechanical drift: removed with the assumption that the drift between base-out and base-in is linear. This is a valid assumption when the non-linear components (tidal) have been removed before the drift rate is calculated and the meter has not suffered significant tares during the course of the loop.

The following equation summarises these corrections to obtain observed gravity:

where:	g_o	=	observed gravity in milligals (1mg = 10 μms^{-2})
	g_{stn}	=	raw gravity reading at each station
	C_{tide}	=	tidal effect (in milligals or μms^{-2})
	$g_{0(base)}$		absolute value of gravity at the base
	C_{drift}	=	$(g_{base-out} - g_{base-in}) / (t_{base-out} - t_{base-in}) \times t_{stn}$
	$g_{base-out}$, $g_{base-in}$		are base readings at start and end of loops
	$t_{base-out}$, $t_{base-in}$		are base times at start and end of loops

2.2. Bouguer Gravity

The following corrections are applied to the observed gravity (AAGD07 gravity datum) to obtain **Bouguer gravity (G_b)**:

$$G_b = G_o - G_t + C_{fa} - C_b + C_t$$

where:	G_o	=	observed gravity described above
	G_t	=	theoretical gravity calculated from the station's latitude.
	C_{fa}	=	free air correction
	$C_b = 2\pi G\rho h$		Bouguer correction, G = universal gravity constant, ρ = density, h = elevation
	C_t	=	terrain correction

Latitude Correction - To correct observed gravity for the effects of the differential centrifugal acceleration due to the reduction in angular velocity at the surface of the earth with latitude (this acceleration is at its maximum at the equator where the observed gravity will be at its minimum). This correction is solely a function of latitude (φ) obtained from survey co-ordinates. For this survey the 1967 gravity formula is used to calculate the theoretical gravity g_t.

$$g_t = 978031.80 \times (1 + 0.0053024 \times \sin^2(\varphi) - 0.0000059 \times \sin^2(2\varphi))$$

Free Air Correction - To correct for the fact that gravity decreases (as the square of the distance) from the elevation datum. This correction is a function of station elevation above the datum and is, approximately, 0.3087 mgals / metre.

Bouguer Correction - Corrects for the gravitational attraction of the rock between the station and elevation datum. This correction is dependent on elevation and the rock density and is approximately $2\pi G\rho h = 0.04191\rho h$ mgals/meter. For this survey, densities of 1.7, 2.2, 2.4, 2.67 and 2.9 gm/cc were used for the Bouguer corrections.

Terrain Correction – To correct for the effects of surrounding topographic features which deviate from the infinite slab or spherical cap that is implicit in the Bouguer correction. Quite small hills close to the reading site can have significant effects on gravity. Major features further from the reading site can also have effects. For this survey, the terrain corrections were applied using SRTM elevation data, which was re-levelled to the datum for this survey. The SRTM data was re-gridded to a cell size of 50m and the corrections were applied within a radius range of 100m to 10,000m of each individual gravity station.

3. Error Analysis

The total probable error in the final Bouguer Gravity data, e_{bg}, is calculated using:

$$e_{bg}^2 = e_g^2 + e_{gt}^2 + (c \times e_h)^2$$

where: e_g is the error in the observed gravity
e_{gt} is the error in the theoretical gravity value used
e_h is the error in the elevation value

$$c = (0.3087 - 2\pi\rho G)$$

where: $G = 6.67 \times 10^{-8}$ (dyne cm^2) / g Universal Gravity Constant
$\rho = 2.67$ g / cc

$$c = 0.1967 \text{ mgals / metre (or } 1.967\ \mu ms^{-2})$$

4. Statistical Analysis and Error Calculation

Assuming all of the factors contributing to the final Bouguer gravity are mutually independent, then the expected error in the final Bouguer gravity is the square root of the sum of the squares of the error in each factor, ie

$$e_{bg}^2 = e_g^2 + e_{gt}^2 + (c \times e_h)^2$$

This assumption is not absolutely valid, since a small amount of cross-correlation does exist (for instance, an error in the vertical will affect the terrain correction if measured elevations rather than grid elevations are used to calculate the terrain correction). These cross-correlations will, however, be generally small, so the above error calculation will yield results that are very close to the true values.

In order to quantitatively measure the so-called expected error, it is necessary to define the confidence limit. This gives some meaning to the term expected error (or, put more positively, expected accuracy) by making the following statement possible:

X percent of the measured values will be accurate to within ±Y

For our purposes, we have defined the confidence limit to be 1 sigma, or roughly 67%, hence, we are after the error range (i.e., ±0.3 mgals or ±3.0 μms^{-2}) that will allow us to confidently state that 67% of the data satisfies this criterion. We could have chosen a 2 sigma limit, in which our expected error would have been larger, since our confidence limit would be about 95%. Similarly, we could have gone for a 50% confidence limit, which would have resulted in a smaller expected error. By choosing the 1 sigma limit, we are conforming to a fairly widely accepted industry standard.

The solution of the error equation for the final Bouguer gravity reduces to collecting enough data to determine the 1 sigma confidence limit of each of the factors in the equation. This is done by repeating enough samples to derive a statistically significant error limit. For simplicity, we will look at the probable error in observed gravity. The calculation of the probable errors in the other factors is analogous.

To derive the probable error in the observed gravity, stations are revisited and the gravity reading is taken again. Each reading at a station is compared with the mean of all readings taken at that station. For example, a station with three readings would yield three deviations from the mean value. It is believed that this method yields a much better statistical analysis of the data. Once all the deviations for a survey have been calculated, they are plotted on a histogram. The repeat differences will fit a normal distribution curve with a mean (zero in theory, very close to zero in practice) and a standard deviation (sigma). Statistically, 67% of the repeat differences will fall within ±1 sigma of the mean.

According to our definition:

$$E_{RPT\ DIFF} = \pm \text{ sigma}$$

In other words, the expected repeatability of an observed gravity reading is ± sigma.

It is very important to realise that expected repeatability is not the expected accuracy of an individual reading. The expected repeatability and expected accuracy of the individual reading are only the same if the repeat reading has an expected error of zero. This follows logically from our definition of expected error, as the square root of the sum of the squares of the expected error of each independent factor (see the formula for expected error of final Bouguer gravity). There may be other small cross-correlations (ie the observer may look up the previous reading to speed up the repeat reading), but, for our purposes, we assume they are totally independent.

Thus

$$E_{RPT.DIFF}^2 = E_{RPT\ RDG}^2 + E_{FIRST\ RDG}^2$$

But we assume:

$$E_{RPT\ RDG} = E_{FIRST\ RDG}$$

(This assumption is a good one as you expect to be able to read a gravimeter on the same spot with the same precision at different times).

Therefore:

$$E_{RPT\ RDG}^2 = 2 \text{ x } E_{FIRST\ RDG}^2$$

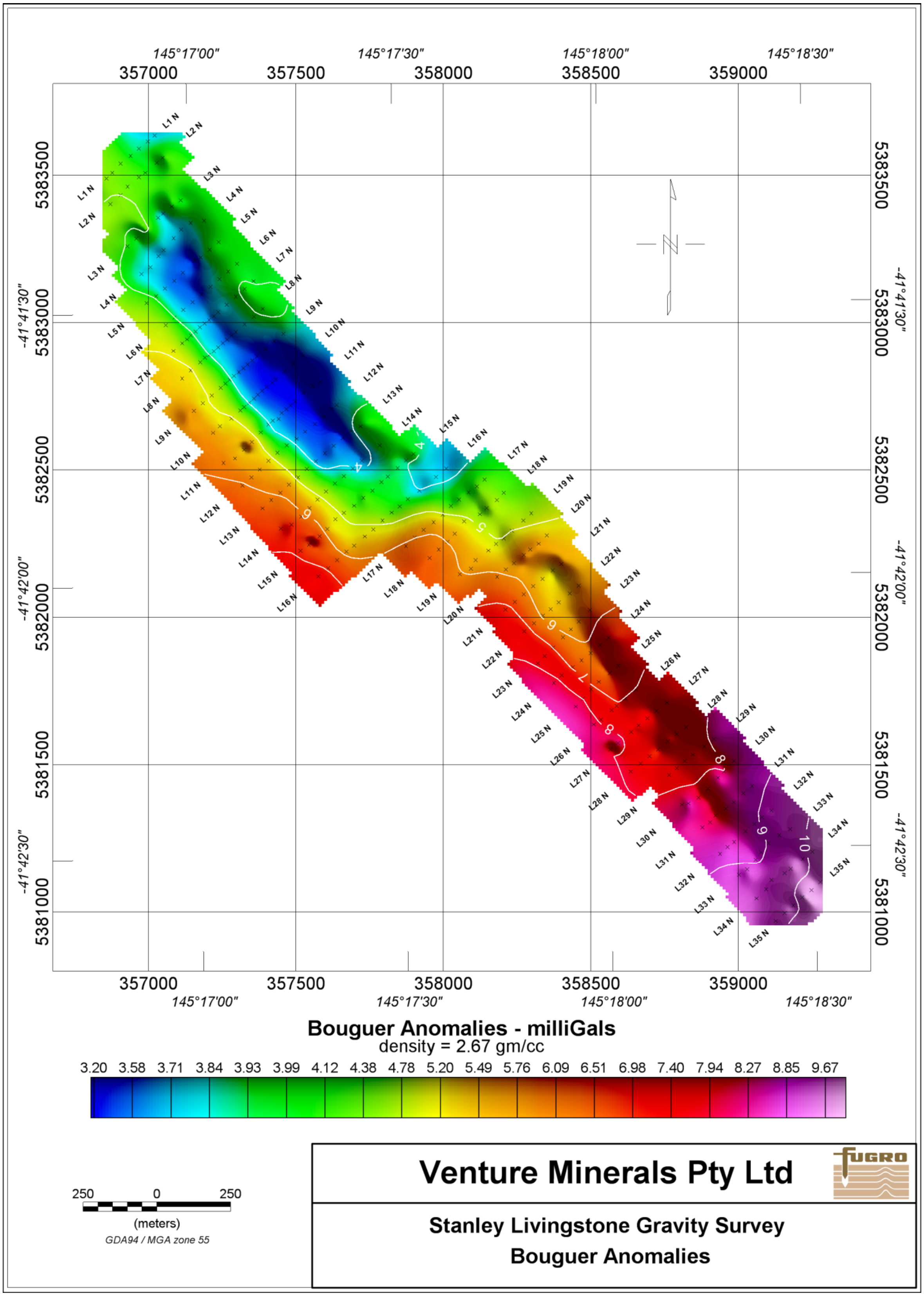
or

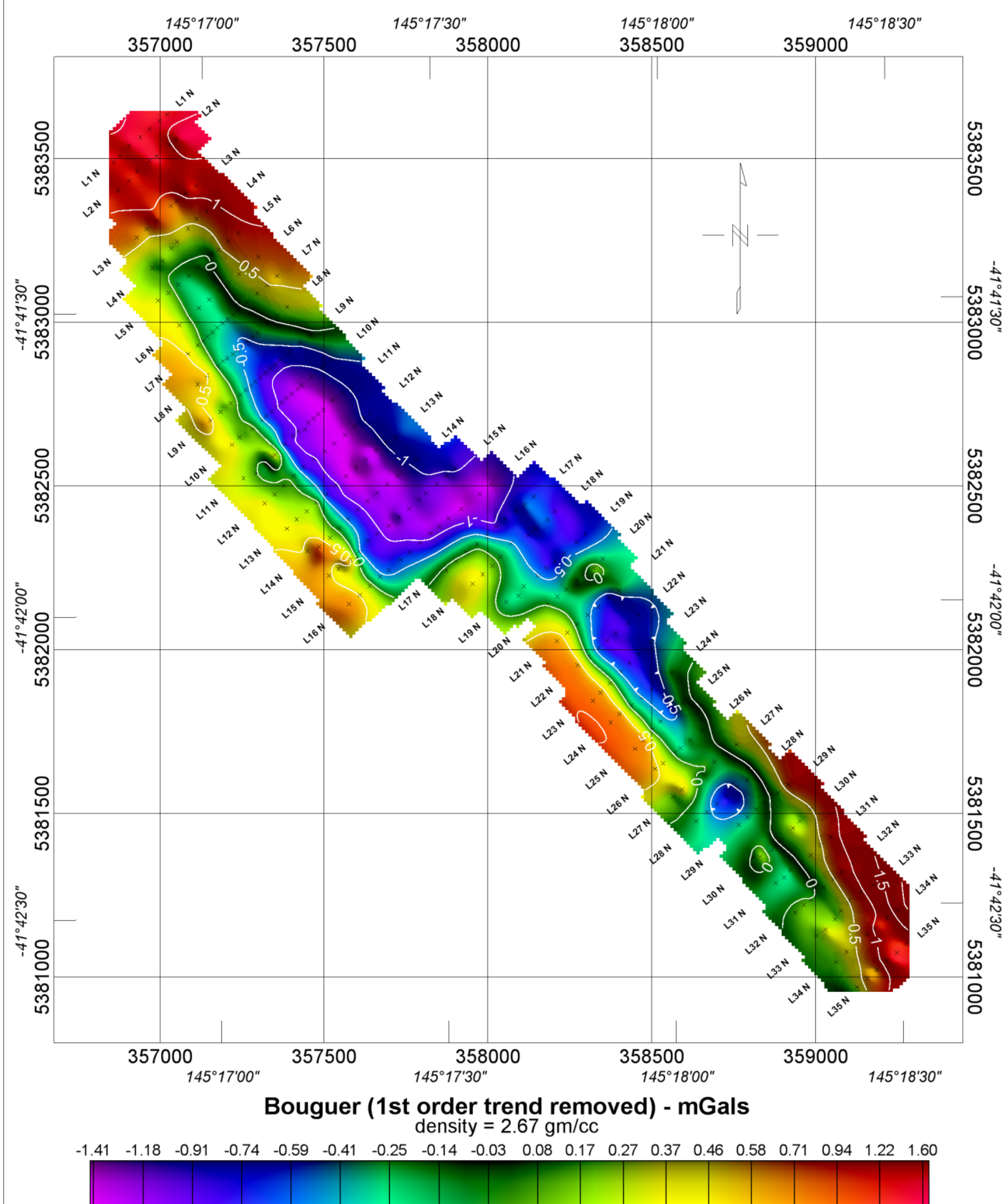
$$E_{FIRST\ RDG} = 0.707 \text{ x Sigma}$$

The expected error of an individual observed gravity value is equal to 0.707 times the expected repeatability. The above calculation for observed gravity is carried through for each factor in the final Bouguer value and the end result is a 67% confidence limit of final Bouguer gravity, which we have defined as expected accuracy.

APPENDIX C

VERIFICATION IMAGES


145°17'00"
145°17'30"
145°18'00"
145°18'30"
357000
357500
358000
358500
359000
5383500
5383000
5382500
5382000
5381500
5381000
-41°41'30"
-41°42'00"
-41°42'30"
Bouguer Anomalies - milliGals
density = 2.67 gm/cc
3.20 3.58 3.71 3.84 3.93 3.99 4.12 4.38 4.78 5.20 5.49 5.76 6.09 6.51 6.98 7.40 7.94 8.27 8.85 9.67
250 0 250
(meters)
GDA94 / MGA zone 55
Venture Minerals Pty Ltd
Stanley Livingstone Gravity Survey
Bouguer Anomalies



250 0 250

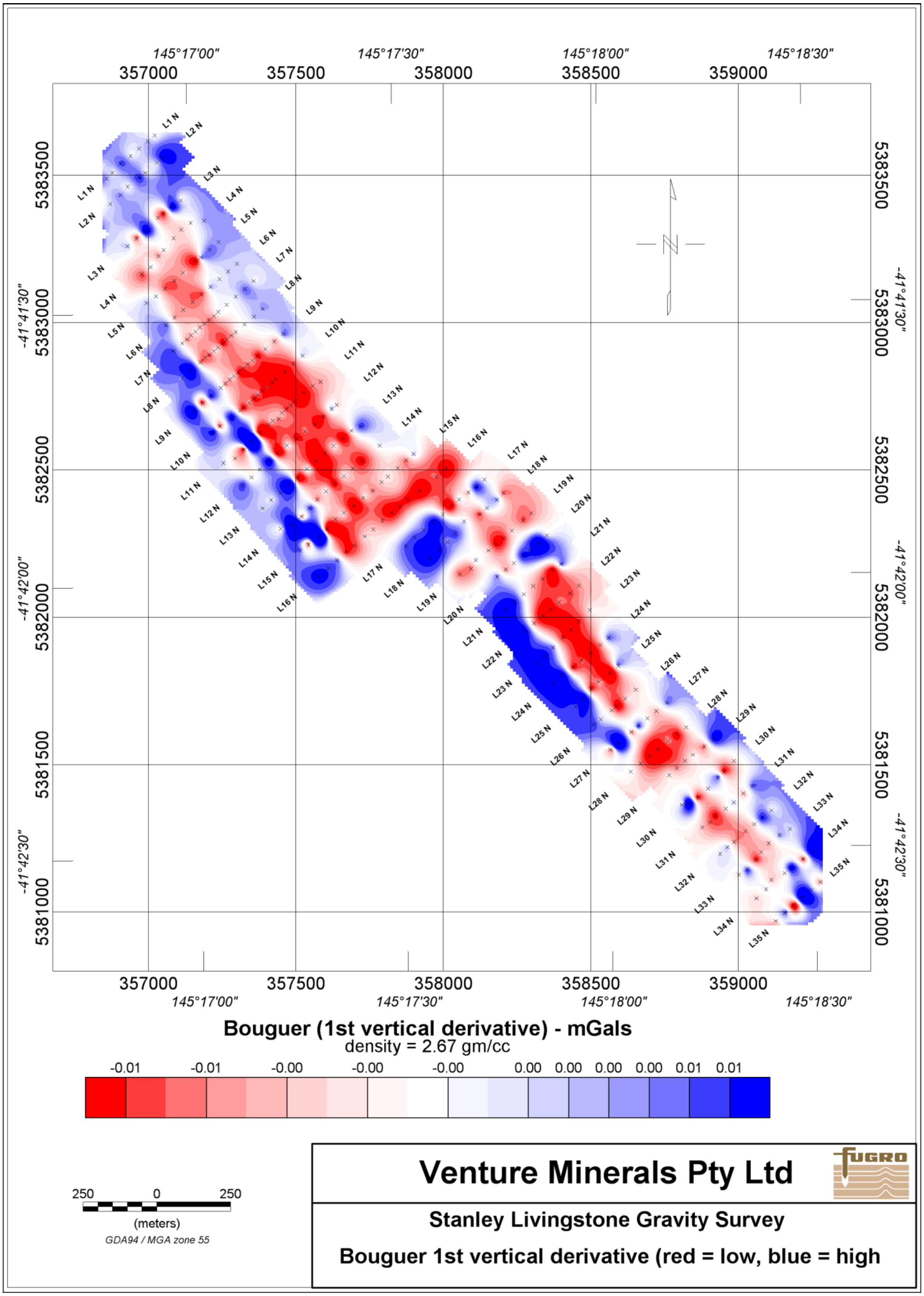
(meters)

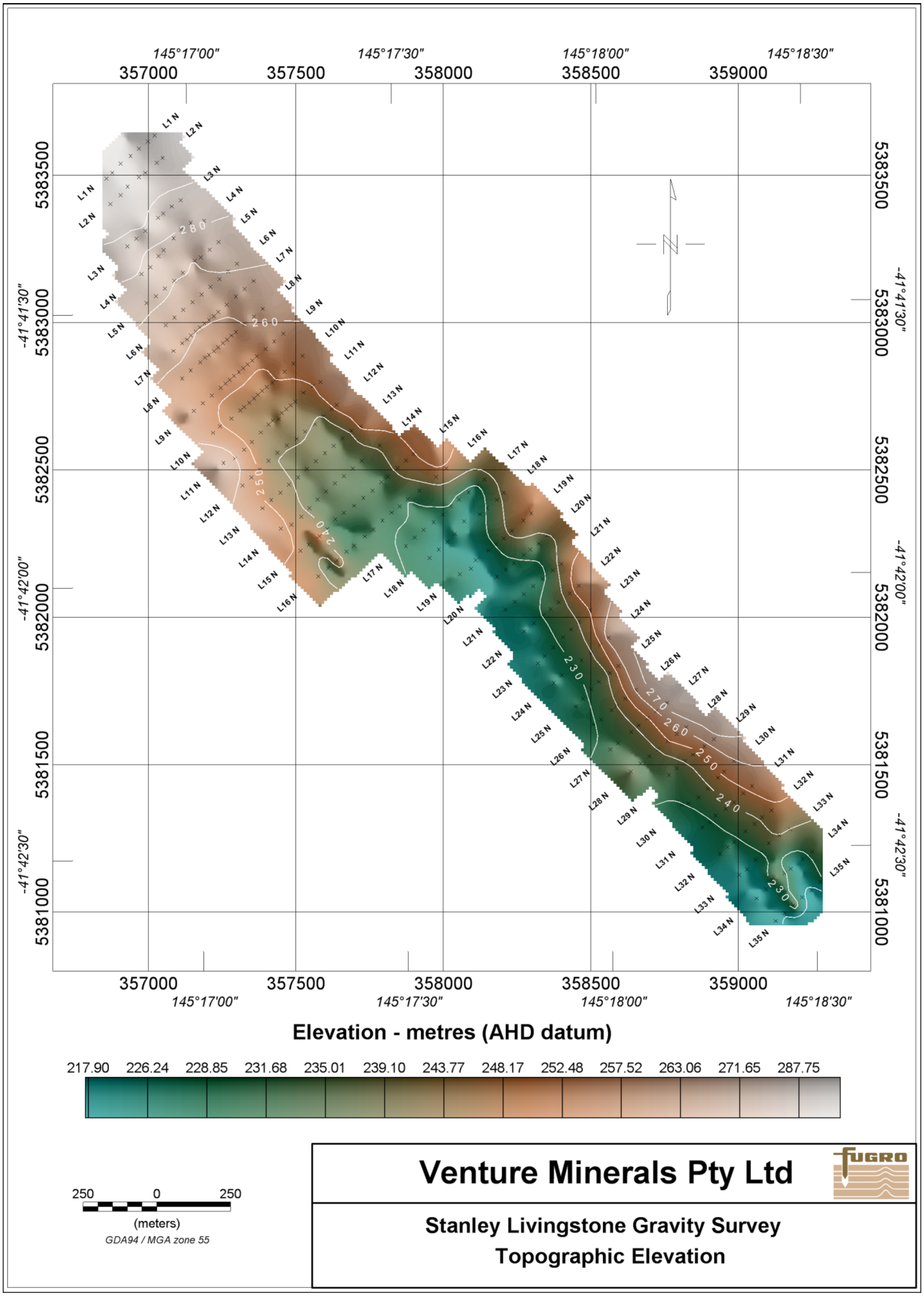
GDA94 / MGA zone 55

Venture Minerals Pty Ltd

Stanley Livingstone Gravity Survey

Bouguer Anomalies - 1st trend removed


145°17'00"
145°17'30"
145°18'00"
145°18'30"
357000
357500
358000
358500
359000
5383500
5383000
5382500
5382000
5381500
5381000
-41°41'30"
-41°42'00"
-41°42'30"
Bouguer (1st vertical derivative) - mGals
density = 2.67 gm/cc
-0.01
-0.01
-0.00
-0.00
-0.00
0.00
0.00
0.00
0.00
0.01
0.01
250
0
250
(meters)
GDA94 / MGA zone 55
Venture Minerals Pty Ltd
Stanley Livingstone Gravity Survey
Bouguer 1st vertical derivative (red = low, blue = high


145°17'00"
145°17'30"
145°18'00"
145°18'30"
357000
357500
358000
358500
359000
5383500
5383000
5382500
5382000
5381500
5381000
-41°41'30"
-41°42'00"
-41°42'30"
280
260
250
240
230
270
Elevation - metres (AHD datum)
217.90
226.24
228.85
231.68
235.01
239.10
243.77
248.17
252.48
257.52
263.06
271.65
287.75
250
0
250
(meters)
GDA94 / MGA zone 55
Venture Minerals Pty Ltd
Stanley Livingstone Gravity Survey
Topographic Elevation

APPENDIX D

DISCLAIMER

It is Fugro Ground Geophysics' understanding that the data provided to the client as part of this report is to be used for the purpose agreed between the parties. That purpose was a significant factor in determining the scope and level of the Services being offered to the Client. Should the purpose for which the data is used change, the data may no longer be valid or appropriate and any further use of, or reliance upon, the data in those circumstances by the Client without Fugro Ground Geophysics' review and advice shall be at the Client's own or sole risk.

The Services were performed by Fugro Ground Geophysics exclusively for the purposes of the Client. Should the data be made available in whole or part to any third party, and such party relies thereon, that party does so wholly at its own and sole risk and Fugro Ground Geophysics disclaims any liability to such party.

Where the Services have involved Fugro Ground Geophysics' use of any information provided by the Client or third parties, upon which, Fugro Ground Geophysics was reasonably entitled to rely, then the Services are limited by the accuracy of such information. Fugro Ground Geophysics is not liable for any inaccuracies (including any incompleteness) in the said information, save as otherwise provided in the terms of the contract between the Client and Fugro Ground Geophysics.

The GPS altitude value is primarily dependent on the number of available satellites, where applicable. Although post-processing of GPS data will yield X and Y accuracies in the order of 1-2 centimetres, the accuracy of the altitude value is somewhat less, usually in the ±10 centimetre range. Further inaccuracies may be introduced during the interpolation and gridding process. Because of the inherent inaccuracies of this method, no guarantee is made or implied that the information displayed is a true representation of the height above sea level. Although this product may be of some use as a general reference, this product must not be used for navigational purposes.