TERRITORY RESOURCES LIMITED
A.C.N. 100 552 118

FRANCES CREEK
ML25396

ANNUAL REPORT

FOR THE PERIOD

24TH April 2007 – 23RD April 2008

Pine Creek SD52-08 1:250,000 Sheet
Pine Creek 5270 1:100, 000 Sheet
NORTHERN TERRITORY

I. P. Hassall
August 2008
SUMMARY

No ground-based field work was undertaken within the tenement area. A multispectral aerial survey was conducted over the entire Frances Creek to Mary River tenement holding. A helicopter electromagnetic survey was also flown over the Frances Creek leases. Both these included the area covered by ML25396.

Total expenditure during the reporting year was $4,486.09.
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1. INTRODUCTION

This report details exploration activities for iron mineralisation conducted by Territory Resources Ltd. within ML25396 (Frances Creek) during the year ended 23rd April 2008.

ML 25396 is located in part within the old Frances Creek iron ore mining district from which about six million tonnes was produced during the period 1967 to 1974. The mining district lies 23km north of the township of Pine Creek which is located on the Stuart Highway about 220km south of Darwin, Figure 1. Access from Pine Creek is along the sealed Kakadu Highway for 2km and then along the graded Frances Creek road for 23km to the Frances Creek iron ore mine site area.

ML 25396 is located immediately west of the Frances Creek Helene orebodies.

2. TENURE

2.1 Mineral Rights

ML 25396 was granted to Territory Resources Limited on 24th April 2007 for a term of 25 years, expiring on 23rd April 2032. The tenement covers 165.1 Hectares.

2.2 Land Tenure

The tenement includes parts of the following land tenure is held 100% by Territory Resources Ltd. It overlies the Ban Ban Springs pastoral lease.
Figure 1   ML25396 Tenement Location
3. **DISTRICT GEOLOGY & MINERALISATION**

Palaeoproterozoic Wildman Siltstone and Mundogie Sandstone sediments of the Mt Partridge Group and Koolpin Formation rocks of the overlying South Alligator Groups, forming the west-dipping limb of a NNW tending antiform, are confined to the northern third of the tenement area. The remainder of the tenement is underlain by Allamber Springs Granite, Figure 2.

The Wildman Siltstone is the most widespread rock unit and comprises two informal sequences. The lower sequence consists of carbonaceous phyllite, ironstone, siltstone and phyllite, which at depth is reported to be pyritic and carbonaceous. The upper sequence consists of similar rock units, but also contains minor sandstone and rare dolarenite. Ironstone, and hence the development of iron occurrences, is absent from this sequence.

The Mundogie Sandstone, which underlies the Wildman Siltstone, is a sequence of coarse clastic sediments mainly comprising pebbly feldspathic conglomerate and arkose. Thin usually pyritic and haematitic intrbeds of phyllite, carbonaceous phyllite and sandy siltstone are also present. The Sandstone crops out over a small area in the NE corner of the tenement.

Sills of pre-orogenic Zamu Dolerite are mapped in the western part of the tenement and appear to have preferentially intruded along the contact between the Koolpin Formation and the underlying Wildman Siltstone.

These sediments, volcanics and dolerite sills have been moderately to tightly folded about NNW trending axes into a series of synforms-antiforms with vertical dips or steep dips to either side of vertical. On a regional scale, these structures form an anticlinorium with a dominant westerly dip within the tenement area.

Regional lower greenschist grade metamorphism accompanied the folding event during a major deformation period between 1870-1810 Ma.

Within the region, and with the exception of the Lewis and Boots deposits which occur in Koolpin Formation rocks, all known iron mineralisation occurs in the lower Wildman Siltstone as stratiform discontinuous lenses consisting of massive hematite with variable inclusions of quartz and siltstone. The ore is structurally controlled, with thickening of ironstone horizons within minor fold axes. In the Koolpin Formation, band iron formation of the Middle Member forms at surface gossanous, haematite-limonite bodies which are reported by Ahmad et al (1993) to give way at depth to ferro-actinolite, Fe-rich chlorite, garnet, siderite, quartz, carbonates and sulphides. No iron occurrences are known within the tenement.
Figure 2  Tenement Geology ML25396
4. EXPLORATION ACTIVITIES – YEAR 1

Exploration activities during Year 1 were restricted to a Hyvista satellite survey that collected multispectral information to target iron ore exploration over the tenement area. A helicopter electromagnetic survey was also flown over the Frances Creek leases. Both these included the area covered by ML25396.

4.1 HYVISTA AERIAL SURVEY

Data acquisition occurred on 15\textsuperscript{th} of October 2007. Three “classes” of imagery were produced:

- Standard colour composites and MNF images to be used for photo-interpretation to delineate geological units and structural features;

- Decorrelation stretch colour composite derived from selected SWIR bands which produces an image that maps the overall distribution of Al-OH, Fe-OH, Mg-OH (and carbonate if present) bearing minerals within the area but not specific mineral species;

- Specific species mineralogical information. Processing of the SWIR bands maps the distribution of clay minerals, mica’s and carbonates and the VNIR bands the iron oxides.

The report for this work is provided in Appendix 2.

4.2 GPX HELI – ELECTROMAGNETIC SURVEY

GPX Aibourne was contracted by Territory Iron to perform a RepTEM over the Frances Creek mining area between 9\textsuperscript{th} November and 11\textsuperscript{th} November 2007.
As shown below, this survey involved towing a transmitter and receiver coil below a civilian helicopter at a height of 35 metres above natural terrain.

The report for this work is provided in Appendix 3.

5. PROPOSED EXPLORATION PROGRAMME – YEAR 2

The geology underlying ML25396 is similar to the rocks hosting iron mineralisation at the Frances Creek mining.

Geological and structural mapping will be conducted along this strike length during late 2008. The ground has not been previously mapped. It is probable that mineralisation continues south of the Helene 10 deposit onto this lease. The FIMCO iron stone line will be evaluated over this section with wide-spaced RC drilling. Anticipated cost is of the order of $25,000.

6. EXPENDITURE

Territory Iron’s expenditure for the reporting year was $4,486.09 and is detailed in the NT Exploration Expenditure sheet attached as Appendix 2 to this report.
APPENDIX 1   EXPENDITURE STATEMENT
## NORTHERN TERRITORY EXPLORATION EXPENDITURE FOR MINERAL TENEMENT

### Section 1. Tenement type, number and operation name: (One licence only per form even if combined reporting has been approved)

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<td>Operation Name (optional)</td>
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### Section 2. Period covered by this return:

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<th>To</th>
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<tbody>
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<td>24th April 2007</td>
<td>23rd April 2008</td>
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</table>

Covenant for the reporting period:

### Section 3. Give title of accompanying technical report:

<table>
<thead>
<tr>
<th>Title of Technical Report</th>
<th>Frances Creek ML25396 Annual Report for the period 24th August 2007 to 23rd April 2008</th>
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<tbody>
<tr>
<td>Author</td>
<td>Ian Hassall</td>
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### Section 4. Locality of operation:

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### Section 5. Work program for the next twelve months:

<table>
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<th>Activities proposed (please mark with an &quot;X&quot;):</th>
<th>Drilling and/or costeasing</th>
<th>Literature review</th>
<th>Airborne geophysics</th>
<th>Geological mapping</th>
<th>Ground geophysics</th>
<th>Rock/soil/stream sediment sampling</th>
<th>Other:</th>
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<td>x</td>
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Estimated Cost: $25,000
### Section 6. Summary of operations and expenditure:

Please include salaries, wages, consultants fees, field expenses, fuel and transport, administration and overheads under the appropriate headings below. Mark the work done for the appropriate subsections with an "X" or similar, except where indicated. Complete the right-hand columns to indicate the data supplied with the Technical Report.

**Do not include the following as expenditure (if relevant, these may be discussed in Section 7):**

- Insurance
- Company Prospectus
- Rent & Department Fees
- Bond
- Transfer costs
- Title Search
- Land Access Compensation
- Legal costs
- Meetings with Land Councils
- Payments to Traditional Owners
- Advertising
- Land Access Compensation
- Fines

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<th>Exploration Work type</th>
<th>Work Done (mark with an &quot;X&quot; or provide details)</th>
<th>Expenditure</th>
<th>Data and Format Supplied in the Technical Report</th>
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Ground Exploration Subtotal $ 

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<td>Rotary air blast (RAB)</td>
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<td>Auger</td>
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Subtotal

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Subtotal $ 

Access and Rehabilitation

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Subtotal

TOTAL EXPENDITURE $ 4,486.09
## Section 7. Comments on your exploration activities:

I certify that the information contained herein, is a true statement of the operations carried out and the monies expended on the above mentioned tenement during the period specified as required under the *Northern Territory Mining Act* and the Regulations thereunder.

I have attached the Technical Report

<table>
<thead>
<tr>
<th>1. Name:</th>
<th>Ian Hassall</th>
<th>2. Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position:</td>
<td>Exploration Manager</td>
<td>Position:</td>
</tr>
<tr>
<td>Signature:</td>
<td>[Signature]</td>
<td>Signature:</td>
</tr>
<tr>
<td>Date:</td>
<td>August 2008</td>
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</tbody>
</table>
HyMap SURVEY AND PROCESSING REPORT

FRANCES CREEK

CUSTOMER: TERRITORY IRON LIMITED

CONTACT: BOB VIVIAN
EXPLORATION MANAGER

SURVEY DATE: 15TH October 2007

REPORT DATE: 3RD January 2008

WRITTEN

Dr M C Hussey and M J Hornibrook

EDITED

T Cocks

ISSUED

January 2008

Disclaimer: No warranty is given for the accuracy or of any of the products or statements made regarding the HyMap data or derived results, however all processing was done to the best of the author’s knowledge.
Executive Summary

HyVista Corporation was contracted by Territory Iron (Contact: Bob Vivian) to acquire and process HyMap airborne hyperspectral scanner imagery from a site in Northern Territory. The data acquisition occurred on 15th of October 2007.

This report describes the processing that has been applied to the HyMap data to produce a number of image products including standard colour composites, a SWIR decorrelation colour composite, minimum noise fraction (MNF) colour composites and unmixed endmember mineral maps. To produce these products the data has had a series of processes applied that converts the raw data into reflectance imagery which is then geometrically corrected and radiometrically levelled so that seamless mosaic images can be produced.

Three (3) “Classes” of imagery have been produced:

1. Standard colour composites and MNF images can be used for photo-interpretation to delineate geological units and structural features. They do not provide information on the mineralogy of geological formations ie the same colour may map different rock types in these images.

2. The decorrelation stretch colour composite is derived from selected SWIR bands and produces an image that maps the overall distribution of Al-OH, Fe-OH, Mg-OH (and carbonate if present) bearing minerals within the area but not specific mineral species. Similarly, the Index Images which uses band depth ratio techniques to depict a specific absorption band; also does not map individual mineral species but may indicate the presence of a mineral “class” such as those minerals typical of advanced argillic alteration (ie pyrophyllite, alunite and / or dickite).

3. Specific species mineralogical information is extracted by applying end-member unmixing processing to the reflectance image mosaic. This requires several procedures that are carried out separately on the Short Wave InfraRed bands (SWIR: 2.00 microns to 2.43 microns) and the Visible Near InfraRed bands (VNIR: 0.488 microns to 1.12 microns). Processing of the SWIR bands maps the distribution of clay minerals, mica’s and carbonates and the VNIR bands the iron oxides.

   • The unmixing has located the 9 mineral:
     Illite-Kaolinite, Kaolinite, Chlorite-Carbonate, 3 Illites and 3 Hematites

All mineral identification is based on analysis of the spectra and since this is a subjective procedure it requires field confirmation. Some minerals, particularly those characterised by Mg-OH / carbonate absorption (~2.30 microns) have very similar spectra.

For each mineral the output products are grey scale and rainbow coloured images where the tone or colour depicts the abundance of the mineral mapped (i.e. increasing abundance from dark to light or from blue to red).

For the SWIR minerals a RGB colour composite image maps have been produced by assigning differing mineral abundance images to the red, green and blue image bands. Other combinations are possible.

The output images are written ENVI, ER Mapper and Jpeg formats. The geo-correction applied to the data results in image maps in the UTM/WGS-84 (Zone 52 South) map projection.

The final delivery of the output image products and intermediate products to the customer is on an external USB2 disk drive.
NOTE THE INTERMEDIATE PRODUCTS ARE NOT INTENDED TO BE USED BY THE CUSTOMER WITHOUT REFERRAL TO HYVISTA, THEY ARE PROVIDED FOR BACK UP PURPOSES AND POSSIBLE FUTURE REFERENCE BY HYVISTA STAFF.
INTRODUCTION

HyVista Corporation was contracted by Territory Iron (Contact: Bob Vivian) to acquire and process HyMap airborne hyperspectral scanner imagery from a site in Northern Territory. The data acquisition occurred on 15\textsuperscript{th} of October 2007.

![Figure 1: Frances_Creek, Northern Territory, surveys location map.](image)

The HyMap is an airborne hyperspectral scanner delivering 126 bands (approx 18 nm width per band) of imagery over the 450nm to 2500nm spectral interval. The HyMap data pre-processing is carried out on a strip by strip basis, to produce radiance and apparent reflectance, and GLT files for later geometric rectification / mosaicing. The reflectance images are cross track and level corrected, (i.e. solar illumination corrected). These reflectance images are then geo-corrected to position each individual pixel in its accurate geo-location in the UTM/WGS-84 map projection. The corrected strips are then mosaiced to produce a seamless, homogeneous data (map) cube for the whole survey area. This data-cube is then processed to produce various band colour composite, minimum noise fraction (MNF), band ratio index images and image-maps that highlight mineralogical and geological / chemical variations.
Figures 2 and 3 are examples of images produced from the cross-track illumination and level correction reflectance data; an RGB colour composite in which bands 109, 28, 03 are displayed in red, green, blue respectively. For colour composite images the order of band numbers, wavelengths or mineral names in the file name is always red, green and blue.

This document outlines the pre-processing (Level1) and details the Level2 and Level3 processing applied to HyMap data. Further information on the sensor specification, survey planning and data pre-processing is available upon request. A summary of the flight line planning supporting this survey is provided in Appendix 2.
DATA PROCESSING

Three levels of process have been applied to the data for this project:

**LEVEL 1 A&B**
Raw and Pre-processed data

**LEVEL 1C**
Cross track corrected mosaiced reflectance image (Data-Cube)

**LEVEL 2**
Albedo Image
Colour composites, true and false colour
SWIR decorrelation stretch colour composite images
Mg-OH, Fe-OH and Mg-OH index images

**LEVEL 3**
SWIR MNF Image from which two 2 Colour Composites have been produced
SWIR and VNIR Endmember Unmixing Images:
  - Spectral Library
  - Unmixed Endmember Abundance
    - Mineral abundance images have been determined from unmixed images and are presented as:
      - Raw BW
      - Thresholded/Scaled BW
      - Rainbow coloured on threshold
      - Mineral Colour Composite
      - Wavelength Shift for White Mica Al-OH content Rainbow coloured.

**MAP PRODUCTS**

The delivered map products are precision geo-rectified mosaic images of products above written in ENVI and ER Mapper formats (UTM/WGS84 Zone 51S) formats.

**LEVEL 1 / PRE-PROCESSING OF DATA**

The HyMap scanner data is collected and stored on a DLT flight tape and converted to ENVI-compatible image files (16-bit integer, BIL data file with an ASCII header file) during pre-processing of the data. The HyMap stores the intensity of light reflected from the surface of the earth as digital numbers (DN). The intensity recorded is the net effect of the wavelength-dependent atmospheric absorption and scattering, solar irradiance, light scattered back from the earth surface, and background voltages from the scanner electronics. Pre-processing involves two corrections.

**Dark Current Subtraction**
This correction removes the “zero light” spectrum in all image pixels. The DN values for subtraction are obtained from the scanner while imaging a non-reflecting surface. It represents system voltages and electronic noise. It is additive and band-dependent.

**Calibration – Radiometric, Spectral and Scaling**
The scanner is calibrated using a standard light source so the response of each detector is known. Every pixel of each band has been scaled by this band constant and a multiplier has been applied so that the data is stored as a 16-bit integer.
Data Units
When the pre-processing corrections described above have been applied, the data are in radiance units of microwatts/cm\(^2\)/steradian/nm before the multiplier of 1000 is applied to convert it to a 16-bit integer.

Atmospheric Correction
Whilst the HyMap’s radiance data is spectrally and radiometrically calibrated, the spectra are distorted by atmospheric absorption and scattering. The data has been processed using the HyCorr program that determines a model of a subset of atmospheric properties that are appropriate for the time (UTC), date, latitude/longitude and acquisition height (AGL) for HyMap data that has been radiance corrected. HyCorr uses radiative transfer calculations and the calibrated hyperspectral data (with artefact suppression) to remove and reduce atmospheric and solar illumination effects. The output of HyCorr is an apparent surface reflectance image from which spectra can be compared to relative reflectance library spectra, i.e. the atmospheric over-print has been removed and mineral absorption features are now recognisable. HyCorr output is apparent surface reflectance. Reflectance imagery is unit-less.

Cross Track Correction and Strip Levelling
Prior to geometric correction each strip is processed to remove the effect of bi-directional reflectance that results from non uniform illumination across the image when the azimuth is to the side of the flight line. This results in the images being brighter on one side than the other. The levelling correction adjusts each data strip to the same data ranges. These corrections improve processing and ensure that the final mosaic images are seamless.

Geometric Correction
Variations in the aircraft orientation, speed and altitude during image acquisition result in spatial distortions of the images, even though the scanner is TalisonWed in a tri-axial, gyro-stabilised platform that compensates for some of these motion effects. An IMU/GPS unit is attached to the scanner and it provides data that can be used remove these distortions which would otherwise result in positional errors of several hundred metres. Using these data with the appropriate software permits geo-correction to be completed without the need for control point picking and, depending on terrain variation; this can reduce positional errors to below 20m.

Software developed by HyVista is used for to produce a ray traced image (.glt) file from combining the output from the IMU/GPS with a DEM (SRTM 90m image). The glt file is then used to georectify the image products produced to the UTM/WGS 84 map projection using proprietary HyVista software.

Level 1C Product
In this survey the cross track corrected and levelled reflectance data have been mosaiced into data cubes for the SWIR and VNIR bands and subsequent Level 2/3 processing has been carried out using these images. This image is a proprietary product and is not supplied to the customer. However, the HyMapView program is supplied which allows the customer to examine the images delivered, including the mineral maps, to check the spectra of any given pixel.
LEVEL 2 PROCESSING

Colour Composite Mosaics

Standard Colour Composites

Three colour composite images have been produced from the reflectance data consisting of:

- **Landsat TM 741 equivalent**: RGB = 2.206um/0.851um/0.481um (HyMap bands 109, 28, 03 respectively)
- **True Colour**: RGB=0.67um/0.58um/0.488um (HyMap bands 15, 09, 03 respectively)
- **False Colour**: RGB =0.851um/0.665um/0.488um HyMap bands 28, 15, 03 respectively)

The contrast in these colour composites has been enhanced by applying the ENVI square root and then linear stretch to the images. Note all colour composite images (DCS, MNF and Mineral Map) have convention that band numbers or mineral names are given in order Red, Green Blue the same as they are displayed.

In addition the 109_28_03 image has been masked to remove vegetation and water showing which pixels have removed prior to processing.

**SWIR Decorrelation Stretch (DCS) Colour Composite**

The SWIR image bands: 2.211microns, 2.264microns and 2.332microns are selected as a RGB colour composite image and the ENVI decorrelation stretch function applied to this image. The resultant image maps the distribution of mineral classes that absorb at these wavelengths i.e. Al-OH, Fe-OH and Mg-OH/Carbonates respectively. However, since it is absorption being mapped the resultant colours are confusing, for example Mg-OH is mapped as not blue. However, by taking the negative of the bands (ie inverting the RGB colour image planes) an image results in which:

- **Red** = Al-OH absorbing minerals (White mica, kaolinite, montmorillonite)
- **Green** = Fe-OH absorbing minerals (Nontronite, Fe smectite, chlorite and epidote)
- **Blue** = Mg-OH absorbing minerals (Amphibole, talc, Mg smectite and Mg carbonate etc)

**Index Images**

By calculating the depth of the absorption features at specific wavelengths it is possible to produce images that show the overall abundance of groups of minerals that have a primary absorption feature at the specified wavelength. In this case the band depths for 4 SWIR absorption features have been mapped to show the distribution of:

- **2.174microns** – Advanced Argillic Minerals (Alunite, Pyrophyllite, Dickite, Ordered Kaolinite)
- **2.205microns** – Al-OH minerals (Kaolinite, White Mica [Sericite-Muscovite-Illite], Montmorillonite)
- **2.26microns** – FeOH minerals and Jarosite (Nontronite, Fe/Mg Smectite, Chlorite)
- **2.315microns** – Mg-OH and Carbonate Minerals

These images are termed Index images and have been produced both as grey scale, rainbow coloured grey scale and colour composite images.
LEVEL 3 PROCESSING

MNF Transform

For the SWIR, MNF transforms have been applied to the reflectance data and from these images colour composites have been produced. The bands selected show the greatest variation is surface materials producing images that highlight geological and regolith variation within the area.

Mineral Mapping

Hyperspectral remote sensing is essentially a mineral mapping technology. Its fundamental principles are based on spectroscopy, so an understanding of the spectral signatures of surface materials is required for its application. Briefly, each pixel of a hyperspectral image contains a spectrum which forms the basis for determining the materials present in a scene. Surface mineralogy and other components are mapped using algorithms which either de-convolve a scene into component endmember signatures (unsupervised un-mixing) or specifically target spectral signatures of known materials (supervised match filtering). The former of these approaches has been applied in the project.

Spectral Endmember Un-mixing

Linear spectral un-mixing is the process of deriving the abundances of component materials in a scene from the individual pixel spectra, given the endmember spectral signatures. To give perfect un-mixing results, the signatures for all endmembers present in a scene would need to be known. However, in practice, un-mixing algorithms map the distribution of automatically scene-derived endmember materials. These are especially useful for analysis where signatures of the target(s) are not known and for general geological and regolith mapping.

Un-mixing methods output a set of endmember spectra with corresponding un-mixed images which are, in effect, mineral maps. There are several programs that can be used for this type of processing. HyVista has several proprietary un-mixing programs that can be applied to mosaiced reflectance imagery (as in this case) or allows for the selection of endmember data from multiple strips without the need to mosaic them. Thus, when they are un-mixed, the distribution of endmembers matches across images strip boundaries. This software produces mineral maps that can be used for geological and regolith interpretation where there is no a priori knowledge of the minerals present in the area.

Prior to applying the un-mixing algorithm, the data are processed to remove pixels that are of shadow, anomalously bright areas (such as active fires and metal roofs), and surface water, green and dry vegetation. These are effectively noise pixels and affect the image statistics. These pixels are masked out (i.e. set to zero).

Running the un-mixing algorithm produces two outputs; an endmember library that contains the spectra for each spectral endmember detected within the data, including minerals, and a series of abundance images (one for each flight line) each band of which maps the distribution of a spectral end member. The program is run several times, with differing parameters, to determine the optimum output in terms of minerals mapped and is run separately on the Visible Near Infra Red bands (VNIR 0.488 microns to 1.12 microns) for iron oxides and Short Wave Infrared bands (SWIR 1.95 microns to 2.43 microns) for phyllosilicates, carbonates and other minerals with cation OH bonds (e.g. amphiboles).

The spectral libraries are examined and endmembers recognised as minerals are determined and then mineral species identified. Non mineral spectra may include those from noisy spectra, residual vegetation, spectrally featureless areas and multiple mixed spectra.
that cannot be identified. The program uses a statistical technique to match each pixel to a spectral endmember and creates the abundance images such that each pixel has a value that is proportional to its closeness of fit to the spectra in question, the higher the value the better the match. In percentage terms, pixels with 0% have no match and the values of 100% have a perfect match and would be “pure” spectra but these will be quite rare within an image as most pixels will contain several different materials. Therefore, in probability terms pixels with percentage values of over 85% have a significant content of the spectral endmember (mineral). Those abundance image bands are then thresholded at ~85% with values below this being set to zero and those above scaled from 0 to 1 (i.e. real data).

**Processing Sequence**

In this case the following processing sequence was applied to the masked reflectance image:

**SWIR**

**Unmixing**

Unmixing set to detect up to 15 endmembers, examination of the spectral libraries and abundance images has identified meaningful mineral endmembers as follows:

- 5 mineral species: Illite(2229-Al-OH poor), Chlorite-Carbonate, Illite(2192-Al-OH rich), illite(2211-muscovite), kaolinite

These abundance images have been thresholded and the spectra examined to validate the mineral identification. Spectra from the highlighted regions of interest and the threshold values are provided in Table 1. Note the spectral identification of the Al-OH minerals that are not kaolinite or smectite is somewhat subjective as illite, muscovite, sericite and generic white mica are all spectrally similar. Hence, in this case these minerals have been referred to as white mica (abbreviated to WM) with the wavelength of the main absorption feature appended to the mineral name, e.g. TalisonW_ref_mos_plflr16_WM-2211, where 2211 means absorption at 2.21 microns.

**VNIR**

**Unmixing**

Unmixing set to detect up to 9 endmembers, examination of the spectral library and abundance images has identified meaningful mineral iron oxide endmembers as follows:

- 3 spectrally slightly different hematite’s. The threshold applied to the hematite images may be higher than required so that the extent is under represented in the image with the scaled, rainbow and cc suffix in the image name. The data will be adjusted to account for this and new images produced.

**Output Products**

After final thresholding the grey scale image then has a rainbow colour look up table applied to it (ENVI Rainbow) such that blue pixels indicate a less perfect match, possibly due to dilution effects, grading through green, yellow...
and red being the best match. This image is also saved in the formats mentioned above and has the identifier “rainbow” in the file name.

The endmember images can also be combined in RGB colour composites, that is, different endmember combined in red, green and blue, in the case of the SWIR for this project with eight (8) mineral end-members having been identified there are numerous combinations that can be produced. In this case one RGB colour composites has been produced. This combination has been selected on the basis of the mineral association; other combinations can be produced if required.

**IMAGE PROCESSING PRODUCTS**

Each delivery output product has been written in ENVI, ER Mapper, Jpeg and Geotiff formats; intermediate images are saved only in ENVI format, it is not intended that the customer use these files they are provided for future reference by HyVista staff.

Table 1 lists all of the files produced in the Level 2 and Level 3 processing. Examples of the images products are presented in Appendix I. The processed data are supplied an external disk with the following directory structure which is the same for both East and West Blocks:

**Frances Creek**

<table>
<thead>
<tr>
<th>Frances Creek 01</th>
</tr>
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<tbody>
<tr>
<td>gs_geocorrection</td>
</tr>
<tr>
<td>Radiance</td>
</tr>
<tr>
<td>Reflectance</td>
</tr>
<tr>
<td>Raw DN</td>
</tr>
</tbody>
</table>

To

<table>
<thead>
<tr>
<th>Frances Creek 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>gs_geocorrection</td>
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<tr>
<td>Radiance</td>
</tr>
<tr>
<td>Reflectance</td>
</tr>
<tr>
<td>Raw DN</td>
</tr>
</tbody>
</table>

**Frances Creek Intermediate Products**

- **Level 1c**
  - Reflectance Data Cube – retained by HyVista
  - Frances Creek Background Image

- **Level 2**
  - Standard_Colour_Composites
  - Colour Composite Veg Off
  - SWIR_Decorrelation_Composites
  - Index_Images

- **Level 3**
  - Endmember Abundance
    - SWIR_Mineral_Library
    - SWIR_Minerals
    - VNIR_Mineral_Library
    - VNIR_Minerals
  - Wavelength Shifts
  - Masks & Ratios
  - MNF

**TalsionE Delivery Products**
Index Images
Standard Colour Composites
Decorrelation Composite
MNF Colour Composites
SWIR Mineral Maps
  MM Rainbow
  MM Grey Scale
SWIR Mineral Maps cc
SWIR Mineral Spectra
Wavelength Shifts
FeOx Mineral Maps
## File Name Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB#</td>
<td>Abundance Band Number Of Unmixing Image</td>
</tr>
<tr>
<td>AMAP</td>
<td>Unmixing Technique That Maps Absorption Features</td>
</tr>
<tr>
<td>CC</td>
<td>Colour Composite</td>
</tr>
<tr>
<td>CUT</td>
<td>Selected Pixel Values Extract From Image Applied To Wavelength Shift Images</td>
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<tr>
<td>BD</td>
<td>Band Depth</td>
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<tr>
<td>DCS</td>
<td>Decorrelation Stretch</td>
</tr>
<tr>
<td>DV</td>
<td>Dry Vegetation</td>
</tr>
<tr>
<td>EQUALISE OR EQ</td>
<td>Histogram Equalise Contrast Stretch</td>
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<tr>
<td>FILT</td>
<td>Edge Sharpened Using Unsharp Mask Convolution Filter</td>
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<tr>
<td>GEO</td>
<td>Geo-Corrected Data Using A HyMap glt (Geometric Lookup Table) File</td>
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<tr>
<td>GUASS</td>
<td>Histogram Gaussian Contrast Stretch</td>
</tr>
<tr>
<td>GV</td>
<td>Green Vegetation</td>
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<tr>
<td>INDEX</td>
<td>Image That Has Been Thresholded To Highlight A Specific Mineral Group</td>
</tr>
<tr>
<td>INVERTED</td>
<td>Negative Image</td>
</tr>
<tr>
<td>MNF</td>
<td>Minimum Noise Fraction Transform Image</td>
</tr>
<tr>
<td>MOS</td>
<td>Mosaic Of All Survey Strips That Have Been Cross Track Corrected And Leveled</td>
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<tr>
<td>NO BG</td>
<td>Background Set To Black</td>
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<tr>
<td>PL</td>
<td>Unmixed Output</td>
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<tr>
<td>RAINBOW</td>
<td>ENVI Colour Look Up Table Applied To Image Such Grey Tones Are Coloured Dark To Light From Blue To Red.</td>
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<tr>
<td>REF</td>
<td>Reflectance Data – Atmospherically Corrected</td>
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<tr>
<td>TH</td>
<td>Threshold Applied</td>
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<td>VNIR</td>
<td>Derived From Processing 35 Selected Visible And Near Infrared Bands</td>
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<td>WM</td>
<td>White Mica</td>
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<td>WVL</td>
<td>Wavelength Shift Image</td>
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<td>XAB</td>
<td>Mineral Abundance File Where X Is Number Of Endmembers Derived From Unmixing Software</td>
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<tr>
<td>XTR</td>
<td>X-Track (Brdf) Corrected Results (Removing Illumination Variations Common To One Survey Strip)</td>
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### Table 1: Image Delivery Product

<table>
<thead>
<tr>
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<th>Image and Comment</th>
<th>Thresholds</th>
<th>Endmember Spectra</th>
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<td>Frances_Creek Delivery</td>
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<td>Products</td>
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<tr>
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<td>frances_ck_ref_cc_bds_15-09-03_rgb_scaled</td>
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<td>MNF (Colour Composite)</td>
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![Frances Creek Illite-2229nm](image)
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<td>FeOx Mineral Maps</td>
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<td>---------------------</td>
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<td>Wavelength Shifts</td>
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</tbody>
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---

**Frances Creek Hematite-10**

- Reflectance vs Wavelength graph showing changes in reflectance across different wavelengths.
Plate 1: RGB colour composite of HyMap bands 109, 28, 03, centred at 2.205 microns, 0.851 microns and 0.488 microns (Image: frances_ck_ref_cc_bds109-28-03_rgb_scaled)
Plate 2: SWIR Decorrelation Stretched Colour Composite (Image frances_ck_ref_dcs_cc_bds2211-2264-2332_rgb_inverted_threshold)
Plate 3: Index Image – Band Depth Colour Composite Al-OH 2.202 microns, Fe-OH 2.265 microns, Mg-OH-Carbonate 2.32 microns (Image: frances_ck_ref_Index_CC_Al-Fe-Mg)
Plate 4: MNF VNIR Colour Composite (Image: frances_ck_ref vnir cc mnf 234 rgb_scaled)
Plate 5: Mineral Map Image Hematite (Image: frances_ck_ref_vnir_sga09_Hematite-09_bw_scaled+SB)
Plate 6: Mineral Map Image of Hematite rainbow coloured (Image: frances_ck_ref_vnir_sga09_Hematite-09_rainbow+SB)
Plate 7: Colour Composite Mineral Map Hematite (Image: frances_ck_ref_vnir_cc_sga010910_Hematite_01-09-10_RGB_scaled)
Plate 8: Colour Composite Mineral Map Image 3 White Micas (Image: frances_ck_ref_swir_cc_sga011210_cc_Illite-2229-2211-2192_rgb_scaled)
Plate 10: Illite Wavelength Shift Image 2.185 microns to 2.215 microns RAINBOW coloured and overlain on greyscale background (Image: frances_ck_ref_swir_cr_wvl_masked_rainbow_scaled_bg:.)
Appendix 2

Survey Planning and Specifications

For survey operations and flight logistics and planning, HyVista utilises two integrated software and hardware packages.

The first is Flitemap (Jeppesen - www.jeppesen.com) which is a high resolution moving map and flight planning application. Using HyVista propriety software, flight line information is plotted as user waypoints and entered to the FliteMap database. This information then can be used to plan day to day flight logistics and flight logging and reporting. Another important feature of Flitemap is the ability to log the GPS signal from the HyMap system while in flight. A GPS signal is transmitted from the HyMap system via the Omnistar 3000LR DGPS as RTCM. This signal is recorded every second and plotted on the Flitemap display and can also be saved for archiving and reporting purposes to easily and quickly show terrain coverage and target acquisition completion.

The second and most important survey operation software/hardware package is Eztrack Aerial Survey System (TRACK’AIR – www.trackair.com). The system is a combination of specially developed software and hardware tools integrated to streamline airborne survey operations. The system consists of an equipment kit and the TRACKER planning and reporting software. This includes the TECI (Tracker External Camera Interface), snapSHOT software running on a laptop, a panel display for pilot viewing and a complementary cross track indicator (CTI) for the pilot. The Eztrack is a complete Aerial Survey System which starts at the planning stages of a survey mission. Utilising snapXYZ and snapPLAN a survey area consisting of flight lines can be planned in minutes from any waypoint or polygon coordinates. Flight lines are stored in a database system making it easy to archive and report survey missions. Tracker also accepts many different projections and datums making it easy to use with different client needs. Actual flight operation utilises the Eztrack hardware and snapSHOT software. The Eztrack receives a GPS signal transmitted from the HyMap system via the Omnistar 3000LR DGPS as RTCM. This increases the accuracy of flight line operations.
Appendix 3

Survey Flight Line Specifications

Project name: AUS2007B

Date: 24/07/2007 10:48:16 AM
Flying height agl: 1400 m
Field of view: 61

TOTAL QUANTITIES
Totals for runs + strips
Total lines: 14
Total length (km): 191 km
Total length (nm): 103 nm

Coordinate system: UTM coordinate system
Projection: Transverse Mercator
Ellipsoid: wgs-84

Strips

Strip number: 1
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 8.8 km
Swath width: 1649 m
Geo Start: -13 13.207  131 54.175
Geo End: -13 17.960  131 54.243
WGS84 Start: -13 13.207 / 131 54.175
WGS84 End: -13 17.960 / 131 54.243
UTM WGS84 Start: [52] 814637 / 8536699
UTM WGS84 End: [52] 814658 / 8527926

Strip number: 2
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 11.0 km
Swath width: 1649 m
Geo Start: -13 13.219  131 53.399
Geo End: -13 19.192  131 53.485
WGS84 Start: -13 13.219 / 131 53.399
Strip number: 3
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 12.3 km
Swath width: 1649 m
Geo Start: -13 13.228  131 52.624
Geo End: -13 19.885  131 52.722
WGS84 Start: -13 13.228 / 131 52.624
WGS84 End: -13 19.885 / 131 52.722
UTM WGS84 Start: [52] 811832 / 8536692
UTM WGS84 End: [52] 811867 / 8524406

Strip number: 4
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 12.3 km
Swath width: 1649 m
Geo Start: -13 13.218  131 51.848
Geo End: -13 19.875  131 51.945
WGS84 Start: -13 13.218 / 131 51.848
WGS84 End: -13 19.875 / 131 51.945
UTM WGS84 Start: [52] 810429 / 8536727
UTM WGS84 End: [52] 810464 / 8524441

Strip number: 5
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 5.0 km
Swath width: 1649 m
Geo Start: -13 17.155  131 51.130
Geo End: -13 19.872  131 51.169
WGS84 Start: -13 17.155 / 131 51.130
WGS84 End: -13 19.872 / 131 51.169
UTM WGS84 Start: [52] 809048 / 8529476
UTM WGS84 End: [52] 809062 / 8524462
Strip number: 6
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 5.0 km
Swath width: 1649 m
Geo Start: -13 17.168 131 50.357
Geo End: -13 19.885 131 50.393
WGS84 Start: -13 17.168 / 131 50.357
WGS84 End: -13 19.885 / 131 50.393
UTM WGS84 Start: [52] 807652 / 8529469
UTM WGS84 End: [52] 807659 / 8524455

Strip number: 7
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 33.8 km
Swath width: 1649 m
Geo Start: -13 17.245 131 49.582
Geo End: -13 35.587 131 49.840
WGS84 Start: -13 17.245 / 131 49.582
WGS84 End: -13 35.587 / 131 49.840
UTM WGS84 Start: [52] 806250 / 8529343
UTM WGS84 End: [52] 806327 / 8495493

Strip number: 8
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 23.5 km
Swath width: 1649 m
Geo Start: -13 17.287 131 48.810
Geo End: -13 30.055 131 48.986
WGS84 Start: -13 17.287 / 131 48.810
WGS84 End: -13 30.055 / 131 48.986
UTM WGS84 Start: [52] 804854 / 8529280
UTM WGS84 End: [52] 804903 / 8505718

Strip number: 9
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 17.8 km
Swath width: 1649 m
Geo Start: -13 18.900  131 48.049
Geo End: -13 28.544  131 48.184
WGS84 Start: -13 18.900 / 131 48.049
WGS84 End: -13 28.544 / 131 48.184
UTM WGS84 Start: [52] 803445 / 8526320
UTM WGS84 End: [52] 803487 / 8508523

Strip number: 10
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 11.0 km
Swath width: 1649 m
Geo Start: -13 21.147  131 47.310
Geo End: -13 27.128  131 47.387
WGS84 Start: -13 21.147 / 131 47.310
WGS84 End: -13 27.128 / 131 47.387
UTM WGS84 Start: [52] 802063 / 8522190
UTM WGS84 End: [52] 802077 / 8511152

Strip number: 11
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 20.0 km
Swath width: 1649 m
Geo Start: -13 26.686  131 50.488
Geo End: -13 37.554  131 50.637
WGS84 Start: -13 26.686 / 131 50.488
WGS84 End: -13 37.554 / 131 50.637
UTM WGS84 Start: [52] 807687 / 8511903
UTM WGS84 End: [52] 807722 / 8491847

Strip number: 12
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 14.8 km
Swath width: 1649 m
Geo Start: -13 29.463  131 51.298
Geo End: -13 37.484  131 51.409
WGS84 Start: -13 29.463 / 131 51.298
WGS84 End: -13 37.484 / 131 51.409
UTM WGS84 Start: [52] 809090 / 8506763
UTM WGS84 End: [52] 809118 / 8491959

Strip number: 13
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 9.0 km
Swath width: 1649 m
Geo Start: -13 30.393 131 52.089
Geo End: -13 35.283 131 52.152
WGS84 Start: -13 30.393 / 131 52.089
WGS84 End: -13 35.283 / 131 52.152
UTM WGS84 Start: [52] 810499 / 8505030
UTM WGS84 End: [52] 810506 / 8496005

Strip number: 14
Terrain height = 0m / 0ft
Course: 180°/360°
Length: 6.3 km
Swath width: 1649 m
Geo Start: -13 31.888 131 52.884
Geo End: -13 35.289 131 52.933
WGS84 Start: -13 31.888 / 131 52.884
WGS84 End: -13 35.289 / 131 52.933
UTM WGS84 Start: [52] 811902 / 8502254
UTM WGS84 End: [52] 811916 / 8495977
APPENDIX 3  GPX HELI – ELECTROMAGNETIC REPORT
RepTEM Airborne Geophysical Survey
North Pine Creek, Northern Territory

November 2007
Survey Operations and Logistics Report

For
TERRITORY IRON

Survey Flown by:

GPX Airborne

GPX Airborne
JOB NUMBER 2237
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GPX Airborne
RepTEM (MkI) Survey

SURVEY SUMMARY

Client: TERRITORY IRON
Job Number: 2237
Survey Area: North Pine Creek, Northern Territory
Data Processing Base: Base of Operations and processing base at Francis Creek Mine.

Mobilisation: 8th November 2007
Production: 9th November – 11th November 2007
Demobilisation: 12th November 2007

Line km surveyed: Total Line kms 306.51 km

Survey Crew: Ben Trevenen (Crew Leader)
Rowan Schneider
Kent Andrews
Nic Scott (Pilot)

In November 2007, GPX Airborne was contracted by Territory Iron to perform a RepTEM survey over the North Pine Creek survey area in the Northern Territory. The job was flown between the 9th of November and the 11th of November 2007.

The base of operations and processing was located at the Francis Creek Mine, with crew accommodation at the Pine Creek Hotel.
Survey Area Map
Overview
RepTEM System Specifications

**Transmitter**
- Waveform – 25% duty cycle square wave
- Pulse on Time - 5 ms (inclusive of 1ms cosine ramp on)
- Pulse off Time - 15 ms
- Pulse Current - 320 Amps
- Switch on Ramp - 1 ms
- Switch off Ramp - 55 μs
- Tx Loop Area - ~350 m²
- Tx NIA – 112,000
- Tx Frequency - 25 Hz

**Receiver**
- A-D Circuitry - 24 bit
- Sample Time - 0 - 12 ms
- Sampling - 121 Linear channels
- Windowed Data - 21 channels

**Receiver Coil**
- Effective NA - 10,000 Square Metres
- Bandwidth – 45,000 Hz
Geometry.

Transmitter loop is towed 35 m below helicopter - Receiver coil is located at centre of Tx loop.

Transmitter / Receiver at nominal 35 m terrain clearance.

Helicopter survey speed is between 45 and 55 knots.

Along line sample interval is between 9 and 11 metres.
EM Data Channel Specifications

NB: Time 0 is at the start of the switch off ramp

<table>
<thead>
<tr>
<th>Channel</th>
<th>Begin Time</th>
<th>End Time</th>
<th>Centre Time</th>
<th>Width in Time</th>
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<td>80</td>
<td>67.500</td>
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<td>10530.626</td>
<td>1721.25</td>
</tr>
</tbody>
</table>
RepTEM Airborne Geophysical System
Magnetic Data Specifications
The helicopter was equipped with a bird-mounted Geometrics G 822A Cesium vapor, optically pumped magnetometer continuously sampling at 1200 Hz. The instrument has a sensitivity of 0.001nT, with a sensor noise level of less than 0.1nT.

The magnetic readings are resampled to 50Hz with each sample containing an array of 24 readings. Adjacent readings are summed to minimise bias from the EM transmissions to produce the 25Hz magnetic array data. The mid time array positions are averaged to create the magnetic response.

The time-synchronized ground magnetic field data was digitally recorded at a 5.0 sec interval with a Geometrics G856 magnetometer to an accuracy of 0.1nT.

Base Station Location: 808834mE, 8493911mN.

DATA PROCESSING SUMMARY
The following processes were carried out at the field processing office:
- Spline removal of birdswing
- Negative decays paired and reversed
- Filtering and correction of laser altimeter
- Data is splined to a uniform sample spacing
- Butterworth filter applied to each channel
- Preliminary gridding and data verification

Final EM Processing
Software used for processing at the GPX Perth office:
- Geosoft
- EmaxAIR by Fullagar Geophysics
- ChrisDBF

System response obtained from high level flights is removed from the data. CDIs are generated using EmaxAIR, and depth slice data is interpolated from the Emax output using in-house software. Final plots are created in Geosoft .MAP format, and include CDIs that are masked to the first and last depth solution at each station.

Magnetic Data processing.
The aircrafts magnetic data is corrected for diurnal and the mean diurnal value added back to the channel. Parallax is applied, followed by the IGRF correction, the mean
IGRF value being added back to data. Where required tie line and a micro-level will be applied to the final magnetic channel.

<table>
<thead>
<tr>
<th>Area Name</th>
<th>Diurnal Value</th>
<th>IGRF Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Pine Creek</td>
<td>47474.17 nT</td>
<td>46957.73 nT</td>
</tr>
</tbody>
</table>

**Digital Elevation Model**

The laser altimeter data was subtracted from the GPS height to give a digital elevation model which represents height above the WGS84 spheroid. This data was then mean levelled with the SRTM (Satellite Radar Topography Mission, NASA) to remove any levelling.
Final DVD Contents

\images
GeoTiff format images of all depth slices, minimum, maximum and last conductivity, digital elevation and magnetic data.

\grids
Conductivity depth slices with name convention of dnnn.grd where nnn is the depth of the conductivity slice, grids are in Geosoft GRD format. ERMapper format grids have also been provided, with a ERM_Dnnn.ers naming convention.

Final Magnetic grid: ERM_Magnetics.ers
Final Digital Terrain: ERM_DEM.ers (WGS84 spheroid)

\cdi_grids
Geosoft format files of the CDI grids.

\located_data

TEM.LDT
Line: Line number
Fiducial: Fiducial number as displayed on the CDI sections.
East: Easting (GDA94 MGA52)(metres)
North: Northing (GDA94 MGA52)(metres)
Heli_Z: GPS altitude of helicopter (metres)
TX_Laser: Height of the laser altimeter on the hoist (metres)
DEM_F: Levelled Digital Elevation Model, WGS84 (metres)
Current: Transmitter current (amps)
Ch[*]: EM response, channels 1-21 (uV)
Mag: Interpolated magnetic channel.
CDI.LDT
Line: Line number
East: Easting (GDA94 MGA52)(metres)
North: Northing (GDA94 MGA52)(metres)
Distance: Distance along line (metres)
Depth: Depth below surface (metres)
Conductivity: Conductivity (mS/m)
RL: GPS depth (WGS84)(metres)

DEPTHSLICE.LDT
Line: Line number
East: Easting (GDA94 MGA52)(metres)
North: Northing (GDA94 MGA52)(metres)
Distance: Distance along line (metres)
RL: GPS depth (WGS84)(metres)
[35-150]: Conductivity at specified depth (mS/m)

COND_SUMMARY.LDT
Line: Line number
East: Easting (GDA94 MGA52)(metres)
North: Northing (GDA94 MGA52)(metres)
Firstcond: First recorded conductivity in a decay (mS/m)
Maxcond: Maximum recorded conductivity in a decay (mS/m)
Lastcond: Last recorded conductivity in a decay (mS/m)
Mincond: Minimum recorded conductivity in a decay (mS/m)

MAGNETICS.LDT (25Hz data)
Line: Line Number
SPM: Seconds past midnight.
East: Easting (GDA94 MGA52)(metres)
North: Northing (GDA94 MGA52)(metres)
Rawmag: Raw magnetics channel
Diurnal: Diurnal data
PreMag: Diurnal corrected.
IGRF: Calculated IGRF value for each point.
MagF: Final magnetics channel
GPS_Z: GPS altitude of helicopter (metres)
Clearance: Ground clearance of the Magnetic Sensor.

Each data type is also accompanied with a similar Geosoft database.

\sections
Linear & logarithmic profiles, and conductivity depth images for each line. In Geosoft .MAP format (viewable with the free interface at http://www.geosoft.com ).

\sections\Images
Linear & logarithmic profiles, and conductivity depth images for each line. In PNG (Portable Network Graphics) format.
Total Magnetic Intensity

TERRITORY IRON
NORTH PINE CREEK SURVEY
TOTAL MAGNETIC INTENSITY
GDA94 MGA52
16th November 2007
Scale 1:25000

GPX Airborne
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+61 6916 8111

GDA94 / Map Grid of Australia zone 52
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Fax: (08) 9316 8033
Web: www.gpx.com.au