Precision GeoSurveys

AIRBORNE MAGNETIC SURVEY REPORT

Search Project

2015 Survey Area

Geoscience BC Report 2016-02

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January 2016

Summary

Precision GeoSurveys Inc. was contracted by Geoscience BC to collect and process high quality aeromagnetic data over the 6755.6 km^2 Search 2015 project area located between Smithers and Terrace, British Columbia. A total of 29,821 line km of magnetic data were collected over 423 survey lines and 45 tie lines using a pre-calculated drape surface during the period August 14 to November 8, 2015.

In-field quality control, quality assurance, and preliminary processing were carried out on a daily basis during the data acquisition phase. Final data processing for the survey, including generation of final digital data and map products, were completed at Precision's head office in Vancouver, British Columbia.

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1.0 Introduction

This report outlines the geophysical survey operations and data processing procedures taken during an airborne magnetic survey flown at the Search 2015 survey area for Geoscience BC. The survey contract was awarded on August 6, 2015, and the survey was flown during the period from August 14th to November 8th, 2015. The survey block was located in west-central British Columbia, Canada, centered approximately between Kitimat and Smithers (Figure 1). It was flown by helicopter with a pre-calculated drape surface in accordance with Geoscience BC specifications. No formal interpretation was requested or completed for this survey.

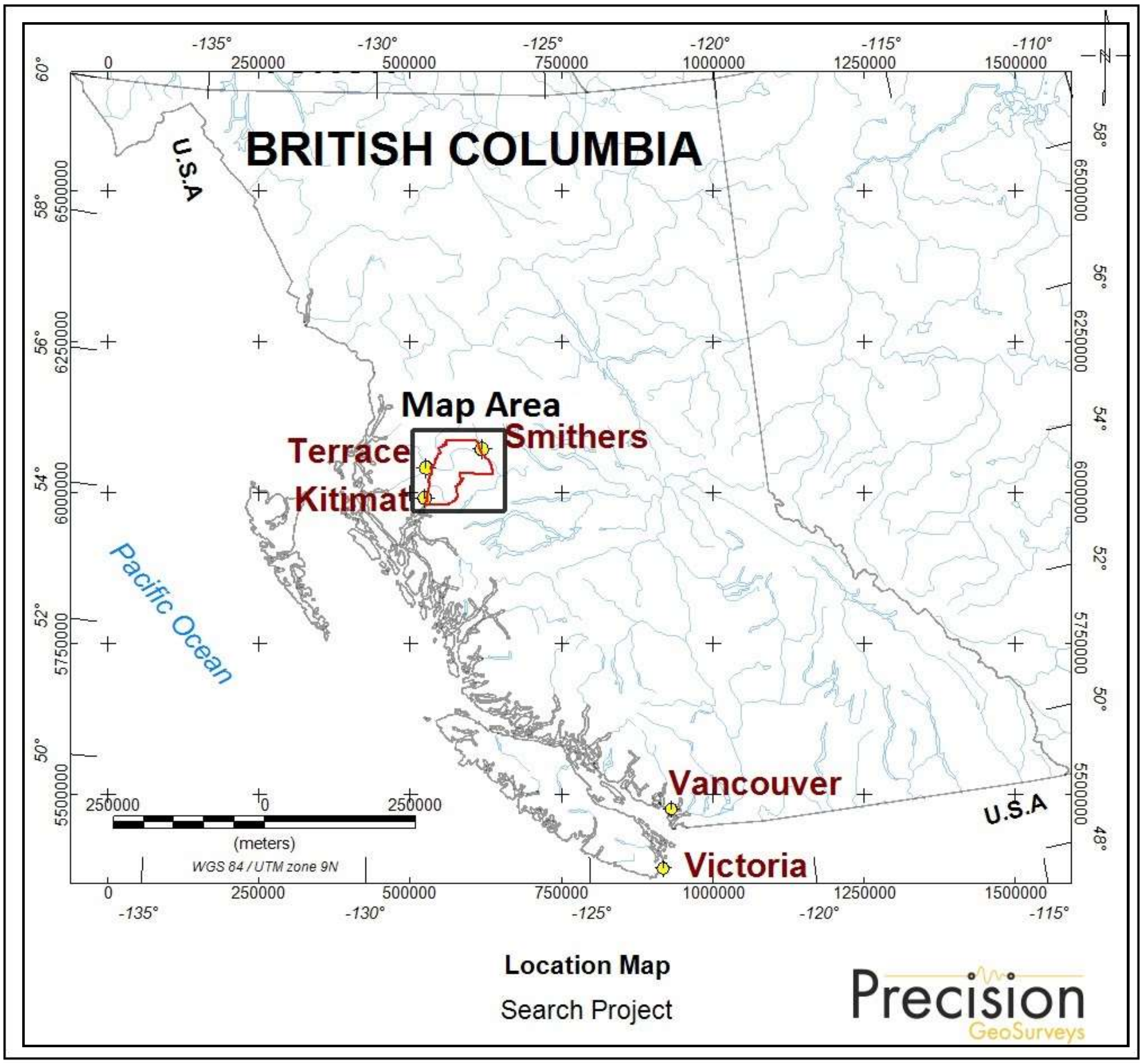

Figure 1: Search Project location map.

1.1 Survey Area

The Search 2015 survey block covers an irregular area of 104.7 km (E-W) by 100.7 km (N-S) (Figure 2) for a total of 6755.6 km^2 within NTS map sheets 93E, 93L, 93M, 103H, 103I, and 103P. The survey area contains rugged mountainous terrain with elevations ranging from 10 meters (along Douglas Channel near Kitimat) to 2758 meters ASL (Howson Peak). The survey plan includes 423 survey lines and 45 tie lines.

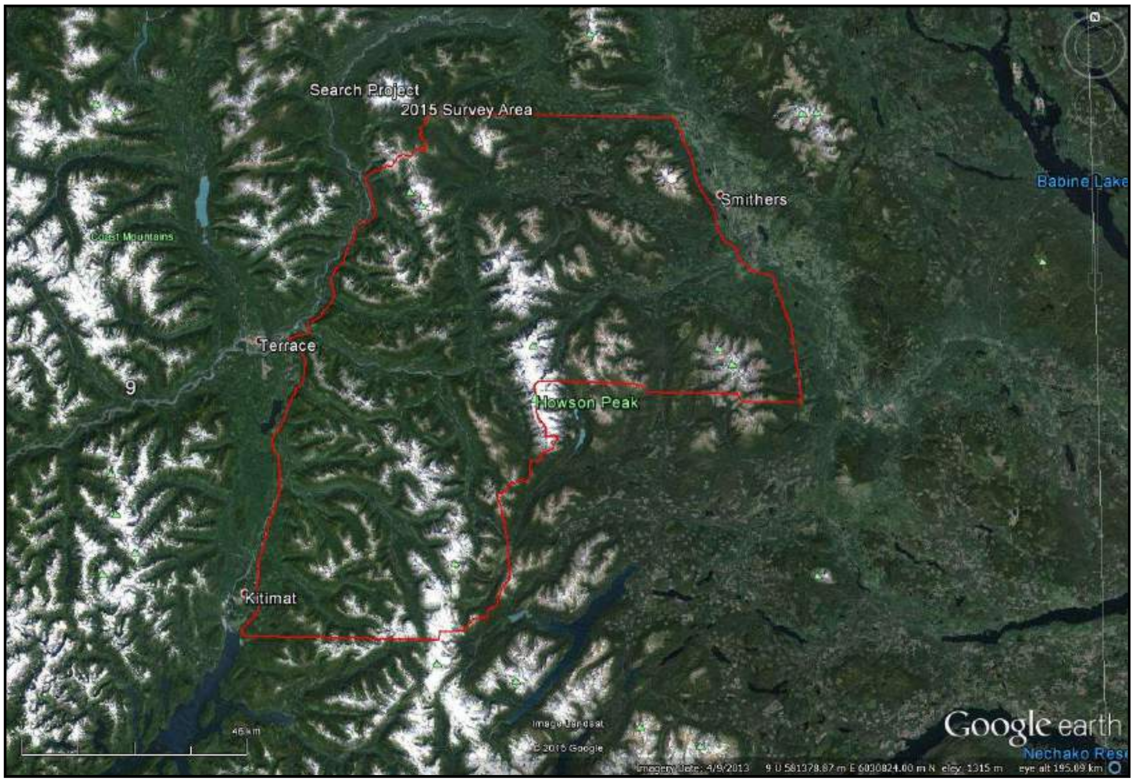

Figure 2: Search 2015 survey area in west-central British Columbia. Block boundary in red. The survey block is located between the communities of Smithers to the northeast, Terrace to the west, and Kitimat to the southwest.

Survey lines were flown at 250 meter spacing at a 090°/270° heading; tie lines were flown at 2,500 meter spacing at a heading of 000°/180° (Figures 3 and 4). A total of 29,821 line km of magnetic data was collected.

The Search 2015 geophysical survey area covered traditional territories of several First Nations. Proponents wishing to use the data presented here for business or land use decisions are encouraged to engage early in relationship-building and information-sharing with the relevant First Nations. Resources are available on BC Government websites to assist with identifying and consulting with First Nations.
Visit: http://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/ consulting-with-first-nations for further information.

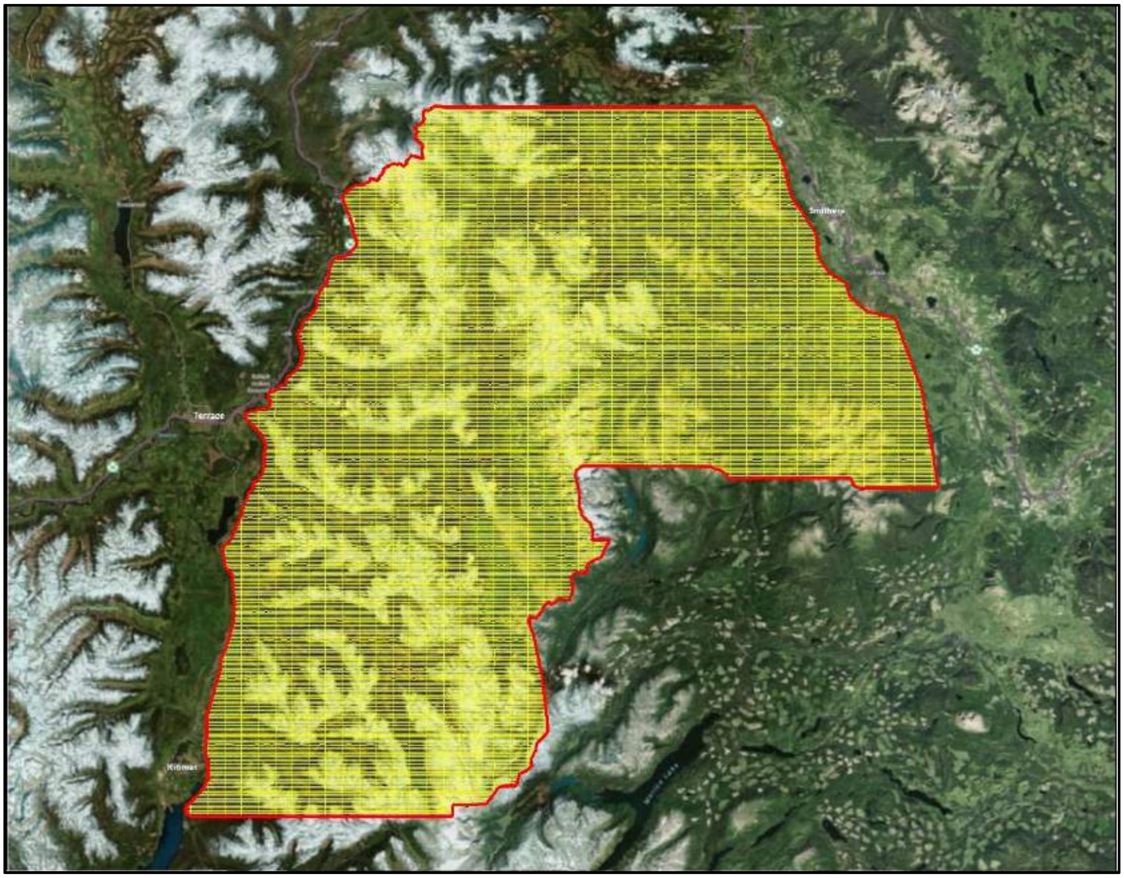

Figure 3: Plan View – Search 2015 survey area with actual flight lines displayed in yellow and the block boundary in red.

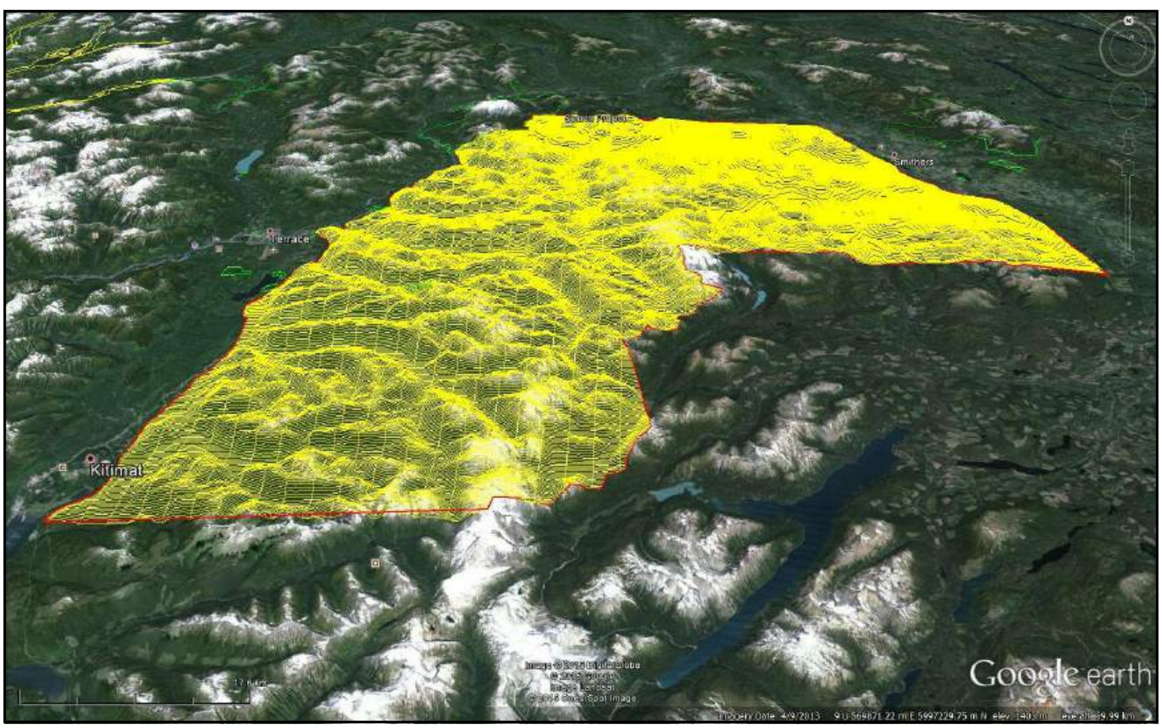

Figure 4: Oblique View – Search 2015 survey area with actual flight lines displayed in yellow and the block boundary in red.

1.2 Survey Specifications

Geoscience BC's Search 2015 aeromagnetic survey covers an irregular area of 6,755.6 km^2 (Figure 5). The geodetic system used for this survey was NAD 83, zone 9N. The survey data acquisition specifications are provided in Table 1.

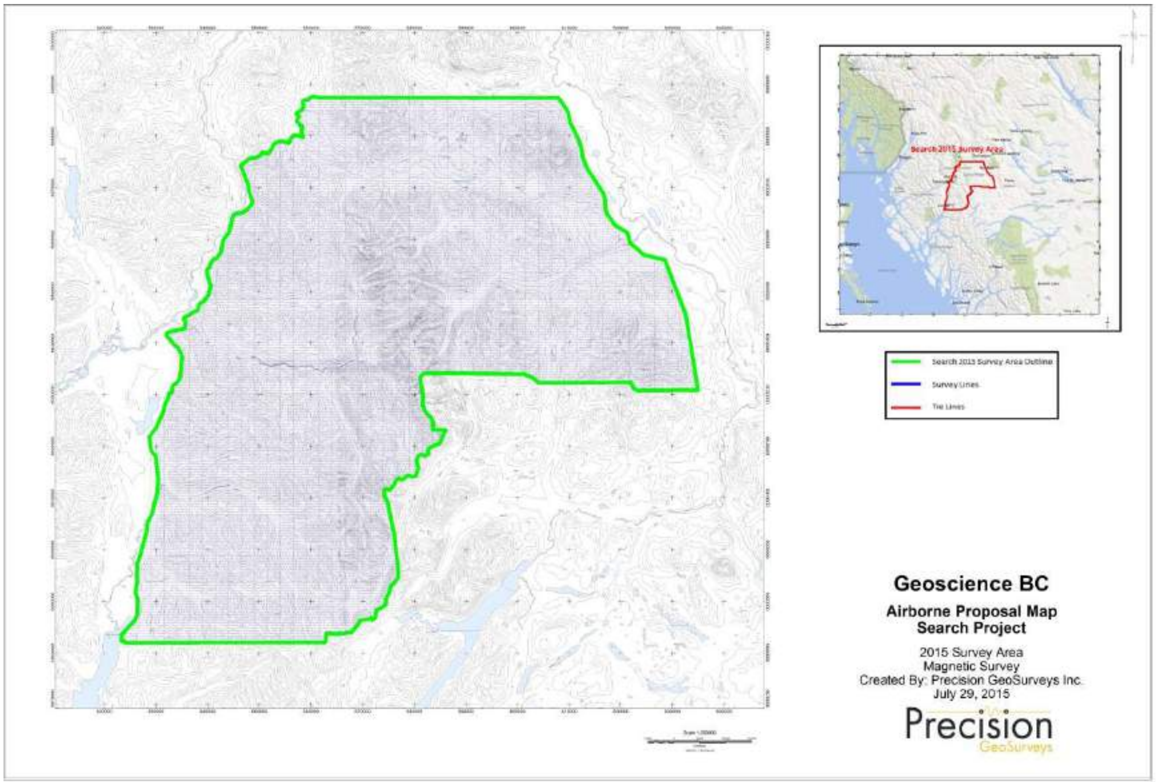

Figure 5: Search 2015 survey area showing proposed survey boundary in green, 423 survey lines in blue, and 45 tie lines in red.

Block Name	Area (km^2)	Line Type	Planned No. of Lines	Planned Line Spacing (m)	Line Orientation	Nominal Survey Height (m)	Total Planned Line km	Total Actual km Flown
Search 2015	6755.6	Survey	423	250	090°/270°	80	27064	27111
		Tie	45	2500	000°/180°	80	2763	2710
		Total:	468				**29827**	**29821**

Table 1: Search 2015 survey area flight line specifications. Planned and actual line km differ due to irregular block boundary. Actual survey height varies in accordance with pre-calculated drape surface.

1.3 Drape

Airborne geophysical data are collected at a predetermined height above ground level. Height is a critical factor in determining many parameters, in particular survey cost and data quality. Typical methods of altitude control during airborne geophysical surveys are constant height AGL (sometimes incorrectly known as contour flying), constant elevation ASL, and a mathematically-derived elevation model called drape. In accordance with Geoscience BC's specifications for the Search 2015 aeromagnetic survey, a pre-calculated drape surface was used for all data collection operations.

The drape model yields a much smoother surface than the actual topography; therefore, when compared to constant height AGL surveys, it has the benefits of quantifying the predicted flight height, increasing production, reducing survey cost, establishing uniform parameters for multiple surveys, and possibly minimizing the difference in elevation between survey and tie lines at their intersection points which is beneficial for leveling routines. However, a smooth drape surface over steep terrain will invariably result in a high variation in ground clearance for the survey aircraft and sensors. Therefore, resolution and amplitude of geophysical anomalies will be affected.

1.3.1 Drape Calculation

The drape surface used to fly the Search 2015 survey area was calculated using GSC (Geological Survey of Canada) Open File 7690 Drape DTM 2.0 software using a DEM (ftp://ftp2.cits.rncan.gc.ca/pub/bndt/250k_shp_en/) retrieved on June 30, 2015 (Figure 6). The drape parameters were set to 80 m nominal terrain clearance and maximum aircraft climb and descent profiles of 40% (2 m of climb or descent for every 5 m of horizontal distance), which was well within the safe operating envelope of the survey helicopter. The resulting drape surface (Figure 7) yielded a planned flight height ranging from 80 m to 1570 m AGL (Figure 8), where the actual flight height above ground is effectively an inverse of the terrain (Figure 9). As a result, a GPS-based flight profile was produced and displayed on the Pilot Guidance Unit (PGU) for pilot height guidance during survey operations.

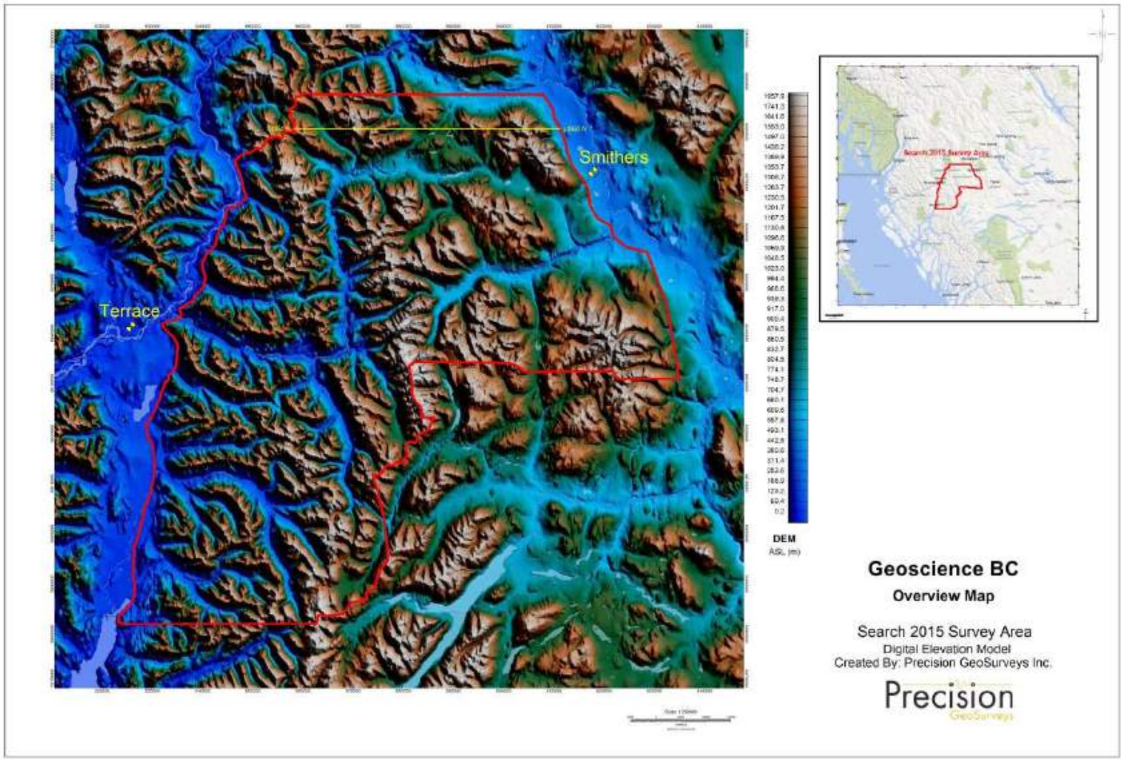

Figure 6: Digital Elevation Model (DEM) used to calculate drape surface. Yellow line is L3590 shown in Figure 9. Source: National Topographic Data Base (NTDB), Canada (ftp://ftp2.cits.rncan.gc.ca/pub/bndt/250k_shp_en/) March 2007. Retrieved June 30, 2015.

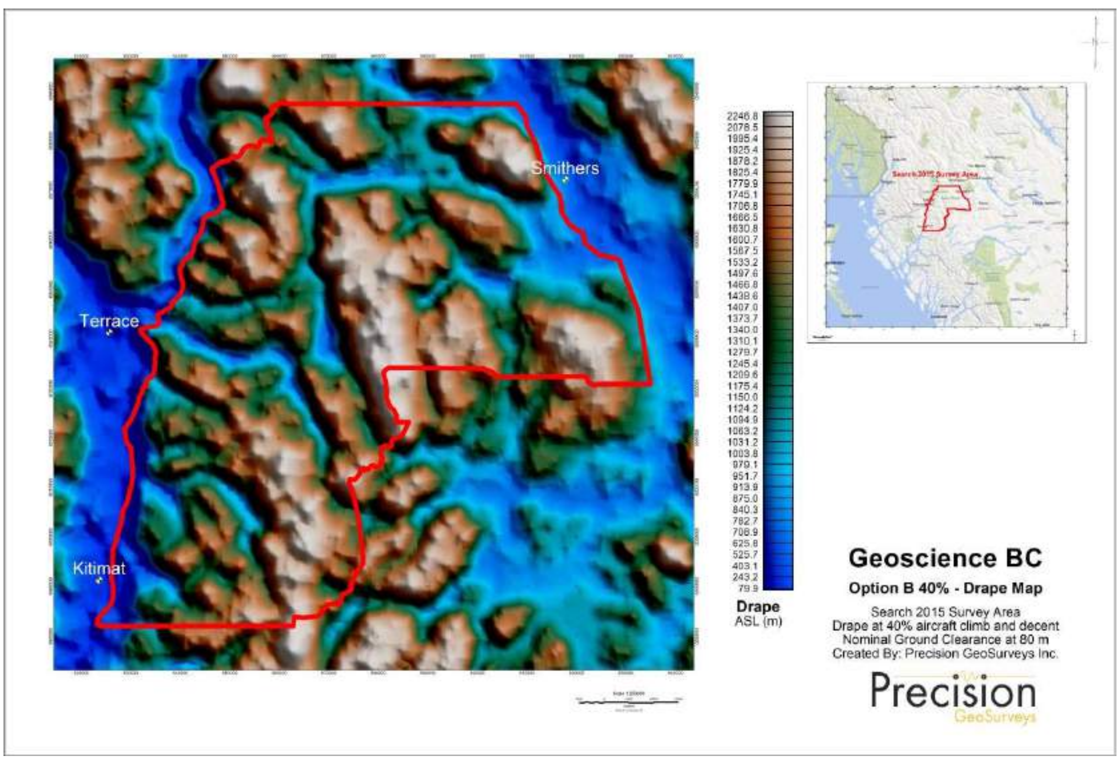

Figure 7: Drape surface at 40% aircraft climb and descent profile with 80 m AGL nominal terrain clearance used to fly Search 2015 aeromagnetic survey area.

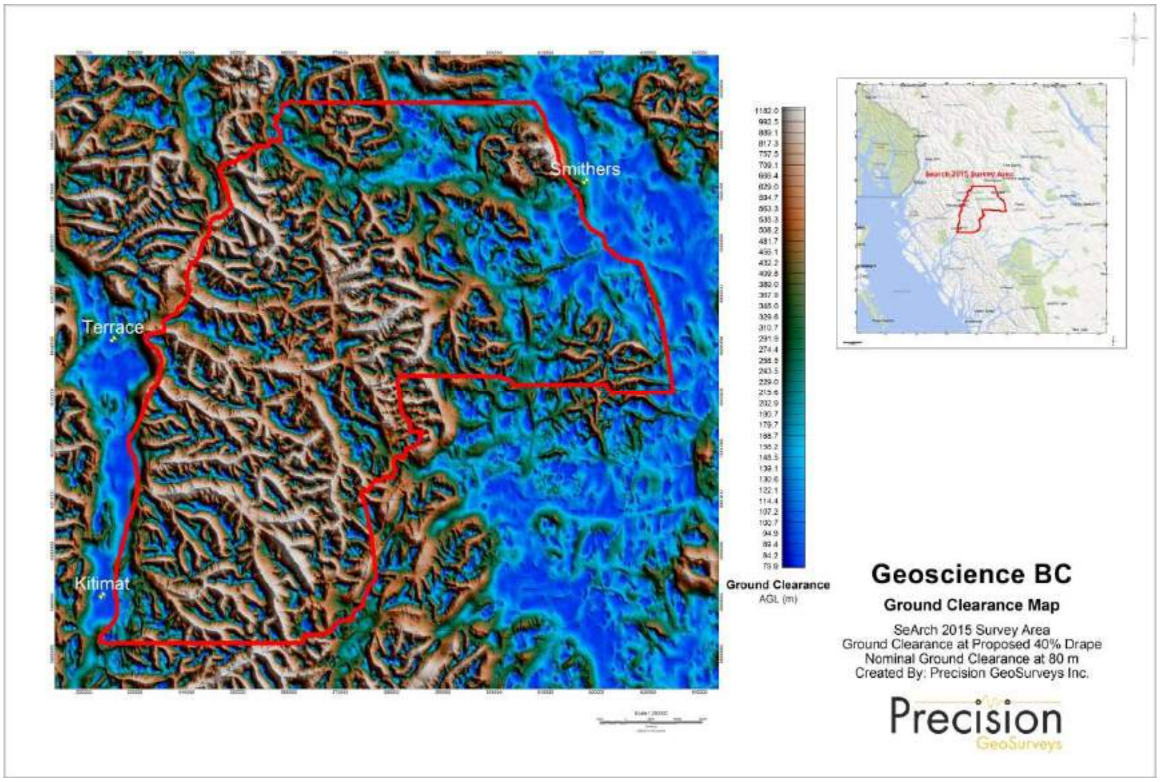

Figure 8: Map showing calculated aircraft height above ground level while following drape surface shown in Figure 7. Aircraft height AGL = drape surface – DEM.

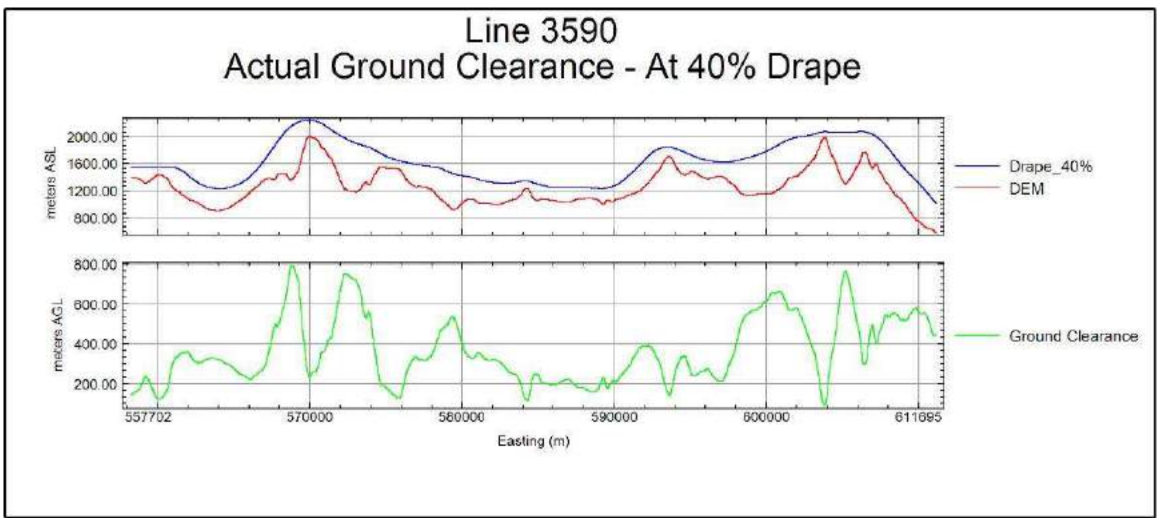

Figure 9: Sample profile of planned ground clearance versus drape surface at 40% slope on Line 3590. Easting (m) as the x-axis, elevation above sea level (m) as the y-axis (top), and the calculated ground clearance at 40% drape (bottom) profile. Refer to Figure 6 for location of Line 3590.

2.0 Geophysical Data

Geophysical surveys contribute to our understanding of the physical properties of the Earth's subsurface. Data are collected in a variety of ways and are used to aid in determination of geology, mineral deposits, oil and gas deposits, geotechnical investigations, contaminated land sites, and other purposes. In order to obtain data which accomplishes this goal the survey technology must be matched to the physical property being mapped.

2.1 Magnetic Data

Magnetic surveying is the most common airborne survey conducted for geological mapping purposes and is also widely used for both mineral and hydrocarbon exploration. Aeromagnetic surveys measure and record the total intensity of the magnetic field at the magnetometer sensor. The recorded data are a combination of the desired magnetic field generated by the earth's magnetized crust as well as undesired magnetic fields due to effects of solar wind interacting with the magnetosphere and the magnetic field generated by the aircraft. By subtracting undesired solar wind effects, diurnal variations, diurnal drift, regional magnetic gradients, and aircraft effects, the resultant aeromagnetic map represents the spatial distribution and relative abundance of magnetic materials (most commonly the iron oxide mineral magnetite $Fe^{2+}Fe^{3+}{}_2O_4$) in the upper levels of the Earth's crust. The shape, dimensions, and amplitude of magnetic variations can be related to the orientation, geometry, size, depth, and magnetic susceptibility of the Earth's subsurface as well as the intensity and inclination of the Earth's magnetic field in the survey area.

For the purpose of the Search 2015 survey area, airborne magnetic data were acquired to map the relative distribution of magnetic minerals within subsurface rock formations. In turn, the distribution and concentration of magnetic minerals can be used to draw conclusions about lithology, geologic structure, and alteration in the survey area.

3.0 Survey Operations

Precision GeoSurveys flew the Search 2015 survey area out of Terrace, BC. The experience of the pilots helped to ensure that the data quality objectives were met and that the safety of the flight crew was never compromised given the potential risks involved in airborne geophysical surveying. Field processing and quality control checks were done daily by on-site geophysicists. The survey was started on August 14, 2015 and completed on November 8, 2015. The survey encountered substantial delays due to poor weather.

3.1 Operations Base and Crew

The base of operations for this survey was Quantum Helicopters Ltd.'s hangar at the Terrace regional airport (CYXT), at the western edge of the Search 2015 survey area. Helicopter fuel was sourced from the Terrace airport, Smithers airport, and several strategically placed road-accessible fuel caches.

Precision's geophysical crew consisted of 12 crew members (Table 2).

Crew Member	Position
Harmen Keyser, P.Geo.	Pilot / Project Manager
Lars Helgesen	Pilot
Cory Mercer	Pilot
Ted McCreery	Pilot
Don Plattel	Pilot
Melody Steele	Geophysical operator and helicopter co-pilot
Brenton Keyser	Geophysical operator and fixed wing support pilot
Geoffrey Pilgrim	Geophysical operator and electronics technician
Lee Guest, B.Sc.	On-site Geophysicist (based in Terrace) and data processor
Shawn Walker, M.Sc., GIT	On-site Geophysicist (based in Terrace) and data processor
Chris Blount	Base station operator (based in Smithers)
Jenny Poon, P.Geo.	Supervising Geophysicist and data processor (off-site)

Table 2: Personnel employed by Precision GeoSurveys to collect and process Search 2015 survey area aeromagnetic data.

3.2 Base Station Specifications

Three GEM GSM-19T proton precession magnetometers were used to accurately record diurnal variations and geomagnetic storms in the survey area. Two of the three GEM GSM-19T base stations were set up in Terrace, BC, and the third in Smithers, BC (Table 3; Figures 10 to 12).

Station name	Location	Easting/Northing	Longitude/Latitude	Datum/ Projection
GEM 1 S/N 8052735	Smithers	616175E 6076208N	54° 49' 10.3152" N 127° 11' 30.7605" W	WGS 84, Zone 9N
GEM 4 S/N 2105651	Terrace	527144E 6037149N	54° 28' 52.5072" N 128° 34' 51.7901" W	WGS 84, Zone 9N
GEM 5 S/N 1094678	Terrace	527176E 6037126N	54° 28' 51.7584" N 128° 34' 50.0197" W	WGS 84, Zone 9N

Table 3: Magnetic base station locations.

The magnetic base stations were located in magnetically noise-free areas, away from metallic items such as ferromagnetic objects, vehicles, or power lines that could affect the base station or survey data. Base station readings were reviewed at regular intervals to ensure that no airborne data were collected during periods of heightened geomagnetic activity, so that airborne data collection was limited to periods when geomagnetic activity did not exceed 10 nT within a five minute interval.

Figure 10: GEM 1 (left), GEM 4 (center), and GEM 5 (right) magnetic base stations.

Figure 11: GEM 1 base station location at Smithers airport (CYYD).

Precision GeoSurveys

Figure 12: GEM 4 and GEM 5 base station magnetometer locations at Terrace airport (CYXT).

In addition to the two base stations set up in Terrace, a third base station (GEM 1) recorded geomagnetic activity at Smithers (98 km NE of GEM 4 and GEM 5 in Terrace) near the northeastern part of the Search 2015 survey area. The large scale of the survey area prompted a comparison between base station data acquired in Terrace versus Smithers. Analysis of the two base station locations showed that when geomagnetic levels were within survey specifications, an extremely high degree of coherence existed between both locations (Figure 13). Therefore, the magnetic data recorded by GEM 5 at Terrace were used for magnetic corrections. GEM 1 and GEM 4 were used as backups.

Geomagnetic and diurnal variations recorded by the stationary base magnetometers were removed from the magnetic data recorded by the helicopter to ensure that the anomalies seen were attributable to changes in subsurface physical properties, specifically crustal magnetization, and not due to solar magnetic activity.

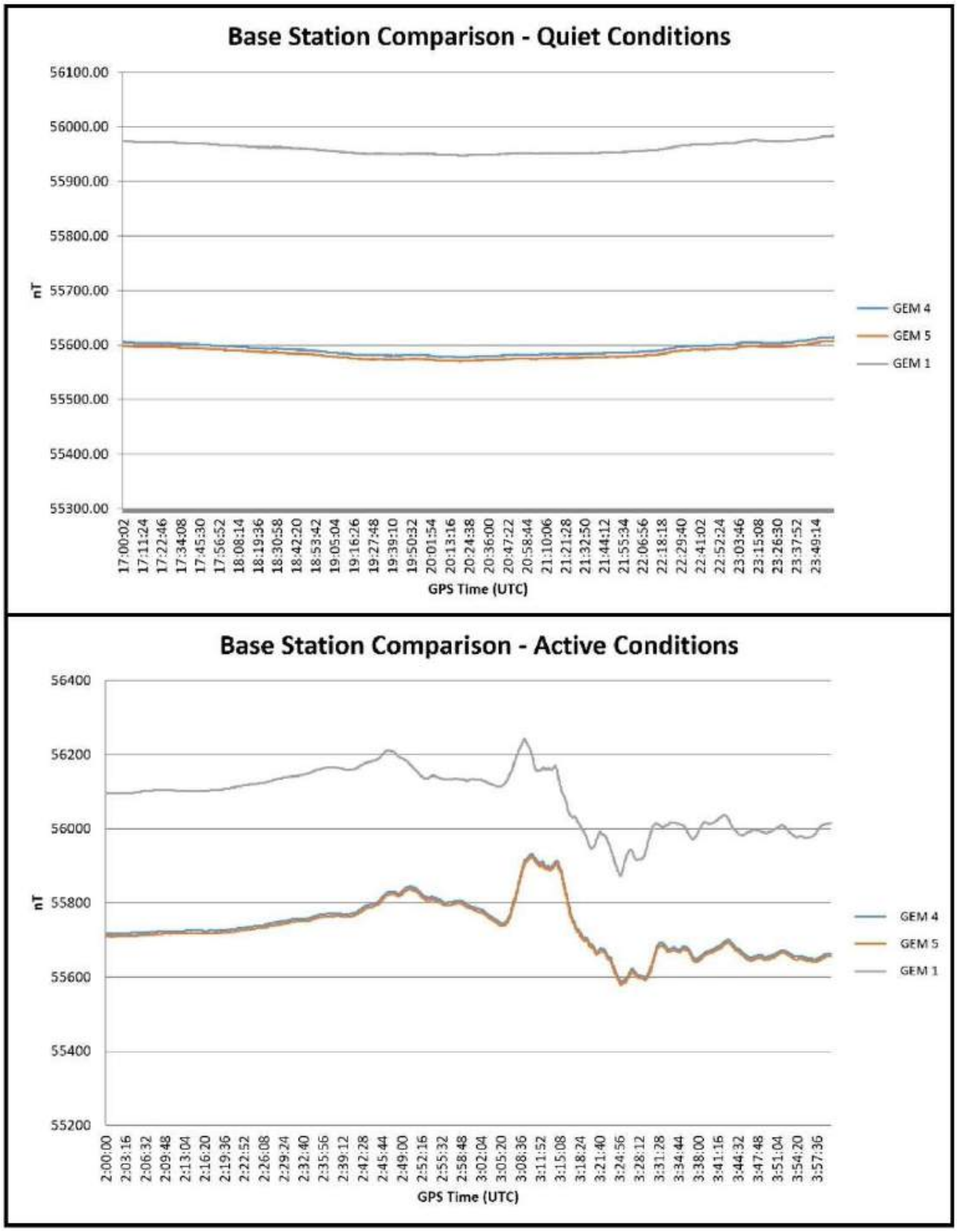

Figure 13: Geomagnetic activity recorded by all three base stations on Aug. 21 (top – quiet) and Aug. 26 (bottom – active). The consistently higher magnetic values recorded by GEM 1 in Smithers (average 369.21 nT difference) are due to regional changes in the Earth's magnetic field.

Geomagnetic activity remained quiet for the majority of the survey. Figure 14 shows diurnal variations for the Search 2015 survey, as recorded on September 17, 18, and 19. A total of six survey lines (L1150, L1230, L1520, L1530, L1580, and L1590) were re-flown due to active solar magnetic storms resulting in magnetic field variations outside of contract specifications.

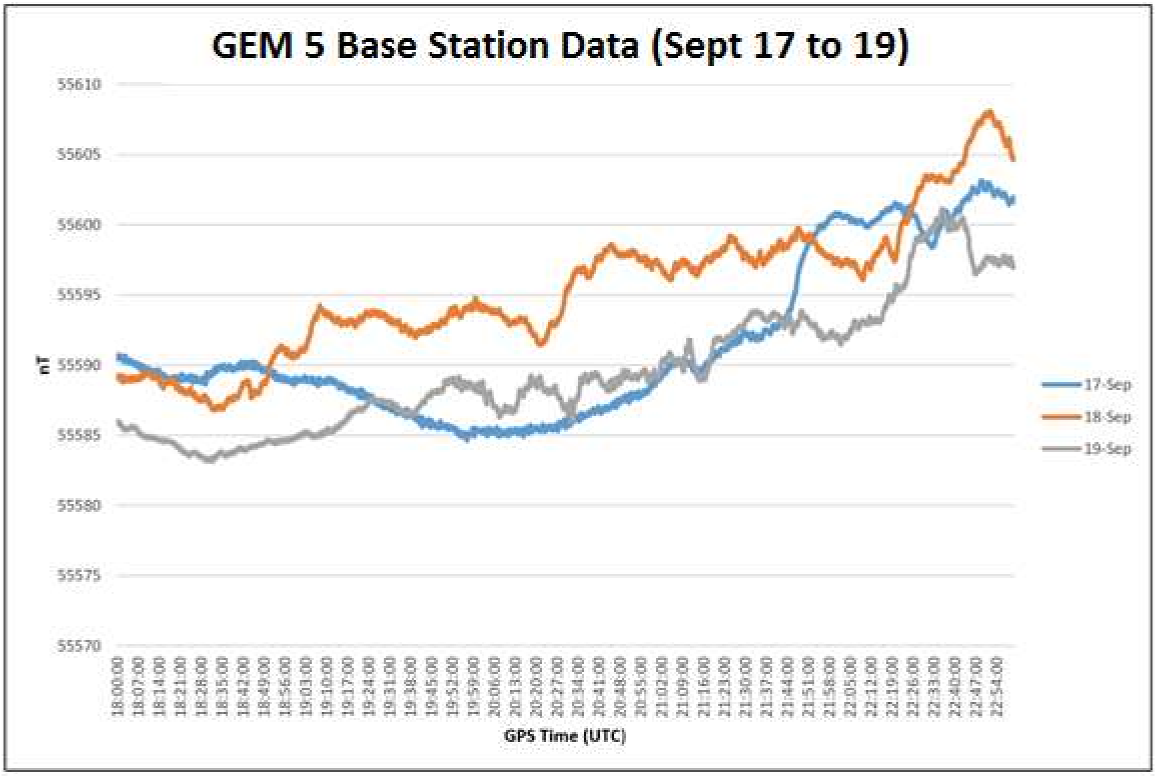

Figure 14: GEM 5 base station data collected during the period Sept. 17 to Sept. 19, 2015. Increasing trend attributable to diurnal fluctuation.

High levels of solar wind and diurnal activity can reduce the effectiveness of base station corrections. Increasing distance between the base station(s) and the survey area will further decrease the reliability of base station corrections. Therefore, a regression analysis of data collected by GEM 1 (Smithers) and GEM 5 (Terrace) was completed (Figure 15). Over the course of seven hours the two base stations recorded near-perfect correlation, and confirmed the suitability of all data to be processed using one base station, Gem 5. The unwanted effects of magnetic storms and diurnal variations were removed from the airborne data during post processing.

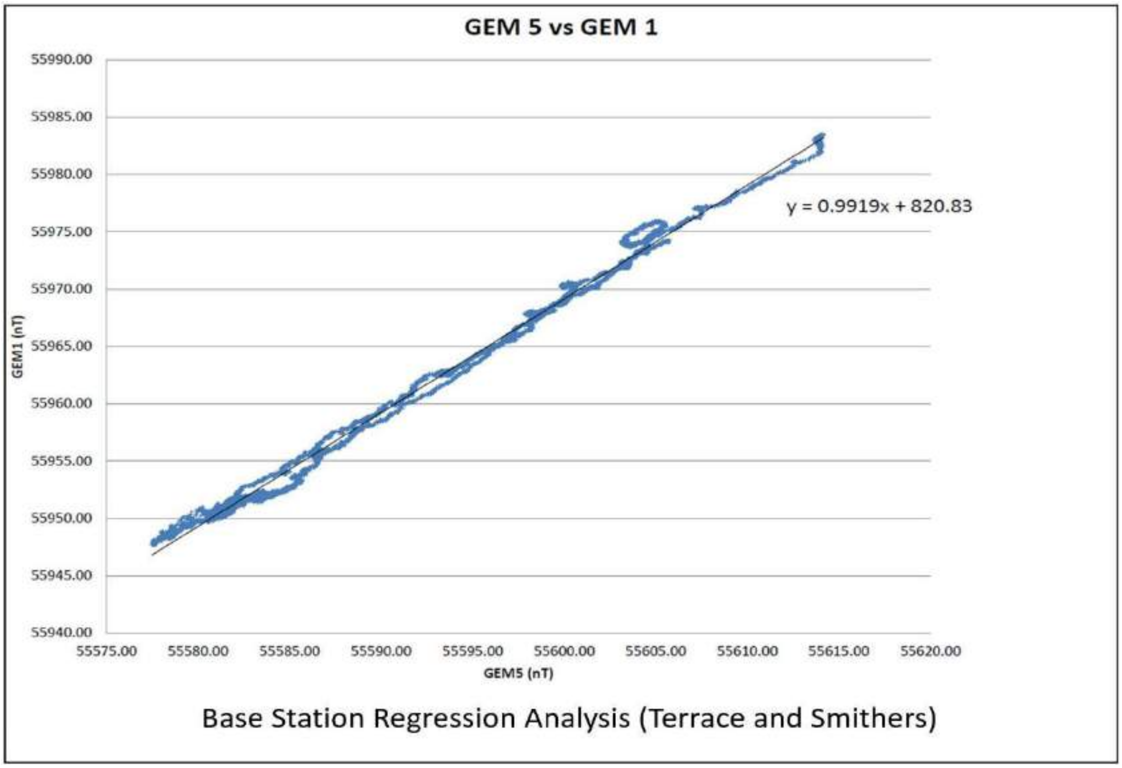

Figure 15: Plot of GEM 5 (Terrace) and GEM 1 (Smithers) base station data collected for 7 hours on August 21st. Regression analysis shows a high degree of magnetic correlation between Smithers and Terrace.

In addition to solar storms which cause dramatic changes in the Earth's magnetosphere, low frequency events which result in either a slow increase or decrease in average recorded values can be measured. To help identify this phenomenon, known as diurnal drifting, base station daily averages were calculated and plotted (Figure 16).

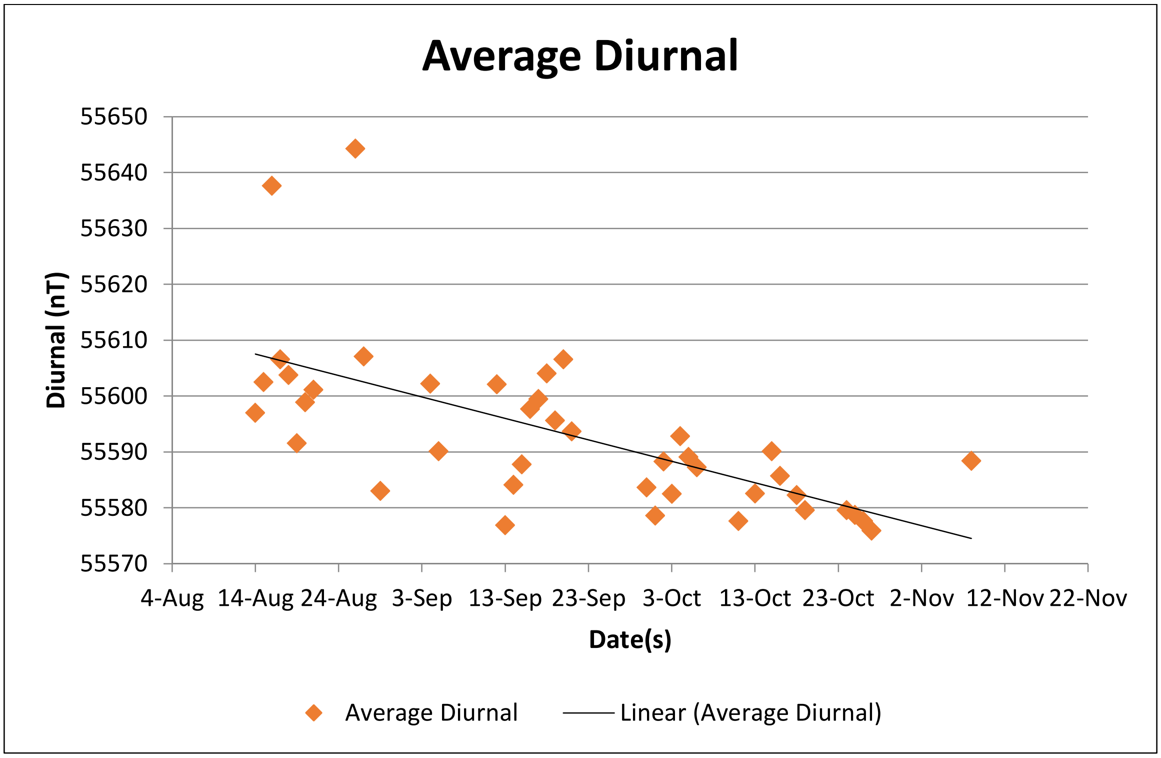

Figure 16: Calculated daily averages from GEM 5 magnetic base station for entire survey period. An apparent downward trend in daily averages represents diurnal drifting. Outliers on August 16th and August 26th are attributable to solar storms. No airborne data were collected on days without data points.

All base station datasets were retained for future reference and re-processing initiatives.

3.3 Field Processing and Quality Control

On a flight-by-flight basis, airborne survey data were transferred from the helicopter's data acquisition system onto a USB flash drive and then copied onto a field data processing laptop. The raw data files were in PEI binary data format and were converted into Geosoft GDB database format. Using Geosoft Oasis Montaj 8.3.3, the quality of the data were inspected to ensure that they met the contract specifications (Tables 4 and 5). All flight lines (Figures 17 and 18) which did not meet survey specifications (left/right and up/down) were re-flown. Selected suspect magnetic anomalies, especially those found on a single flight line, were re-flown for confirmation. Where required, re-flight lines were a minimum of 3000 m long; so that survey line re-flights crossed at least two tie lines, and tie line re-flights crossed at least 10 survey lines.

Parameter	Specification	Details
Position	Line Spacing	Flight line deviation from flight path by more than 50 m left/ right for 1.0 km or more.
	Height	Flight height deviation from drape surface by more than 15 m up/down for 1.0 km or more, provided line deviation from height is not due to tall trees, topography, cultural features, mitigation of wildlife harassment, or other obstacles beyond the pilot's control. Any tie lines where more than 10% of the absolute altitudes between survey line and tie line intersection points vary more than 30 m will be re-flown.
	GPS	Any flight lines where 3 or less GPS satellites received for distances of greater than 1 km, provided signal loss is not due to topography.
Magnetics	Geomagnetic & Diurnal Variation	Non-linear magnetic diurnal variations exceed 10 nT from a linear chord of length five (5) minutes.
	Normalized 4th Difference	Magnetic data exceeding 0.30 nT peak to peak for distances greater than 1 km or more (provided noise is not due to geological or cultural features).

Table 4: Contract re-flight specifications.

Geoscience BC Specification	Tolerance	Actual
L-R navigation	max 1 km at 50 m	97.68% within 10 m
Up/Down navigation	90% at 15 m	98.44% of flight lines within 15 m of drape
SL/TL intersection points	90% within 30 m height	99.89% within 30 m of height (10847 of 10859 intersecting points).

Table 5: Summary of Geoscience BC flight specification statistics for 29,821 km of survey and tie lines.

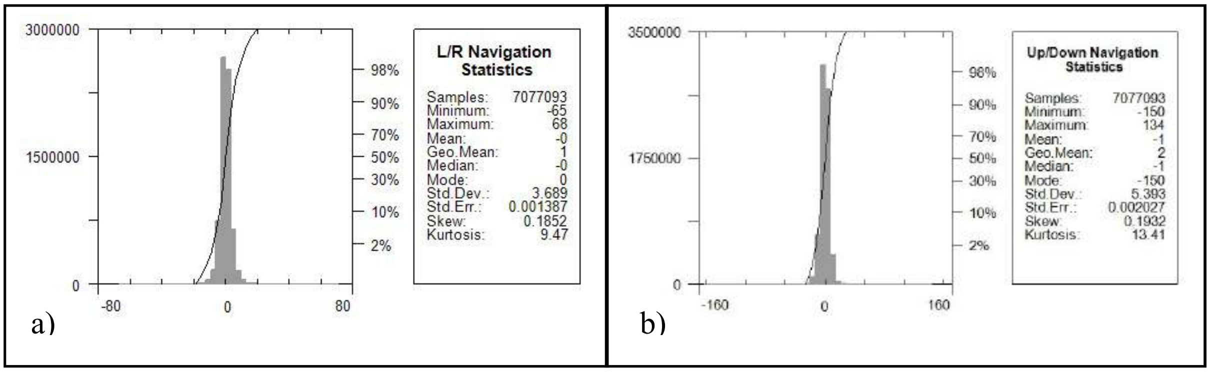

Figure 17: Histograms showing navigation statistics on (a) L/R and (b) Up/Down for 29,821 km of survey and tie lines on Search Project.

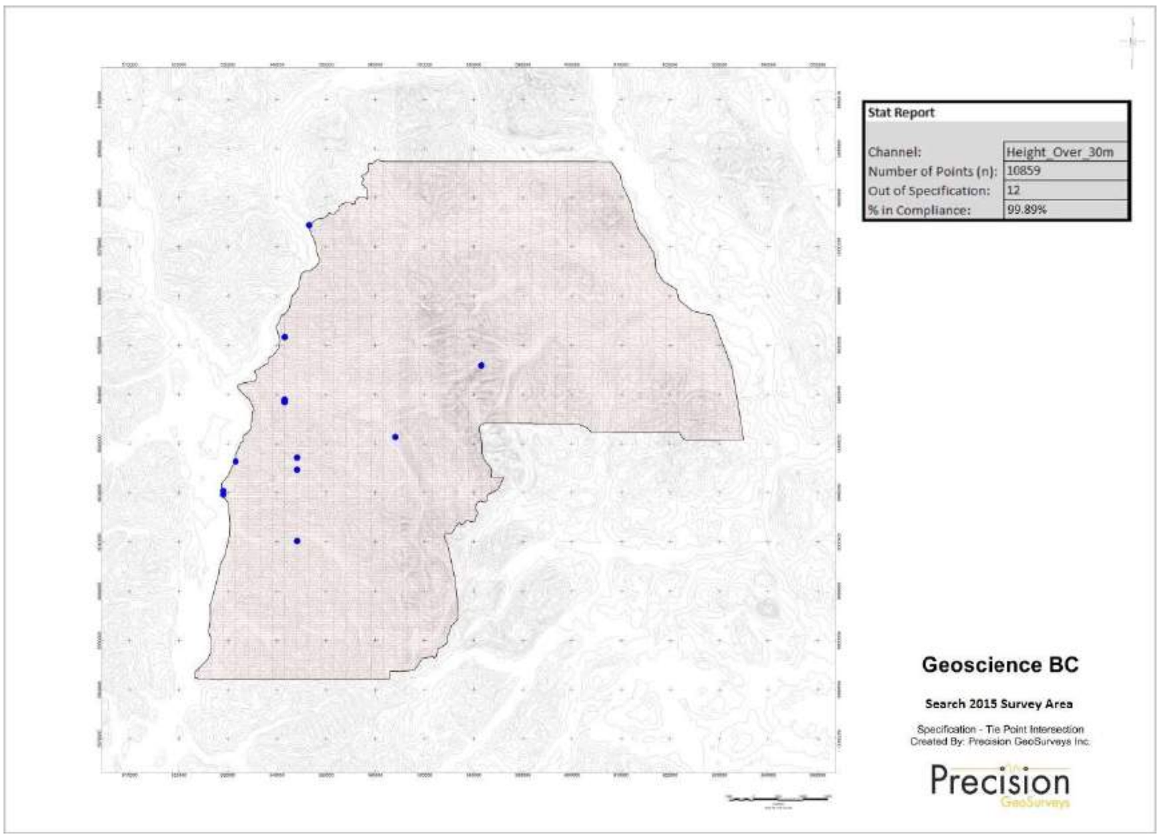

Figure 18: Map showing 10,859 SL/TL intersection points, with 12 SL/TL intersection points exceeding 30 m in height difference shown with blue dots.

3.4 Wildlife Observations

As part of the Geoscience BC survey contract, it was recognized that noise from the survey helicopter could negatively affect various wildlife in the survey area, especially caribou from the Telkwa herd (Hemmera Envirochem Inc. report, August 2015). Accordingly, Precision's flight crews were provided authority to modify or abandon flight paths in the event of ungulate wildlife disturbance as noise mitigation measures, and were required to record animal sightings and behavior. No caribou were observed during the 29,821 line km survey, and observations of mountain goats and bears were noted in the flight logs (Appendix E).

4.0 Aircraft and Equipment

All geophysical and subsidiary equipment were carefully installed on Precision GeoSurveys geophysical aircraft. For this survey, a magnetometer, a data acquisition system, magnetic compensation system, a pilot guidance unit (PGU), a GPS navigation system, and magnetic base stations were required to carry out the survey and collect high quality data. The survey magnetometer was carried in an approved “stinger” configuration to enhance flight safety, increase survey production, and improve data quality.

4.1 Aircraft

Precision GeoSurveys flew the Search 2015 survey area using a Bell 206B JetRanger helicopter, registration C-GTVL (Figure 19). The aircraft’s ferromagnetic and paramagnetic properties were reduced prior to commencing the survey, and at regular intervals during the survey, using a proprietary degaussing process to help improve the quality of the collected magnetic data.

Figure 19: Bell 206B JetRanger helicopter C-GTVL at Terrace airport (CYXT) equipped with mag stinger for magnetic data acquisition.

4.2 Geophysical Equipment

The survey helicopter was equipped with magnetic sensors, a navigation system, and a data logger to allow the recording of magnetic data on the Search 2015 survey. The total field magnetic signal recorded at the airborne magnetic sensor is a measurement of the Earth's magnetic field at a specific time and location, and is a combination of the desired magnetic field generated by the Earth's subsurface as well as a small but significant contribution from the aircraft's magnetic field, solar magnetic disturbances, and a regional magnetic gradient. The magnetic signal that is not part of the desired Earth's subsurface magnetic field is considered noise, and is therefore removed so that the final magnetic product is accurate.

4.2.1 IMPAC

The Integrated Multi-Parameter Acquisition Console (IMPAC) (Figure 20) is the main computer used in data recording, data synchronizing, displaying real-time quality control data for the geophysical operator, and generating navigation information for the pilot and operator display system. External sensors are connected to the system using various RS-232, USB serial communication, and coax cables.

Figure 20: IMPAC data acquisition system.

4.2.2 AGIS

IMPAC uses the Microsoft Windows operating system and geophysical parameters are based on Pico's Airborne Geophysical Information System (AGIS) software. Depending on survey specifications, information such as magnetic field, electromagnetic data, total gamma count, counts of various radioelements (K, U, Th, etc.), temperature, cosmic radiation, barometric pressure, atmospheric humidity, and survey altitude can all be monitored on the AGIS on-board display for immediate quality control (Figure 21).

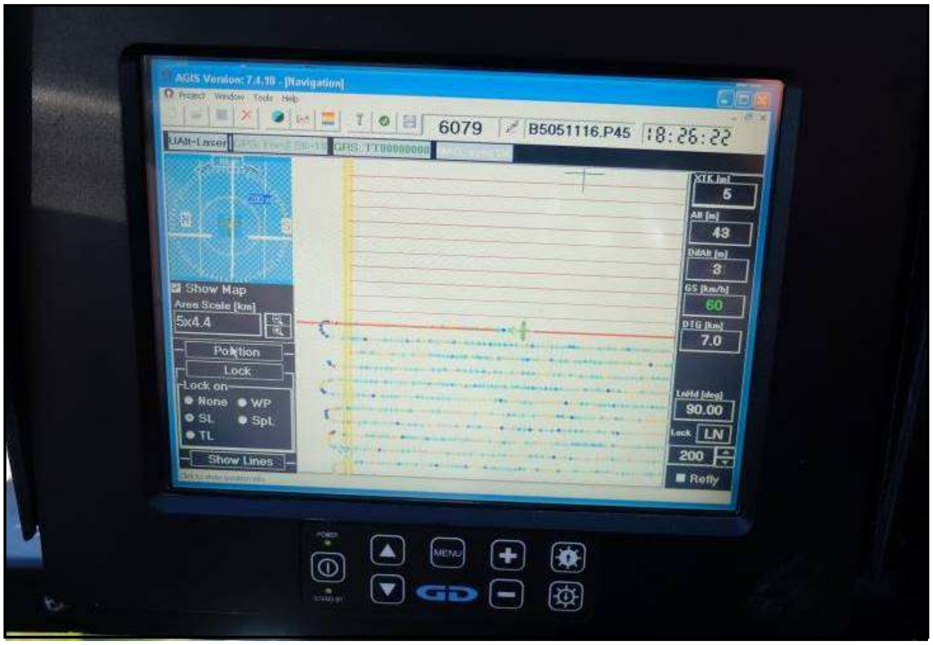

Figure 21: IMPAC/AGIS operator display installed in the Bell 206B helicopter, with screen displaying real time flight line recording and navigation parameters. Additional windows display real time geophysical data to operator.

The AGIS data format is converted into Geosoft or ASCII file formats by a conversion program called PEIView. The operator can view raw magnetic response, magnetic fourth difference, compensated and uncompensated data, aircraft position, survey altitude, cross track error, and other parameters for immediate QC (quality control) of the geophysical data. Additional Pico software allows for post or real time magnetic compensation and survey quality control procedures.

4.2.3 Magnetometer

The airborne magnetic sensor used by Precision GeoSurveys for the Search 2015 survey area was a Scintrex cesium vapor CS-3 magnetometer (S/N 1107379). The system was mounted on the front of the helicopter in an approved “stinger” configuration (Figure 22). The CS-3 is a high sensitivity/low noise magnetometer with automatic hemisphere switching and a wide voltage range; the static noise rating for the unit is +/- 0.01 nT. Magnetic data were recorded at 10 Hz. A separate fluxgate magnetometer determined the helicopter’s attitude (pitches, rolls, and yaws) relative to the inclination and declination of the Earth’s magnetic field, which was necessary to remove magnetic noise created by the movement of the helicopter through a compensation process.

Figure 22: View of mag stinger installed on Bell 206B C-GTVL, used on Search 2015 survey.

4.2.4 Base Stations

To monitor and record the Earth's diurnal magnetic field variation, Precision GeoSurveys operated three GEM GSM-19T magnetometer base stations. Two of the base stations were operated continuously on the north side of the Terrace airport throughout the airborne data acquisition operation, and a third magnetic base station was operated near the Highland Helicopters hangar at the Smithers airport during survey operations within 50 km of Smithers. The base stations were located in secluded areas with low magnetic gradient, away from electric power transmission lines and moving ferrous objects, such as motor vehicles, that could affect the survey data integrity.

The GEM GSM-19T magnetometer (Figure 23) with integrated GPS time synchronization uses proton precession technology with a 0.5 Hz sampling rate. The GSM-19T has an accuracy of +/- 0.2 nT at 1 Hz. Base station magnetic data were recorded on internal solid-state memory, and downloaded onto a field laptop computer using a serial cable and GEMLink 5.0 software. Profile plots of the base station readings were generated, updated, and reviewed at the end of each survey day.

Figure 23: GEM GSM-19T proton precession magnetometer.

4.2.5 Pilot Guidance Unit

The PGU (Pilot Guidance Unit) is a graphical display type unit that provides continuous steering and elevation information to the pilot (Figure 24). It is mounted remotely from the data system on top of the helicopter's instrument panel. The PGU assists the pilot in keeping the helicopter on the planned flight path and on the desired drape surface based on GPS position data.

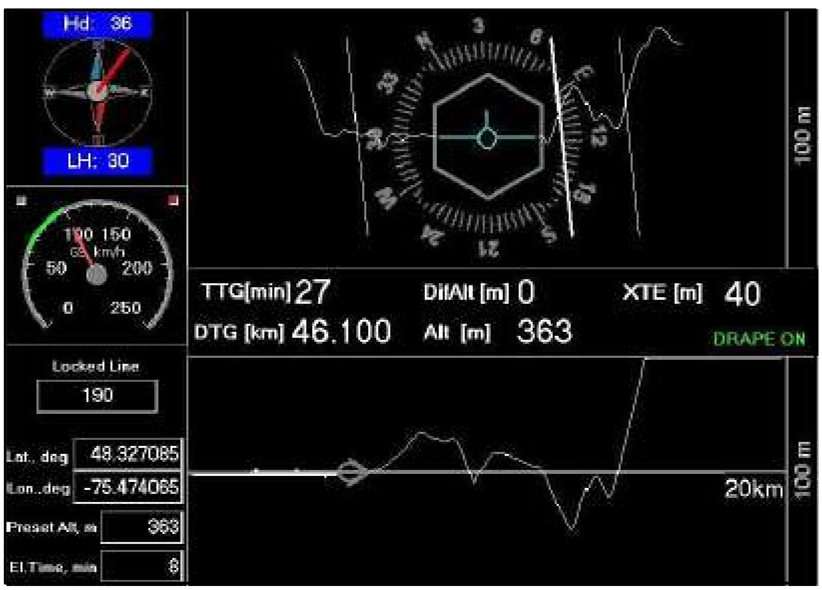

Figure 24: PGU screen displaying navigation information and the desired drape surface based on GPS position data.

The LCD monitor measures 7 inches, with a full VGA 800 x 600 pixel display. The CPU for the PGU is contained in a PC-104 console and uses Microsoft Windows operating system control, with input from the GPS antenna, embedded drape surface profile, and AGIS.

4.2.6 GPS Navigation System

A Hemisphere R220 GPS receiver (Figure 25) and a Hemisphere A52 Geodetic GPS antenna integrated with the AGIS navigation system and pilot display (PGU) provided navigational information and control. The R220 GPS receiver supports fast updates and outputs messages at a rate of up to 20 Hz (20 times per second); delivering sub-meter positioning. It is capable of providing reliable and fast positions of up to centimeter-level accuracy using SBAS enhancement.

Figure 25: Hemisphere R220 GPS Receiver.

Hemisphere's COAST technology allows continuous operation for at least 40 minutes during temporary differential signal outages. It can track GPS, SBAS (Satellite-Based Augmentation System), and L-Band (OmniSTAR HP and XP) differential corrections to provide high precision positioning.

5.0 Data Acquisition Equipment Checks and Calibration

Airborne equipment tests and calibrations were conducted at the start of the survey, and at regular intervals during the survey. There were three tests conducted for the airborne magnetometer: compensation flight, lag test, and heading error test.

5.1 Magnetometer Tests

Before acquiring magnetic data the magnetometer was tested and calibrated. A series of dedicated flights were completed to collect data specifically for removing undesired side-effects of aircraft movement, speed, and heading direction.

5.1.1 Compensation Flight Test

During aeromagnetic surveying a small but significant amount of noise is introduced to the magnetic data by the aircraft itself, as the magnetometer is within the helicopter's magnetic field. Movement of the aircraft (roll, pitch and yaw) combined with the permanent magnetization of certain aircraft parts (in particular the engine and other ferrous magnetic objects) contribute to this noise. The aircraft was degaussed at regular intervals and the remaining magnetic noise was removed by a process called magnetic compensation. A magnetic compensation flight was completed prior to beginning the survey, and every time helicopter maintenance was performed that could have affected the helicopter's magnetic field (Table 6). The process consists of a series of maneuvers where the aircraft flies in the four orthogonal headings required for the survey (000°/180° and 090°/270° in the case of this survey) at a sufficient altitude (typically > 2,500 m AGL) in an area of low magnetic gradient where the Earth's magnetic field becomes nearly uniform at the scale of the compensation flight. In each heading direction, three specified roll, pitch, and yaw maneuvers (total 36) are performed by the pilot at constant elevation so that any magnetic variation recorded by the airborne magnetometer can be attributed to aircraft movement. These maneuvers provide the data that are required to calculate the necessary parameters for compensating the magnetic data and removing aircraft noise from survey data.

Date	Pilot	Location	Aircraft	Headings	Result (FOM)
Aug. 14	Harmen Keyser	Lakelse Lake	C-GTVL	000°/180° - 090°/270°	0.7769 nT
Sept. 4	Don Plattel	Lakelse Lake	C-GTVL	000°/180° - 090°/270°	0.6772 nT
Oct. 14	Harmen Keyser	Lakelse Lake	C-GTVL	000°/180° - 090°/270°	0.6454 nT

Table 6: Compensation flight result summary.

5.1.2 Lag Test

A lag test was performed to determine the relationship between the time the digital reading was recorded by the instrument magnetic sensor and the time for the position fix that the fiducial of the reading was obtained by the GPS system. The test was flown in the four orthogonal headings over an identifiable magnetic anomaly (a bulldozer at the Terrace airport) at survey speed and height. A lag of 5 fiducials (0.5 seconds) was determined from the lag test.

5.1.3 Heading Error Test

To determine the magnetic heading effect a cloverleaf pattern flight test was conducted. The cloverleaf test was flown in the same orthogonal headings as the survey and tie lines (000°/180° and 090°/270°) at >1000 m AGL in an area with low magnetic gradient. For all four directions the survey helicopter must pass over the same mid-point all four times at the same elevation.

6.0 Data Processing

After all the data were collected from a survey flight several procedures were undertaken to ensure that the data met a high standard of quality. All data were processed using Pico Envirotec software and Geosoft Oasis Montaj 8.3.3 geophysical processing software along with proprietary processing algorithms.

6.1 Magnetic Processing

The data obtained from the compensation flight test were applied to the raw magnetic data before any further processing and editing. A computer program called PEIComp was used to create a model from the compensation flight test for each survey to remove the noise induced by aircraft movement; this model was applied to each survey flight so the data could be further processed.

The compensated raw magnetic data were then corrected for diurnal variations, lag, and heading. Any evidence of noise or noisy spikes was removed. The initial corrected data from the survey and tie lines were then used to level the entire survey dataset. Lastly, the International Geomagnetic Reference Field (IGRF) was used to remove the background magnetic field of the earth.

6.1.1 Diurnal Correction

The processing of the magnetic data first involved the correction for diurnal variations. The base station data that were used for the correction came from GEM 5 based in Terrace, BC. The diurnal data were edited, plotted and merged into a Geosoft database (.GDB) on a daily basis. The airborne magnetic data were corrected for diurnal variations by subtracting the observed magnetic base station deviations from the data collected on the helicopter, which effectively removed the effects of diurnal variation, diurnal drift, and geomagnetic storms.

6.1.2 Lag Correction

Following the diurnal correction, a lag correction of 0.5 seconds was applied to the total magnetic field data to compensate for the combination of lag in the recording system and the magnetometer sensor flying 5.4 m ahead of the GPS antenna.

6.1.3 Heading Correction

For each survey heading the magnetic instrument travels along a flight line, changes in instrument magnetic fields are detected and these systematic shifts are recorded. These values are used to construct a heading .TBL table file and applied to the magnetic data to correct for heading errors.

6.1.4 Leveling and Micro-leveling

The initial Total Magnetic Intensity (TMI) data from survey and tie lines were used to level the entire survey dataset. Two forms of leveling were applied to the corrected data: conventional leveling and micro-leveling. There were two components to conventional leveling; Statistical Leveling to level tie lines and Full Leveling to level survey lines. The Statistical Leveling method corrected for mis-ties (SL/TL intersection errors) following a specific pattern or trend. Through the error channel, an algorithm calculated a least-squares trend line and derived a trend error curve, which was then added to the channel to be leveled. The second component was Full Leveling. This adjusted the magnetic value of the survey lines so that all lines matched the trended tie lines at each intersection point.

Lastly, micro-leveling was applied to the corrected conventional leveled data. This iterative grid-based process removed low amplitude components of flight line noise that still remained in the data after tie line and survey line leveling.

6.1.5 IGRF Removal and Leveling to NRCan

The International Geomagnetic Reference Field (IGRF) model is the empirical representation of the Earth's magnetic field (main core field without external sources) collected and disseminated from satellite data and from magnetic observatories around the world. The IGRF is generally revised and updated every five years by a group of modelers associated with the International Association of Geomagnetism and Aeronomy (IAGA). In this case, the IGRF values were calculated from the recently updated model (IGRF – 12) year 2015 and of September 24 filling the "Date Channel".

By subtracting the calculated IGRF from TMI, Residual Magnetic Intensity (RMI) of the Search 2015 survey area was calculated. This created a more valid model of individual near-surface anomalies so that the data were not referenced to a specific time. This will allow for other magnetic data (historic or future) to be more easily incorporated into the Search 2015 survey database.

In accordance with a Geoscience BC request, the Search 2015 RMI was leveled to the residual magnetic intensity grid, obtained from the NRCan Canadian Aeromagnetic Database, by adding 52.54 nT. The leveled Search RMI data will then match other regional magnetic surveys, such as Geoscience BC's TREK survey (located 275 km to the southeast) to account for offsets caused by the local datum chosen for each of the individual surveys.

6.1.6 Calculation of the First Vertical Derivative

The first vertical derivative (1VD) was computed from the leveled Residual Magnetic Intensity (RMI) data. Long wavelengths and vertical rate of change were suppressed in the magnetic field. Therefore, the edges of magnetic anomalies were highlighted and spatial resolution was increased.

7.0 Deliverables

All digital data are presented on a compact disc (CD) and USB memory stick with the logistic report. The survey data are presented as digital databases, maps, and a report.

7.1 Digital Data

The digital files will be provided in two formats, the first will be a .GDB file for use in Geosoft Oasis Montaj and the second format will be a .XYZ (text) file. Full descriptions of the digital data and contents are included in the report (Appendix C).

The digital data were represented as grids, as listed below:

- Digital Elevation Model (DEM) –digital elevation data obtained from NRCan
- Total Magnetic Intensity (TMI)
- Residual Magnetic Intensity (RMI) – removal of IGRF from TMI and leveled to NRCan
- First Vertical Derivative (1VD) - first vertical derivative of RMI
- Second Vertical Derivative (2VD) - second vertical derivative of RMI
- Reduced to Pole (RTP) – reduce to pole of RMI
- Tilt Derivative (TD) – tilt derivative of RMI
- Horizontal Gradient (HG) –horizontal gradient of RMI
- Analytic Signal (AS) – analytic signal of RMI

7.1.1 Gridding

The digital data were gridded and displayed using the following Geosoft parameters:

- Grid cell size: 62.5 m
- Low-pass desampling factor: 3
- Tolerance: 0.0001
- % pass tolerance: 99.99

TMI, RMI, and RTP grids were linearly color shaded; sun angle inclination at 45° and declination at 045°. All other grids were drawn with a histogram-equalized color ramp.

7.2 KMZ Grids

The digital grid data were exported into .KMZ files which can be displayed using Google Earth. The grids can be draped onto topography and rendered to give a 3D view.

7.3 Maps

Digital maps were created for the Search 2015 survey area. The following map products were prepared:

Survey overview maps (colour images with elevation contour lines):

- Actual Flight Lines
- Digital Elevation Model

Magnetic maps (colour images with either elevation contour lines or magnetic contour lines):

- Total Magnetic Intensity
- Total Magnetic Intensity - with plotted flight lines
- Residual Magnetic Intensity
- First Vertical Derivative - of the residual magnetic intensity
- Second Vertical Derivative - of the residual magnetic intensity
- Reduced to Pole
- Analytic Signal - of the residual magnetic intensity
- Horizontal Gradient - of the residual magnetic intensity
- Tilt Derivative - of the residual magnetic intensity

All maps were prepared in NAD 83 and UTM zone 9N at a scale of 1:250,000.

7.4 Report

The logistics report provides information on the acquisition procedures, magnetic data processing, and presentation of the Search 2015 survey area data. A PDF copy of the report is included along with the digital data and maps that are provided on the CD and USB stick.

8.0 Conclusions

Precision GeoSurveys Inc. collected 29,821 line km of high quality magnetic data over the Search 2015 survey area. All of the data exceeded Geoscience BC specifications.

The total magnetic field ranged from 55,259.45 nT to 59,186.56 nT, yielding a magnetic relief of 3,927.11 nT. The magnetic patterns correspond to the concentration and distribution of magnetite and other magnetic minerals in the Earth's subsurface. Therefore the aeromagnetic data will be useful in mapping lithology, structure, and alteration.

9.0 Recommendations

Geoscience BC's stated purpose for acquiring the aeromagnetic data over the Search 2015 survey area was "to help explorers identify new mineral deposits and diversify the local economy." As geophysical data are not a direct indication of mineral deposits, careful integration with existing and new geological, geochemical, and geophysical data is recommended to obtain maximum value from the survey investment.

10.0 Acknowledgements

Logistical support from Quantum Helicopters in Terrace and Highland Helicopters in Smithers is gratefully acknowledged. We also thank Peter Kowalczyk, Janice Fingler, Jeff Hamilton, and Bruce Madu at Geoscience BC for their constructive comments.

Respectfully submitted,
Precision GeoSurveys Inc.

Jenny Poon, P.Geo.
January 8, 2016

Appendix A

Search 2015 Survey Area Polygon Coordinates

Search 2015 Survey Area Polygon

Longitude	Latitude	Easting	Northing	N/S	E/W
127.31739515	54.92226426	607835	6087438	N	W
127.30368667	54.91103698	608744	6086210	N	W
127.28820363	54.89655148	609776	6084622	N	W
127.28357063	54.87936403	610120	6082717	N	W
127.27256811	54.86660423	610861	6081315	N	W
127.25770932	54.84784285	611866	6079251	N	W
127.24909071	54.82798064	612475	6077055	N	W
127.24823649	54.81916932	612554	6076076	N	W
127.23862987	54.80333473	613216	6074330	N	W
127.23205098	54.79372656	613665	6073272	N	W
127.21734505	54.78185853	614644	6071975	N	W
127.19761028	54.76301737	615967	6069911	N	W
127.18850784	54.75503383	616576	6069038	N	W
127.18335113	54.74163899	616946	6067557	N	W
127.18317854	54.72712960	616999	6065943	N	W
127.17943457	54.71898765	617264	6065043	N	W
127.15774954	54.69892105	618719	6062847	N	W
127.11816458	54.68475696	621312	6061339	N	W
127.11204092	54.66634941	621762	6059302	N	W
127.07119073	54.64525289	624460	6057026	N	W
127.00866092	54.63578052	628525	6056085	N	W
126.95219938	54.54071272	632476	6045614	N	W
126.93289045	54.46064549	633987	6036743	N	W
126.92081949	54.40783694	634943	6030891	N	W
126.93202056	54.40802932	634215	6030891	N	W
126.97999589	54.40884152	631100	6030891	N	W
126.98454284	54.40891751	630804	6030891	N	W
127.08701459	54.40989530	624152	6030815	N	W
127.09218760	54.40894301	623819	6030700	N	W
127.09696108	54.40908668	623509	6030707	N	W
127.10743783	54.41145328	622822	6030952	N	W
127.10946642	54.41264448	622686	6031081	N	W
127.11505518	54.41477758	622317	6031309	N	W
127.11505061	54.41571172	622315	6031413	N	W
127.11750125	54.41916137	622146	6031792	N	W
127.11940937	54.42083232	622017	6031975	N	W
127.12030136	54.42252264	621954	6032161	N	W
127.12048850	54.42460248	621936	6032392	N	W
127.34520543	54.42738375	607351	6032336	N	W
127.34995107	54.42687381	607044	6032272	N	W
127.35382755	54.42698377	606793	6032278	N	W
127.35687984	54.42746175	606593	6032327	N	W
127.36201159	54.42741468	606261	6032314	N	W
127.36631727	54.42770707	605981	6032340	N	W
127.36866788	54.42773002	605828	6032339	N	W
127.37327471	54.42762867	605530	6032321	N	W
127.39603669	54.42793309	604052	6032321	N	W
127.39936364	54.42831896	603835	6032359	N	W
127.40089472	54.43016468	603731	6032562	N	W
127.40348267	54.43201000	603559	6032763	N	W
127.41104908	54.43609067	603058	6033206	N	W
127.41739963	54.43854742	602640	6033470	N	W
127.42535350	54.44027276	602120	6033651	N	W
127.42754811	54.44031545	601977	6033652	N	W
127.42887727	54.44022485	601891	6033640	N	W

Longitude	Latitude	Easting	Northing	N/S	E/W
127.43083808	54.44076643	601763	6033698	N	W
127.43248585	54.44161071	601654	6033789	N	W
127.43515074	54.44208570	601480	6033838	N	W
127.43656029	54.44263478	601387	6033897	N	W
127.44020922	54.44438510	601146	6034087	N	W
127.44557330	54.44357684	600801	6033989	N	W
127.62436554	54.44716533	589199	6034147	N	W
127.73504990	54.44837485	582020	6034147	N	W
127.74809151	54.44277802	581185	6033509	N	W
127.74960920	54.43662971	581099	6032824	N	W
127.74344153	54.41954631	581533	6030930	N	W
127.74131352	54.40613739	581698	6029441	N	W
127.74265748	54.39328390	581636	6028009	N	W
127.73896560	54.38861250	581885	6027493	N	W
127.73685330	54.38322614	582033	6026897	N	W
127.72764557	54.37548555	582647	6026046	N	W
127.71935991	54.37167438	583192	6025632	N	W
127.71238578	54.36197693	583665	6024561	N	W
127.71418807	54.34952873	583573	6023174	N	W
127.67573567	54.34911091	586073	6023174	N	W
127.69436485	54.32652485	584909	6020639	N	W
127.72675735	54.31790987	582820	6019642	N	W
127.72946719	54.31131068	582657	6018904	N	W
127.72772288	54.30763052	582778	6018497	N	W
127.73900139	54.30413837	582051	6018095	N	W
127.74825556	54.30706370	581443	6018410	N	W
127.75939684	54.30455424	580723	6018118	N	W
127.76449735	54.29662708	580407	6017230	N	W
127.76357497	54.29113393	580477	6016620	N	W
127.75812156	54.28428631	580846	6015864	N	W
127.76339870	54.27861369	580513	6015227	N	W
127.76773624	54.26972947	580248	6014234	N	W
127.78052335	54.26884219	579417	6014121	N	W
127.78692119	54.27135734	578996	6014393	N	W
127.79350102	54.27120069	578568	6014368	N	W
127.80077607	54.26630425	578103	6013816	N	W
127.81087427	54.26409245	577450	6013558	N	W
127.81729751	54.26772847	577024	6013956	N	W
127.82717963	54.26180373	576392	6013286	N	W
127.83159208	54.25654416	576114	6012696	N	W
127.83843928	54.25094559	575678	6012066	N	W
127.84535572	54.24662168	575236	6011577	N	W
127.85489447	54.24776390	574612	6011694	N	W
127.86162740	54.24752891	574174	6011661	N	W
127.86236274	54.23779016	574143	6010577	N	W
127.85549639	54.22943453	574606	6009654	N	W
127.85208254	54.22279038	574840	6008919	N	W
127.83372821	54.16711320	576139	6002744	N	W
127.82375965	54.10406624	576907	5995740	N	W
127.82427766	54.09367720	576892	5994584	N	W
127.82964042	54.08950434	576549	5994114	N	W
127.84712016	54.07955339	575424	5992988	N	W
127.85137190	54.06899288	575165	5991809	N	W
127.85964011	54.06046328	574639	5990851	N	W
127.86218592	54.05225415	574487	5989935	N	W

Longitude	Latitude	Easting	Northing	N/S	E/W
127.86094577	54.04895710	574574	5989569	N	W
127.86601606	54.04580532	574248	5989213	N	W
127.87891413	54.04089749	573412	5988654	N	W
127.88888965	54.03905369	572762	5988438	N	W
127.89361027	54.02858663	572471	5987269	N	W
127.89426090	54.02465390	572435	5986831	N	W
127.90253350	54.02097281	571900	5986413	N	W
127.90632136	54.02546050	571644	5986908	N	W
127.91089717	54.02279152	571349	5986607	N	W
127.92409184	54.02203528	570486	5986509	N	W
127.93901642	54.02057974	569510	5986333	N	W
127.94452819	54.01417792	569160	5985615	N	W
127.96504218	53.99987272	567839	5984004	N	W
128.00853045	53.99777976	564992	5983730	N	W
128.03880141	53.99893362	563006	5983831	N	W
128.04265966	53.98321730	562776	5982079	N	W
128.63603089	53.98591211	523865	5982016	N	W
128.63600777	53.98856357	523865	5982311	N	W
128.64544932	53.98869058	523246	5982322	N	W
128.64544410	53.98930520	523246	5982391	N	W
128.64343752	54.00127933	523371	5983723	N	W
128.63789127	54.00402674	523733	5984031	N	W
128.60573726	54.02333064	525828	5986190	N	W
128.59657215	54.03557105	526421	5987555	N	W
128.59600362	54.06087166	526442	5990370	N	W
128.60208808	54.07305161	526036	5991723	N	W
128.60207780	54.07368737	526036	5991794	N	W
128.59749060	54.09103027	526325	5993725	N	W
128.59783986	54.10510942	526294	5995292	N	W
128.59659697	54.11642469	526368	5996551	N	W
128.59790946	54.12229699	526278	5997204	N	W
128.59018687	54.13327183	526776	5998428	N	W
128.56795349	54.18071306	528196	6003715	N	W
128.56558826	54.19499569	528341	6005305	N	W
128.55111844	54.21095645	529274	6007087	N	W
128.53545091	54.24733967	530269	6011142	N	W
128.53281026	54.27064051	530424	6013735	N	W
128.53930426	54.30988035	529972	6018098	N	W
128.55292748	54.31908334	529080	6019117	N	W
128.55931996	54.34314359	528647	6021791	N	W
128.53824078	54.35876541	530006	6023538	N	W
128.51405126	54.39057654	531554	6027088	N	W
128.51412392	54.39092508	531549	6027127	N	W
128.51226342	54.39886922	531663	6028012	N	W
128.50702513	54.40502523	531998	6028699	N	W
128.50257654	54.40982828	532283	6029235	N	W
128.50018240	54.41554368	532434	6029872	N	W
128.49963091	54.41840403	532468	6030191	N	W
128.49781336	54.41914981	532585	6030275	N	W
128.49393272	54.41958561	532837	6030325	N	W
128.49289378	54.42003325	532904	6030375	N	W
128.48949787	54.42303225	533122	6030711	N	W
128.48870403	54.42453554	533172	6030878	N	W
128.48944731	54.42709999	533122	6031163	N	W
128.48887991	54.43116554	533155	6031616	N	W

Longitude	Latitude	Easting	Northing	N/S	E/W
128.48497537	54.43340893	533407	6031867	N	W
128.47978774	54.43489336	533742	6032035	N	W
128.47796144	54.43624146	533859	6032186	N	W
128.47640885	54.43638541	533960	6032203	N	W
128.46780008	54.44252505	534513	6032890	N	W
128.46410065	54.44868595	534748	6033577	N	W
128.46327188	54.45275022	534798	6034030	N	W
128.46374763	54.45591628	534765	6034382	N	W
128.46189023	54.45952397	534882	6034784	N	W
128.46199469	54.47127624	534865	6036092	N	W
128.45826988	54.47909413	535100	6036964	N	W
128.45999950	54.48527909	534982	6037651	N	W
128.46993501	54.49737614	534329	6038992	N	W
128.48330869	54.50421387	533457	6039746	N	W
128.49743770	54.51316252	532535	6040736	N	W
128.50461851	54.51891733	532066	6041373	N	W
128.50534079	54.52344016	532015	6041876	N	W
128.49417044	54.52610588	532736	6042177	N	W
128.48923415	54.52729044	533055	6042311	N	W
128.48015697	54.52815574	533641	6042412	N	W
128.47030232	54.52901696	534278	6042513	N	W
128.45291913	54.53104887	535402	6042747	N	W
128.44972642	54.53384746	535606	6043060	N	W
128.44751371	54.53874157	535745	6043606	N	W
128.44989047	54.54445931	535586	6044241	N	W
128.45352041	54.54828036	535348	6044664	N	W
128.45062217	54.55088290	535533	6044955	N	W
128.43830851	54.55391760	536327	6045299	N	W
128.42513804	54.55956265	537173	6045934	N	W
128.41241073	54.56259275	537994	6046278	N	W
128.40949168	54.56638314	538179	6046702	N	W
128.40944013	54.56994970	538179	6047098	N	W
128.40528900	54.57397176	538443	6047548	N	W
128.39335668	54.57819270	539211	6048024	N	W
128.37762539	54.58976440	540216	6049321	N	W
128.37166288	54.60471417	540587	6050988	N	W
128.38120777	54.62354842	539952	6053078	N	W
128.38189032	54.63258775	539899	6054083	N	W
128.37360187	54.63848980	540428	6054745	N	W
128.37062965	54.64513237	540613	6055486	N	W
128.36439092	54.65080663	541010	6056121	N	W
128.35368848	54.65336564	541698	6056412	N	W
128.33997537	54.66446759	542571	6057655	N	W
128.33777753	54.67349141	542703	6058661	N	W
128.33099052	54.68700782	543127	6060169	N	W
128.31480076	54.69785543	544158	6061386	N	W
128.30926624	54.70947542	544502	6062682	N	W
128.30620923	54.72015821	544688	6063873	N	W
128.30197936	54.72726742	544952	6064667	N	W
128.29040627	54.73124255	545693	6065117	N	W
128.27560751	54.73163061	546646	6065170	N	W
128.26154370	54.73677701	547545	6065752	N	W
128.24699482	54.74572330	548471	6066757	N	W
128.24319399	54.75116865	548709	6067366	N	W
128.24921882	54.75881514	548312	6068212	N	W

Longitude	Latitude	Easting	Northing	N/S	E/W
128.25198266	54.76501456	548127	6068900	N	W
128.25743882	54.78145503	547757	6070726	N	W
128.27755779	54.81116205	546429	6074018	N	W
128.27627646	54.81116477	546511	6074019	N	W
128.27628876	54.81284979	546508	6074206	N	W
128.27630249	54.81476870	546505	6074420	N	W
128.27719797	54.81478303	546448	6074421	N	W
128.25114416	54.82595875	548109	6075682	N	W
128.24682768	54.82629926	548386	6075723	N	W
128.23650610	54.82724298	549048	6075835	N	W
128.23623154	54.82713448	549065	6075823	N	W
128.22903618	54.82770111	549527	6075891	N	W
128.22020575	54.83095299	550090	6076260	N	W
128.21927029	54.83153861	550149	6076325	N	W
128.21875743	54.83148623	550182	6076320	N	W
128.21518017	54.83280318	550411	6076469	N	W
128.21261693	54.83686666	550570	6076923	N	W
128.20518306	54.83503406	551050	6076724	N	W
128.20405267	54.83512687	551122	6076736	N	W
128.20150394	54.83468661	551287	6076688	N	W
128.19920707	54.83388638	551435	6076601	N	W
128.19806126	54.83376666	551509	6076589	N	W
128.19691528	54.83387430	551582	6076601	N	W
128.19294133	54.83527237	551836	6076760	N	W
128.19190080	54.83694204	551901	6076947	N	W
128.18615880	54.84113918	552264	6077418	N	W
128.18488677	54.84164993	552345	6077476	N	W
128.18442239	54.84254796	552374	6077576	N	W
128.18341617	54.84323095	552437	6077653	N	W
128.18218076	54.84486965	552515	6077836	N	W
128.18199583	54.84598503	552525	6077960	N	W
128.18201460	54.84643409	552523	6078010	N	W
128.18163016	54.84751928	552546	6078131	N	W
128.17875521	54.84961384	552728	6078366	N	W
128.17344783	54.85179515	553066	6078613	N	W
128.17136672	54.85304485	553198	6078754	N	W
128.16982178	54.85316694	553297	6078768	N	W
128.15887526	54.85582997	553996	6079073	N	W
128.15626210	54.85504513	554165	6078988	N	W
128.15548325	54.85504595	554215	6078989	N	W
128.15509773	54.85501781	554240	6078986	N	W
128.15432193	54.85505450	554290	6078990	N	W
128.15007887	54.85474168	554563	6078959	N	W
128.14740480	54.85500803	554734	6078991	N	W
128.14548545	54.85484757	554857	6078974	N	W
128.13479411	54.85231909	555547	6078701	N	W
128.13278859	54.85235969	555676	6078707	N	W
128.12977220	54.85408100	555867	6078901	N	W
128.12919887	54.85556004	555902	6079066	N	W
128.12940573	54.85712728	555886	6079241	N	W
128.12890027	54.85865645	555917	6079411	N	W
128.12701882	54.85954168	556036	6079511	N	W
128.12694199	54.86023947	556040	6079589	N	W
128.11723285	54.86588890	556656	6080225	N	W
128.10624416	54.86439996	557363	6080069	N	W

Longitude	Latitude	Easting	Northing	N/S	E/W
128.10158144	54.86497484	557661	6080136	N	W
128.09424984	54.86297480	558135	6079920	N	W
128.09241759	54.86160882	558254	6079769	N	W
128.09132549	54.86149881	558325	6079758	N	W
128.08919377	54.86203091	558461	6079819	N	W
128.08907710	54.86398796	558465	6080037	N	W
128.09227534	54.86778613	558255	6080457	N	W
128.09338901	54.87469857	558173	6081225	N	W
128.09261877	54.87571097	558221	6081338	N	W
128.08954064	54.87771171	558416	6081564	N	W
128.09084377	54.87950270	558330	6081762	N	W
128.09066108	54.87993649	558341	6081810	N	W
128.09193856	54.88148661	558256	6081982	N	W
128.09349106	54.88155521	558157	6081988	N	W
128.09388136	54.88154348	558132	6081986	N	W
128.09541706	54.88166972	558033	6081999	N	W
128.09955074	54.88402658	557764	6082258	N	W
128.10250301	54.88666704	557571	6082549	N	W
128.10553472	54.88800895	557375	6082696	N	W
128.10676046	54.88886775	557295	6082791	N	W
128.10712756	54.88995279	557270	6082911	N	W
128.10648165	54.89239455	557308	6083183	N	W
128.10546458	54.89432499	557370	6083399	N	W
128.10335697	54.89592323	557503	6083579	N	W
128.10082223	54.89695584	557664	6083696	N	W
128.10302478	54.90006187	557519	6084039	N	W
128.10829708	54.90146499	557179	6084191	N	W
128.10953549	54.90309159	557097	6084371	N	W
128.10653897	54.90447705	557287	6084528	N	W
128.10436605	54.90483744	557426	6084570	N	W
128.10259051	54.90572754	557539	6084670	N	W
128.09001488	54.91020579	558338	6085179	N	W
128.08776148	54.91143846	558481	6085318	N	W
128.08680216	54.91289103	558540	6085480	N	W
128.08659149	54.91513430	558551	6085730	N	W
128.08823328	54.92270369	558434	6086571	N	W
128.08707955	54.92481643	558505	6086807	N	W
128.08528480	54.92599736	558619	6086940	N	W
128.07982812	54.92712577	558967	6087070	N	W
128.07568010	54.92653125	559233	6087008	N	W
128.07268347	54.92665342	559425	6087024	N	W
128.07064608	54.92728598	559555	6087096	N	W
128.06849621	54.92914013	559690	6087304	N	W
128.05819250	54.93252712	560345	6087690	N	W
128.04639540	54.93129971	561103	6087563	N	W
128.03780475	54.93010270	561655	6087438	N	W
127.31740125	54.92211796	607835	6087421	N	W

Revised block boundary as approved by Geoscience BC.

Appendix B

Equipment Specifications

- GEM GSM-19T Proton Precession Magnetometer (Base Station)
- Hemisphere R220 GPS Receiver
- Hemisphere GPS Mini- Max
- Hemisphere GPS A52 Geodetic Antenna
- HC-S3 Temperature and Relative Humidity Probe
- Setra Model 276 Barometric Pressure Sensor
- Scintrex CS-3 Survey Magnetometer
- Bartington Mag-03 three-axis fluxgate magnetic field sensor
- Pico Envirotec IMPAC (Integrated Multi-Parameter Airborne Console)

GEM GSM-19T Proton Precession Magnetometer (Base Station) Specifications

Configuration Options	15
Cycle Time	999 sec to 0.5 sec
Environmental	-40°C to +60°C
Gradient Tolerance	7,000 nT/m
Magnetic Readings	299,593
Operating Range	10,000 to 120,000 nT
Power	12 V @ 0.62 A
Sensitivity	0.1 nT @ 1 sec
Weight (Console/ Sensor)	3.2 Kg
Integrated GPS	Yes

Hemisphere R120 GPS Receiver Specifications

GPS Sensor	Receiver Type	L1 and L2 RTK with carrier phase	
	Channels	12 L1CA GPS 12 L1P GPS 12 L2P GPS 3 SBAS or 3 additional L1CA GPS	
	Update Rate	10 Hz standard, 20 Hz available	
	Cold Start Time	<60 s	
	Warm Start Time 1	30 s (valid ephemeris)	
	Warm Start Time 2	30 s (almanac and RTC)	
	Hot Start Time	10 s typical (valid ephemeris and RTC)	
	Reacquisition	<1 s	
	Differential Options	SBAS, Autonomous, External RTCM, RTK, OmniSTAR (HP/XP)	
Horizontal Accuracy		RMS (67%)	2DRMS (95%)
	RTK [1, 2]	10 mm + 1 ppm	20 mm+2 ppm
	OmniSTAR HP [1, 3]	0.1 m	0.2 m
	SBAS (WAAS) [1]	0.3 m	0.6 m
	Autonomous, no SA [1]	1.2 m	2.5 m
L-Band Sensor	Channel	Single channel	
	Frequency Range	1530 MHz to 1560 MHz	
	Satellite Selection	Manual or Automatic (based on location)	
	Startup and Satellite Reacquisition Time	15 seconds typical	
Communications	Serial Ports	2 full duplex RS232	
	Baud Rates	4800 – 115200	
	USB Ports	1 Communications, 1 Flash Drive data storage	
	Correction I/O Protocol	Hemisphere GPS proprietary, RTCM v2.3 (DGPS), RTCM v3 (RTK), CMR, CMR+NMEA 0183, Hemisphere GPS binary	
	Timing Output	1 PPS (HCMOS, active high, rising edge sync, 10kΩ, 10pF load)	
	Event Marker Input	HCMOS, active low, falling edge sync, 10kΩ	
Environmental	Operating Temperature	-30°C to +65°C	
	Storage Temperature	-40°C to +85°C	
	Humidity	95% non-condensing	
Power GPS Sensor	Input Voltage Range	8 to 36 VDC	
	Consumption, RTK	<4.9W (0.40A @ 12 VDC typical)	
	Consumption, OmniSTAR	<5.5W (0.46A @ 12 VDC typical)	

[1] Depends on multipath environment, number of satellites in view, satellite geometry and ionospheric activity.
[2] Depends also on baseline length.
[3] Requires a subscription from OmniSTAR.

Hemisphere GPS – MiniMax

GPS Sensor Specifications	Receiver Type	LI, C/A code, with carrier phase smoothing
	Channels	I2-channel, parallel tracking (10-channel when tracking SBAS)
	WAAS Tracking	2-channel, parallel tracking
	Update Rate	1 Hz default, 5 Hz max
	Horizontal Accuracy	< 1 m 95% confidence (DGPS) < 5 m 95% confidence (autonomous, no SA)
	Cold Start	1 min typical
	Antenna Input Impedance	50 Ω
Beacon Sensor Specifications	Channels	2-channel, parallel tracking
	Frequency Range	283.5 to 325 kHz
	Channel Spacing	500 Hz
	MSK Bit Rates	50, 100, and 200 bps
	Operating Modes	Manual, automatic, semi-automatic
	Cold Start Time	< 1 minute typical
	Reacquisition Time	< 2 seconds typical
	Demodulation	Minimum shift keying (MSK)
	Sensitivity	2.5µV for 6dB SNR @ 200 bps
	Dynamic Range	100dB
	Frequency Offset	±8 Hz (~ 27 ppm)
	Adjacent Channel Rejection	61 dB ± 1dB @ fo ± 400 Hz
Communications	Serial ports	2 full duplex
	Interface Level	RS-232C
	Baud Rates	4800, 9600, 19200
	Correction Input/ Output Protocol	RTCM SC-104
	Raw Measurement Data	Proprietary binary (RINEX utility available)
	Timing Output	1 PPS (HCMOS, active high, rising edge sync, 10kΩ, 10pF load)
Environmental	Operating Temperature	-32□C to +74ºC
	Storage Temperature	-40□C to +85ºC
	Humidity	95% non-condensing
	EMC	FCC Part I 5, Subpart B, Class B CISPR 22
Power	Input Voltage Range	9 to 32 VDC
	Reverse Polarity Protection	Yes
	Power Consumption	3W
	Current Consumption	<250 mA @ 12 VDC
	Antenna Short Circuit Protection	Yes

Hemisphere GPS A52 Geodetic Antenna

GNSS Reception	GPS L1/L2/L5, GLONASS L1/L2, Beidou, SBAS, L-band (OmniSTAR), and Galileo E1/E5a and b
GNSS Frequency	1.165 to 1.253 GHz 1.525 to 1.613 GHz
LNA Gain	30 dB
LNA Noise	2.0 dB, typical
Power Input Voltage	3.3 to 12 VDC
Power Input Current	35 mA, typical
Temperature	Storage: -40° C to +85° C Operating: -40° C to +70° C
Phase Center Variation	Less than 3 mm at GPS L1 and L2, for elevations above 15 degrees
Casing	Aluminum base with ASA plastic cap 7.6 H x 18.5 D (cm)
Weight	.78 kg (1.71 lbs)
RF Connector	TNC (straight or right angle)

HC-S3 Temperature and Relative Humidity Probe Specifications

Operating Temperature	-40°C to +60°C
Temperature Output Signal Range	0 to 1.0 VDC
Temperature Resolution	0.1°C or better
Relative Humidity(RH) Measurement Range	0 to 100 % non-condensing
RH Output Signal Range	0 to 1.0 VDC
RH Accuracy At 23°C	± 1.5 % RH
RH Response Time	12 to 15 secs
RH Typical Long Term Stability	Better than 1% RH per year
Probe Length	168 mm (6.6")
Probe Body Diameter	15.25 mm (0.6 ")
Housing Material	Polycarbonate
Power Consumption	< 4 mA
Supply Voltage	3.5 to 50 VDC (typically 5 VDC)
Settling Time after power is switched on	3 secs

Setra Model 276 Specifications Barometric Pressure Sensor

Pressure Ranges	600 to 1100 hPa/mb 800 to 1100 hPa/mb 0 to 20 psia
Accuracy	±0.25% FS
Output	0.1 to 5.1 VDC 0.5 to 4.5 VDC
Excitation	12 VDC (9.0 to 14.5) 24 VDC (21.6 to 26.0) 5 VDC (4.9 to 7.1)
Size	5 cm x 2.5 cm (2” dia. x 1”)

Scintrex CS-3 Magnetometer Specifications

Operating Principal	Self-oscillation split-beam Cesium Vapor (non-radioactive Cs-133)
Operating Range	15,000 to 105,000 nT
Gradient Tolerance	40,000 nT/metre
Operating Zones	10° to 85° and 95° to 170°
Hemisphere Switching	a) Automatic b) Electronic control actuated by the control voltage levels (TTL/CMOS) c) Manual
Sensitivity	0.0006 nT √Hz rms
Noise Envelope	Typically 0.002 nT P-P, 0.1 to 1 Hz bandwidth
Heading Error	+/- 0.25 nT (inside the optical axis to the field direction angle range 15° to 75° and 105° to 165°)
Absolute Accuracy	<2.5 nT throughout range
Output	a) Continuous signal at the Larmor frequency which is proportional to the magnetic field (proportionality constant 3.49857 Hz/nT) sine wave signal amplitude modulated on the power supply voltage b) Square wave signal at the I/O connector, TTL/CMOS compatible
Information Bandwidth	Only limited by the magnetometer processor used
Sensor Head	Diameter: 63 mm (2.5”) Length: 160 mm (6.3”) Weight: 1.15 kg (2.6 lb)
Sensor Electronics	Diameter: 63 mm (2.5”) Length: 350 mm (13.8”) Weight: 1.5 kg (3.3 lb)
Cable, Sensor to Sensor Electronics	3m (9’ 8”), lengths up to 5m (16’ 4”) available
Operating Temperature	-40°C to +50°C
Humidity	Up to 100%, splash proof
Supply Power	24 to 35 Volts DC
Supply Current	Approx. 1.5A at start up, decreasing to 0.5A at 20°C
Power Up Time	Less than 15 minutes at -30°C

Bartington Mag-03 three-axis fluxgate magnetic field sensor Specifications

Number of Axes	3
Bandwidth	0 to 3kHz at 50μT peak
Internal Noise	Basic version: >10 to 20pTrms/√Hz at 1Hz Standard version: 6 to ≤10pTrms/√Hz at 1Hz Low Noise version: <6pTrms/√Hz at 1Hz
Scaling error (DC)	<±0.5%
Orthogonality error	<0.1°
Alignment error (Z axis to reference face)	<0.1°
Linearity error	<0.0015%
Frequency response	0 to 1kHz maximally flat, ±5% maximum at 1kHz
Input voltage	±12V to ±17V
Supply current	+30mA, -10mA (+1.4mA per 100μT for each axis)
Power supply rejection ratio	5μV/V (-106dB)
Analog output	±10V (±12V supply) swings to within 0.5V of supply voltage
Output impedance	10 Ω
Operating temperature range	-40°C to +70°C
Environmental protection	IP51
Dimensions (W x H x L)	32 x 32 x 152mm
Weight	160g
Enclosure material	Reinforced epoxy
Connector	ITT Cannon DEM-9P-NMB
Mating connector	ITT Cannon DEM-9S-NMB
Mounting	2 x M5 fixing holes

Pico Envirotec IMPAC (Integrated Multi-Parameter Airborne Console)

Functions	Real-time acquisition and navigation system. The IMPAC system eliminates interconnect wires. All acquired data is synchronized with GPS time and position and recorded to solid state memory. Recorded data can be extracted to USB flash drive
Display	Touch screen with display of 800 x 600 pixels; customized keypad and operator keyboard. Multi-screen options for real-time viewing of all data inputs, fiducial points, flight line tracking, and GPS channels by operator.
Input	Up to 8 cesium Mag sensors
Resolution	0.2 pT (Limited only by sensor)
Sampling Rate (internal)	1200 Hz
Output	5 Hz – 120 Hz
Data Synchronization	GPS – PPS @ 1µs
Analog Inputs	8 differential simultaneous sampled, 16 bit resolution
Dynamic Range	15000 – 100000 nT (Limited only by sensor)
Supplied Software	PEIView: Allows fast data Quality Control (QC) Data Format: Geosoft GBN and ASCII output PEIConv: For survey preparation and survey plot after data acquisition PEIComp: Calculate compensation coefficient and viewing compensation results PEIFOM: Calculate the efficiency of the magnetic compensation. Calculated for both pre- and post-compensated data AGRSCalib: Provide means of verification of proper operation of the digital spectral detection
Drape	Drape profile view displayed both on the operator touch screen monitor or pilot guidance unit
Compensation (Optional)	Fluxgate magnetometers or Attitude reference

Appendix C

Digital File Descriptions

- Magnetic database description
- Grids
- Maps

Magnetic Database:

Abbreviations used in the GDB files listed below:

Channel	Units	Description
X_NAD83	m	UTM Easting – NAD 83 Zone 9 North
Y_NAD83	m	UTM Northing – NAD 83 Zone 9 North
X_WGS84	m	UTM Easting – WGS 84 Zone 9 North
Y_WGS84	m	UTM Northing – WGS 84 Zone 9 North
Lon_deg	degree	Longitude
Lat_deg	degree	Latitude
Date	yyyy/mm/dd	Dates of the survey flight(s), UTC
FLT		Flight Line numbers
LineNo		Line numbers
STL		Number of satellite(s)
GPSfix		GPS fix
GPStime	Hours:min:secs	GPS time (UTC)
Geos_m	m	Geoidal separation
GHead_deg	degree	Heading of the helicopter
Galt	m ASL	GPS height of helicopter– WGS 84 Zone 9 North
GaltD	m ASL	Difference between drape surface and actual elevation of the helicopter
Drape	m ASL	Elevation of the drape surface (from MSL)
XTE_m	m	Flight line cross distance
Lalt	m AGL	Laser Altimeter readings
DTM	m	Digital Terrain Model
basemag	nT	Base station diurnal data
IGRF		International Geomagnetic Reference Field 2015
Declin	Decimal degree	Calculated declination of magnetic field
Inclin	Decimal degree	Calculated inclination of magnetic field
Raw_Mag	nT	Raw magnetic data
Comp_Mag	nT	Compensated magnetic data
Lag_Cor_Mag	nT	Lag Corrected magnetic data
Diurnal_Cor_Mag	nT	Diurnal Corrected magnetic data
TMI	nT	Total Magnetic Intensity
S_RMI	nT	Search Residual Magnetic Intensity
RMI	nT	Residual Magnetic Intensity (leveled to NRcan RMI)

Grids: Search 2015 Survey Area, NAD 83 Datum, Zone 9N

FILE NAME	DESCRIPTION
Search_2015_SurveyArea_DEM_62.5m.grd	Search 2015 survey area digital elevation model gridded at 62.5 m cell size
Search_2015_SurveyArea_TMI_62.5m.grd	Search 2015 survey area total magnetic intensity gridded at 62.5 m cell size
Search_2015_SurveyArea_RMI_62.5m.grd	Search 2015 survey area residual magnetic intensity (leveled to NRcan) gridded at 62.5 m cell size
Search_2015_SurveyArea_1VD_62.5m.grd	Search 2015 survey area first vertical derivative of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_2VD_62.5m.grd	Search 2015 survey area second vertical derivative of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_RTP_62.5m.grd	Search 2015 survey area reduced to pole of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_AS_62.5m.grd	Search 2015 survey area analytic signal of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_HG_62.5m.grd	Search 2015 survey area horizontal gradient of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_TD_62.5m.grd	Search 2015 survey area tilt derivative of RMI in radians gridded at 62.5 m cell size

KMZ: Search 2015 Survey Area, NAD 83 Datum, Zone 9N

FILE NAME	DESCRIPTION
Search_2015_SurveyArea_DEM_62.5m.grd	Search 2015 survey area digital elevation model gridded at 62.5 m cell size
Search_2015_SurveyArea_TMI_62.5m.grd	Search 2015 survey area total magnetic intensity gridded at 62.5 m cell size
Search_2015_SurveyArea_RMI_62.5m.grd	Search 2015 survey area residual magnetic intensity (leveled to NRCan) gridded at 62.5 m cell size
Search_2015_SurveyArea_1VD_62.5m.grd	Search 2015 survey area first vertical derivative of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_2VD_62.5m.grd	Search 2015 survey area second vertical derivative of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_RTP_62.5m.grd	Search 2015 survey area reduced to pole of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_AS_62.5m.grd	Search 2015 survey area analytic signal of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_HG_62.5m.grd	Search 2015 survey area horizontal gradient of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_TD_62.5m.grd	Search 2015 survey area tilt derivative of RMI in radians gridded at 62.5 m cell size

Maps: Search 2015 Survey Area, NAD 83 Datum, Zone 9N (jpegs and pdfs)

FILE NAME	DESCRIPTION
Search_2015_SurveyArea_ActualFlightLines	Search 2015 survey area plotted actual flown flight lines
Search_2015_SurveyArea_DEM_62.5m	Search 2015 survey area digital elevation model gridded at 62.5 m cell size
Search_2015_SurveyArea_TMI_62.5m	Search 2015 survey area survey block total magnetic intensity gridded at 62.5 m cell size
Search_2015_SurveyArea_TMI_with_FlightLines_62.5m	Search 2015 survey area total magnetic intensity with plotted actual flight lines gridded at 62.5 m cell size
Search_2015_SurveyArea_TMI_MC_62.5m	Search 2015 survey area total magnetic intensity with magnetic contours gridded at 62.5 m cell size
Search_2015_SurveyArea_RMI_62.5m	Search 2015 survey area residual magnetic intensity (leveled to NRCan) gridded at 62.5 m cell size
Search_2015_SurveyArea_RMI_MC_62.5m	Search 2015 survey area residual magnetic intensity (leveled to NRCan) with magnetic contours gridded at 62.5 m cell size
Search_2015_SurveyArea_1VD_62.5m	Search 2015 survey area first vertical gradient of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_1VD_MC_62.5m	Search 2015 survey area first vertical gradient of RMI gridded at 62.5 m cell size with magnetic contours
Search_2015_SurveyArea_2VD_62.5m	Search 2015 survey area second vertical gradient of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_2VD_MC_62.5m	Search 2015 survey area second vertical gradient of RMI gridded at 62.5 m cell size with magnetic contours
Search_2015_SurveyArea_RTP_62.5m.grd	Search 2015 survey area reduced to pole of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_RTP_MC_62.5m.grd	Search 2015 survey area reduced to pole of RMI gridded at 62.5 m cell size with magnetic contours
Search_2015_SurveyArea_AS_62.5m.grd	Search 2015 survey area analytic signal of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_AS_MC_62.5m.grd	Search 2015 survey area analytic signal of RMI gridded at 62.5 m cell size with magnetic contour
Search_2015_SurveyArea_HG_62.5m.grd	Search 2015 survey area horizontal gradient of RMI gridded at 62.5 m cell size
Search_2015_SurveyArea_HG_MC_62.5m.grd	Search 2015 survey area horizontal gradient of RMI gridded at 62.5 m cell size with magnetic contour
Search_2015_SurveyArea_TD_62.5m.grd	Search 2015 survey area tilt derivative of RMI in radians gridded at 62.5 m cell size
Search_2015_SurveyArea_TD_MC_62.5m.grd	Search 2015 survey area tilt derivative of RMI in radians gridded at 62.5 m cell size with magnetic contour

Appendix D
Calibration Reports

- Compensation Test Flights
- Heading Tables

Compensation Test Flights:

August 14, 2015

Flightpath:

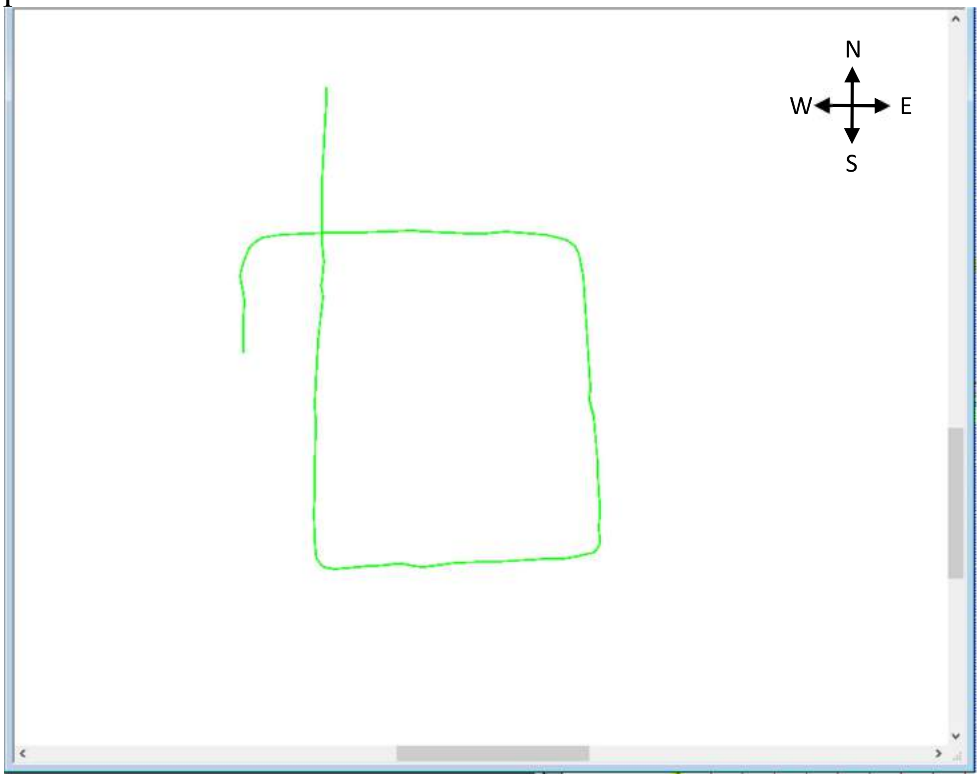

Figure of Merit (FOM):

Pre-Compensation

Heading	Roll	Pitch	Yaw	Total
87	0.7181	0.6713	0.1511	1.5405
176	0.419	0.6933	0.3431	1.4554
267	0.3575	0.7234	0.285	1.3659
352	0.5784	0.5189	0.3199	1.4172
Total	2.073	2.6069	1.0991	

FOM = 5.779 nT

Post-Compensation

Heading	Roll	Pitch	Yaw	Total
87	0.0438	0.056	0.0655	0.1653
176	0.067	0.0423	0.0393	0.1486
267	0.0673	0.0641	0.0495	0.1809
352	0.1782	0.0576	0.0463	0.2821
Total	0.3563	0.22	0.2006	

FOM = 0.7769 nT

September 4, 2015

Flightpath:

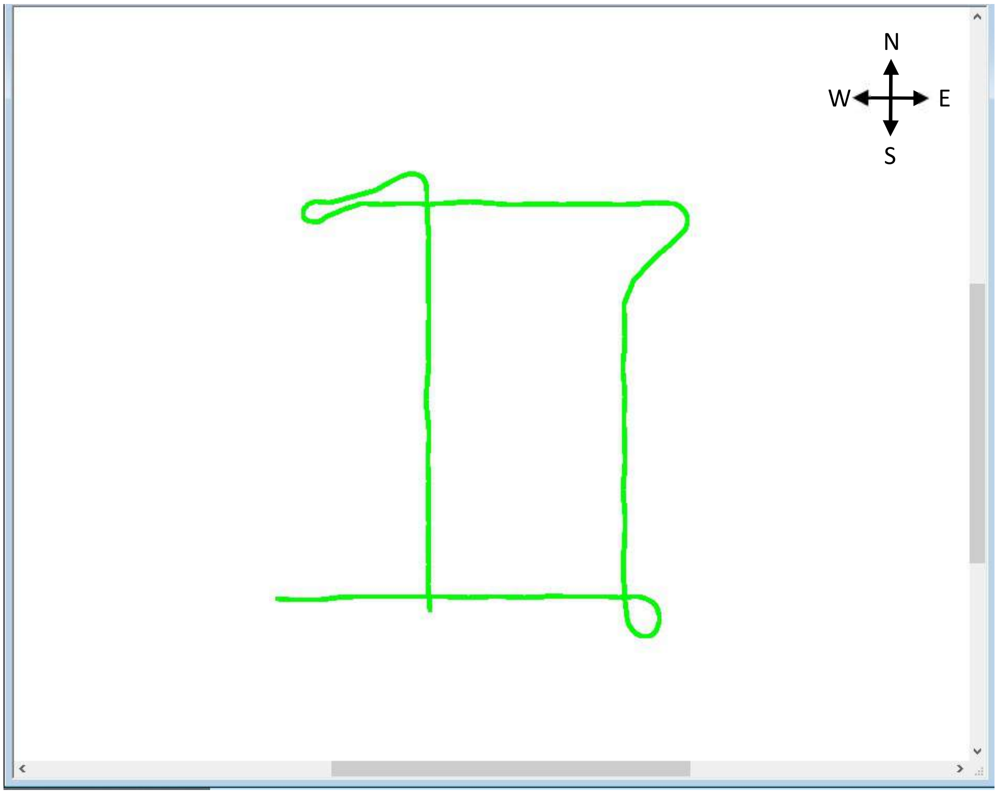

Figure of Merit (FOM):

Pre-Compensation

Heading	Roll	Pitch	Yaw	Total
2	0.7714	0.3926	0.286	1.45
89	0.9576	0.5328	0.3943	1.8847
184	0.9534	0.7604	0.5387	2.2525
269	0.88	0.5024	0.4269	1.8093
Total	3.5624	2.1882	1.6459	

FOM = 7.3965 nT

Post-Compensation

Heading	Roll	Pitch	Yaw	Total
2	0.0311	0.0581	0.0429	0.1321
89	0.0843	0.1059	0.0558	0.246
184	0.0391	0.0404	0.0314	0.1109
269	0.0836	0.0503	0.0543	0.1882
Total	0.2381	0.2547	0.1844	

FOM = 0.6772 nT

October 14, 2015

Flightpath:

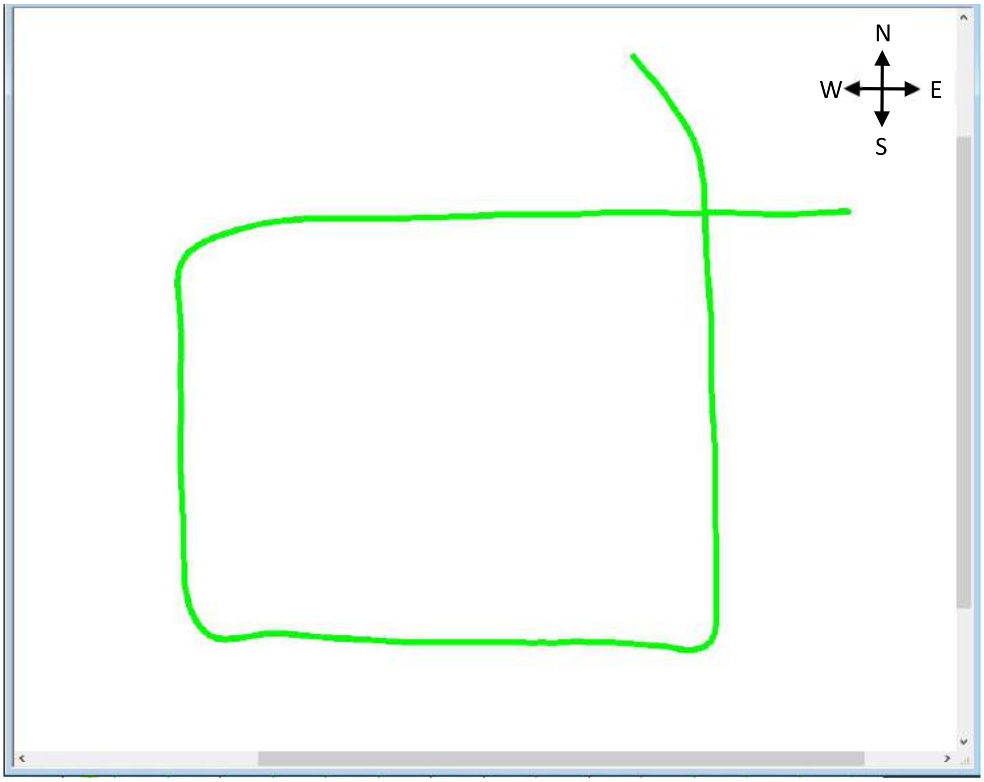

Figure of Merit (FOM):

Pre-Compensation

Heading	Roll	Pitch	Yaw	Total
87	0.2814	0.7227	0.308	1.3121
178	0.1421	0.6712	0.2725	1.0858
265	0.1611	0.6169	0.2603	1.0383
355	0.2125	0.4211	0.2087	0.8423
Total	0.7971	2.4319	1.0495	

FOM = 4.2785 nT

Post-Compensation

Heading	Roll	Pitch	Yaw	Total
87	0.0518	0.0421	0.0605	0.1544
178	0.0395	0.0355	0.0498	0.1248
265	0.0624	0.0735	0.0841	0.22
355	0.0622	0.0429	0.0411	0.1462
Total	0.2159	0.194	0.2355	

FOM = 0.6454 nT

Heading Tables:

August 14, 2015

Line Number	Fiducials	Heading	Mag (nT)	Correction (nT)
L000	1545.6	N – 000°	55539.7758	0.5563
L090	1683.8	E – 090°	55537.4270	2.9051
L180	1414.5	S - 180°	55542.2774	-1.9453
L270	1748.6	W - 270°	55541.8482	-1.5161
		Average	**55540.3321**	
		Total		**0.0000**

September 3, 2015

Line Number	Fiducials	Heading	Mag (nT)	Correction (nT)
L000	2529.6	N – 000°	55682.6066	2.8526
L090	3064.8	E – 090°	55682.5878	2.8714
L180	2676.9	S - 180°	55688.0210	-2.5618
L270	2867.2	W - 270°	55688.6214	-3.1622
		Average	**55685.4592**	
		Total		**0.0000**

Appendix E

Daily Progress Report Summary

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
12/08/2015	-	0	Survey equipment installed, aircraft degaussed		Clear	-
13/08/2015	-	0	Pilot training and safety planning		Clear	-
14/08/2015	1 - 4	727	Compensation flight flown, first production flights flown	Pilot observed a bear on L1810	Clear	-
15/08/2015	5 - 10	971	-	Operator observed a mountain goat on L1620	Clouds on mountain peaks early morning. Clear skies later during the day and windy late afternoon	-
16/08/2015	11	44	Onboard data acquisition system reported nav errors which postponed further flights	-	Low level cloud prevented flying in the morning	-
17/08/2015	12 - 14	380	Power cable for GPS receiver repaired and tested; flights resumed	-	Sparse high level cloud prevented high elevation surveying throughout the day	-
18/08/2015	15 - 18	873	-	Operator observed a mountain goat on line L2200	Sparse high level cloud prevented high elevation surveying throughout the day	-
19/08/2015	19 - 24	983	-	-	High levels of geomagnetic activity in the early morning delayed the first flight of the day. Moderate cloud cover throughout the day interrupted some survey lines	-
20/08/2015	25	77	-	-	Low level cloud in the morning prevented full line acquisition. Rainy and windy conditions in the late morning and afternoon prevented further flying	-

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
21/08/2015	26 - 28	299	-	-	Low level cloud in the morning and early afternoon prevented full line acquisition. Skies cleared in the evening	-
22/08/2015	0	0	-	-	Rainy conditions and low level cloud prevented flying throughout the day	-
23/08/2015	0	0	-	-	Rainy conditions and low level cloud prevented flying throughout the day	-
24/08/2015	0	0	-	-	Rainy conditions and low level cloud prevented flying throughout the day	-
25/08/2015	0	0	-	-	Rainy conditions and low level cloud prevented flying throughout the day	-
26/08/2015	29 - 32	530	-	Four mountain goat sightings along L1160 – mountain goats were seen in groups of 1, 5, 6 and 1	Morning fog delayed the first flight of the day. Sparse high level cloud interrupted select survey lines	-
27/08/2015	33 - 34	136	-	-	High levels of geomagnetic activity delayed the first flight of the day. Gusting winds and low clouds prohibited flying in the afternoon	-
28/08/2015	0	0	-	-	Heavy rain, gusting winds and cloud cover preventing flying throughout the day	-

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
29/08/2015	35	19	-	-	One flight attempt was made in the morning but was terminated due to cloud cover. Heavy rain, gusting winds and cloud cover preventing flying for the remainder of the day	-
30/08/2015	0	0	-	-	Heavy rain, gusting winds and cloud cover prevented flying throughout the day	-
31/08/2015	0	0	-	-	Heavy rain, gusting winds and cloud cover prevented flying throughout the day	-
01/09/2015	0	0	-	-	Heavy rain, gusting winds and cloud cover prevented flying throughout the day	-
02/09/2015	0	0	-	-	Low level cloud prevented flying throughout the day	-
03/09/2015	0	0	Aircraft degaussed	-	Low level cloud prevented flying throughout the day	-
04/09/2015	36 - 37	294	Technical downtime due to replacement of the onboard data recording system, New comp flight flown.	-	Mountain goats seen on L1490 and L1500	-
05/09/2015	38	197	-	-	Rainy conditions and low level cloud prevented flying in the late morning and afternoon	-

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
06/09/2015	0	0	-	-	Rainy conditions and low level cloud prevented flying throughout the day	-
07/09/2015	0	0	High levels of geomagnetic activity throughout the day	-	Rainy conditions and low level cloud prevented flying throughout the day	-
08/09/2015	0	0	-	-	Rainy conditions and low level cloud prevented flying throughout the day	-
09/09/2015	0	0	-	-	Rainy conditions and low level cloud prevented flying throughout the day	-
10/09/2015	0	0	-	-	Thick fog in the morning and early afternoon prevented flying	-
11/09/2015	0	0	-	-	Low level cloud and windy conditions prevented flying throughout the day	-
12/09/2015	39 - 42	800	-	-	Low level cloud prevented flying in the morning	-
13/09/2015	43 - 44	456	-	-	Low level cloud prevented flying in the morning	-
14/09/2015	45 - 46	716	-	-	Low level cloud prevented flying in the early morning	-

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
15/09/2015	47 - 49	928	-	Mountain goats observed on L2410 (group of two), L2890 (group of two)	Clear	-
16/09/2015	50 - 54	1400	-	Mountain goats observed on L3850 (group of three)	Clear	-
17/09/2015	55 - 58	1437	-	-	Cloud cover prevented full line acquisition	-
18/09/2015	59 - 61	959	-	-	Low cloud prevented full line acquisition	-
19/09/2015	62 - 63	750	-	Ten mountain goats observed on L3220	Clear	-
20/09/2015	64 - 65	815	-	One mountain goat observed on L2430	Low level cloud prevented flying in the morning	-
21/09/2015	66 - 68	1000	-	-	Low level cloud prevented flying in the early morning and full line acquisition in the afternoon	-
22/09/2015	0	0	-	-	Heavy rain and low visibility prevented flying throughout the day	-
23/09/2015	0	0	-	-	Heavy rain and low visibility prevented flying throughout the day	-
24/09/2015	0	0	-	-	Heavy rain and low visibility prevented flying throughout the day	-

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
25/09/2015	0	0	-	-	Thick fog, rain and low level cloud prevented flying throughout the day	-
26/09/2015	0	0	-	-	Thick fog, rain and low level cloud prevented flying throughout the day	-
27/09/2015	0	0	-	-	Thick fog, rain and low level cloud prevented flying throughout the day	-
28/09/2015	0	0	-	-	Low level cloud and heavy rain prevented flying throughout the day	-
29/09/2015	0	0	-	-	Low level cloud prevented flying throughout the day	-
30/09/2015	69 - 70	605	-	Four mountain goats observed on line L4000	Low level cloud prevented flying in the morning	-
01/10/2015	71 - 73	1069	-	Two mountain goats observed on line L3380. Three mountain goats observed on lines L2090 and L2040	Low level cloud prevented flying in the early morning	-
02/10/2015	74 - 77	1172	-	-	Cap clouds on mountains prevented full line acquisition	-
03/10/2015	78 - 82	1520	-	Ten mountain goats observed on line L2250	Clear	-

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
04/10/2015	83 - 86	1248	-	Two mountain goats observed on line T10210. Six mountain goats observed on line L3810	Clear	-
05/10/2015	87 - 91	1477	-	Five mountain goats observed on line T10200	Clear	-
06/10/2015	92 - 95	1203	-	-	Clear	-
07/10/2015	0	0	-	-	High levels of geomagnetic activity and low level cloud prevented flying throughout the day	-
08/10/2015	0	0	-	-	Heavy rain and cloud cover prevented flying throughout the day	-
09/10/2015	0	0	Shawn Walker takes over from Lee Guest as on-site Geophysicist	-	Heavy rain and cloud cover prevented flying throughout the day	-
10/10/2015	0	0	-	-	Heavy rain and cloud cover prevented flying throughout the day	-
11/10/2015	96 - 97	283	-	-	Heavy rain and cloud cover prevented flying for most of the day. Surveyed two flights before conditions deteriorated	-
12/10/2015	0	0	-	-	Heavy rain and cloud cover prevented flying throughout the day	-
13/10/2015	98 - 99	228	-	-	Rain and cloud cover prevented flying for most of the day	-

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
14/10/2015	0	0	Aircraft de-gaussed, new comp flight flown	-	Heavy cloud cover prevented flying until late in the afternoon.	-
15/10/2015	100 - 101	737	-	-	Cloud cover prevented flying in the morning	-
16/10/2015	102 - 105	937	-	-	Clear	-
17/10/2015	0	0	-	-	Heavy cloud cover prevented flying throughout the day	-
18/10/2015	106 - 107	442	-	-	Low ceiling and icing conditions limited production	-
19/10/2015	108 - 109	207	-	-	Heavy clouds prevented surveying until mid-afternoon	-
20/10/2015	0	0	-	-	Rain and heavily overcast conditions prevented surveying	-
21/10/2015	0	0	-	-	Rain and heavy cloud cover prevented flying throughout the day	-
22/10/2015	0	0	-	-	Rain and heavy cloud cover prevented flying throughout the day	-
23/10/2015	0	0	-	-	Clear	-

Project Date DD/MM/YY	Flight(s)	Line km Flown	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
24/10/2015	110 - 113	1197	-	-	Cloud cover on L100 pushed helicopter off survey line for less than 100m and out of spec by 77m.	-
25/10/2015	114 - 117	1230	-	-	Clear	-
26/10/2015	118 - 120	1121	-	-	Clear	-
27/10/2015	121 - 123	700	-	-	Low lying clouds prevented surveying lower areas	-
28/10/2015	0	0	-	-	Low cloud cover and rain prevented surveying	-
29/10/2015	0	0	-	-	Low cloud cover and rain prevented surveying	-
30/10/2015	0	0	-	-	Rain and heavy cloud prevented surveying	-
31/10/2015	0	0	-	-	Rain and heavy cloud prevented surveying	-
01/11/2015	0	0	-	-	Rain and heavy cloud prevented surveying	-
02/11/2015	0	0	-	-	Rain and heavy cloud prevented surveying	-
03/11/2015	0	0	Distance remaining recalculated to account for re-flights and overlap sections	-	Rain and heavy cloud prevented surveying	-
04/11/2015	0	0	-	-	Rain and heavy cloud prevented surveying	-
05/11/2015	0	0	-	-	Cloud cover prevented surveying	-

Project Date DD/MM/YY	Flight(s)	Flown Line km	Comments			
			Safety or Operational	Ungulate or Other Wildlife	Weather	First Nations or Community
06/11/2015	0	0	-	-	Rain and cloud cover prevented surveying	-
07/11/2015	0	0	-	-	Cloud cover and icing conditions prevented surveying	-
08/11/2015	124 - 125	171	Data checked, all reflights flown. Survey complete.	-	Partial cloud cover on lines slowed surveying	-

Appendix F

Abbreviations

List of abbreviations used in this report

AGIS	Airborne Geophysical Information System
AGL	Above Ground Level
ASL	Above Sea Level
BC	British Columbia
C	degrees Celsius
CPU	Central Processing Unit
CYXT	ICAO code for Terrace, BC airport
CYYD	ICAO code for Smithers, BC airport
DD	Day
DEM	Digital Elevation Model
DTM	Digital Topographic/Terrain Model
E	East
Fe	chemical symbol for iron
FOM	Figure of Merit
GPS	Geographic Positioning System
GSC	Geological Survey of Canada
Hz	Hertz
IAGA	International Association of Geomagnetism and Aeronomy
ICAO	International Civil Aviation Organization
IGRF	International Geomagnetic Reference Field
km	kilometer(s)
L	Flight Line (tie line or survey line) *or* Left direction
m	meter(s)
mag	magnetic *or* magnetometer
MM	month
N	North
NAD	North American Datum
nT	nanotesla(s)
NRCan	Natural Resources Canada
NTS	National Topographic System
O	chemical symbol for oxygen
PGU	Pilot Guidance System
R	Right direction
RMI	Residual Magnetic Intensity
RTP	Reduced to Pole
S	South
SBAS	Satellite-based Augmentation System
Search	A Geoscience BC-defined region in west-central BC, “an area arching two of the province's mineral-rich geological terranes”
SL	Survey Line
S/N	Serial Number
TAD	Tilt Angle Derivative
THG	Tilt Horizontal Gradient
TL	Tie Line

TMI	Total Magnetic Intensity
USB	Universal Serial Bus
UTC	Universal Time Coordinated
UTM	Universal Transverse Mercator
V	Volts
W	West
WGS	World Geodetic System
YY	Year

Plates

Search 2015 Survey Area Maps

- Plate 1: Search 2015 Survey Area - Actual Flight Lines
- Plate 2: Search 2015 Survey Area - Digital Elevation Model
- Plate 3: Search 2015 Survey Area - Total Magnetic Intensity
- Plate 4: Search 2015 Survey Area - Total Magnetic Intensity with Flight Lines
- Plate 5: Search 2015 Survey Area - Total Magnetic Intensity with Magnetic Contours
- Plate 6: Search 2015 Survey Area - Residual Magnetic Intensity
- Plate 7: Search 2015 Survey Area - Residual Magnetic Intensity with Magnetic Contours
- Plate 8: Search 2015 Survey Area - First Vertical Derivative
- Plate 9: Search 2015 Survey Area - First Vertical Derivative with Magnetic Contours
- Plate 10: Search 2015 Survey Area - Second Vertical Derivative
- Plate 11: Search 2015 Survey Area - Second Vertical Derivative with Magnetic Contours
- Plate 12: Search 2015 Survey Area - Reduced to Pole
- Plate 13: Search 2015 Survey Area - Reduced to Pole with Magnetic Contours
- Plate 14: Search 2015 Survey Area - Analytic Signal
- Plate 15: Search 2015 Survey Area - Analytic Signal with Magnetic Contours
- Plate 16: Search 2015 Survey Area - Horizontal Gradient
- Plate 17: Search 2015 Survey Area - Horizontal Gradient with Magnetic Contours
- Plate 18: Search 2015 Survey Area - Tilt Derivative
- Plate 19: Search 2015 Survey Area - Tilt Derivative with Magnetic Contours