

TECHNICAL MEMO

CREATING AND DELIVERING BETTER SOLUTIONS

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TO: David Morrison
Yukon Energy Corporation

DATE: June 4, 2009
ISSUED FOR USE

C: Scott Schillereff, Bengt Pettersson

MEMO NO: 1

FROM: George Carlson, Morgan Zondervan

FILE: W23101159.011

SUBJECT: Yukon Geothermal Project - Results of Satellite Imagery Analysis

1.0 INTRODUCTION

This Technical Memo outlines and documents the results of efforts completed under Phase 011, Satellite Image Survey, for Yukon Energy Corporation (YEC) for the Yukon Geothermal Project (EBA project W23101159). The work associated with this phase was initially proposed to test a ‘proof of concept’ of using satellite thermal data to facilitate the identification of potential thermal anomalies at a regional or macro scale in the Yukon. Similar applications of remotely sensed thermal data have been employed in other geographic areas, but to our knowledge it has not been attempted to this degree in latitudes this far north. The results of this phase will be used to focus the next phase of exploration, low-level helicopter-based thermal infrared (TIR) survey, and provide information for consideration by the geological team.

2.0 METHODS

For more than 30 years, satellites have helped to classify the Earth’s surface on regional scales (Goetz and Rock, 1983). The same mineral mapping techniques that have been widely reported for use in the mining industry have more recently been adopted by those interested in geothermal exploration. Two satellites were selected based on the specifications of their onboard sensors, Landsat Enhanced Thematic Mapper Plus (ETM+) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER).

ETM+ is a sensor carried onboard the Landsat 7 satellite and has acquired images of the Earth nearly continuously since July 1999, with a 16-day repeat cycle. The ETM+ instrument is an eight-band multispectral scanning radiometer capable of providing high-resolution imaging information of the Earth's surface. It detects spectrally-filtered radiation at visible, near-infrared, short-wave, and thermal infrared frequency bands from the sun-lit Earth in a 183 kilometre-wide swath when orbiting at an altitude of 705 kilometres. Nominal ground sample distances or “pixel” sizes are 15 meters in the panchromatic band; 30 meters in the 6 visible, near and short-wave infrared bands; and 60 meters in the thermal infrared band.

ASTER, launched in December 1999, provides multispectral images in 14 different bands: (1) three visible and near-infrared (VNIR) channels (wavelengths 0.5 to 0.9 μm) at 15 m

spatial resolution; (2) six short-wave infrared (SWIR) channels (1.6 to 2.43 μm) at 30 m resolution; and (3) five thermal infrared (TIR) channels (8 to 12 μm) at 90 m resolution. The ASTER scenes are of size ~ 60 km X 60 km. The satellite passes every 16 days over a given site, although scenes are not necessarily collected with each passage.

Mr. Chris Kratt, M.Sc., Remote Sensing Scientist, Desert Research Institute, Reno, Nevada, provided independent, expert consultation and peer review during the work. His efforts were very helpful and beneficial to the project.

3.0 DATA ACQUISITION

Analysis of Landsat 7 and ASTER data was performed for various study areas over the Yukon Territory (Figure 1). The selection of satellite scenes involved acquiring imagery with the least amount of cloud cover, and when possible night time thermal data. Multiple scenes were required to cover different times of the year and different study areas. The data acquisition process and considerations are described below in more detail.

3.1 LANDSAT DATA SEARCH

Three online data sources were explored for archived Landsat 7 ETM+ imagery: GeoBase, Glovis, and WIST. GeoBase, a search portal managed by the Canadian Council on Geomatics, did not provide a diverse enough catalogue of imagery for our applications. At this time, their archives only include daytime scenes from July and August over the study areas. Glovis, a search portal managed by the United States Geologic Survey (USGS), has a larger, more diverse archive to draw from. Data search parameters can be set for SLC-ON/OFF¹ imagery, date ranges, and cloud cover percentage. Once the results were narrowed down using these parameters, there still remained the selection of various months and years to choose from, which varied by study area. Glovis does not have the option to search for Landsat 7 night scenes. WIST is a second search portal operated by the USGS where the same search parameters as Glovis can be applied with the additional functionality to narrow your search by day or night scenes. The results of the search for night scenes were more limited than the day scene search in terms of both coverage and range of available months. It was not possible to get full coverage of day/night pairs for the Whitehorse and McArthur study areas and it was not possible to get any night scene coverage for the Nash Creek study area. The results of the Landsat data searches from all three sources are summarized in the table below. The scenes used in the analysis for each study area are highlighted in yellow. It should be noted that none of the data providers charged a fee for these data sets.

¹ In May of 2003, the Scan Line Corrector (SLC) sensor aboard the Landsat 7 Satellite malfunctioned. Data continued to be collected and made available after this date; however, it contains data gaps and overlaps at the edges of swaths (NASA, 2009).

STUDY AREA	LANDSAT SCENE ID	DATE	NIGHT/DAY	SLC ON/OFF	SOURCE
Nash Creek	061015_0101_990714_17	1999/07/14	D	On	GeoBase
McArthur/Volcano Mountain	061016_0101_990714_17	1999/07/14	D	On	GeoBase
Jarvis River	061017_0100_010719_17	2001/07/19	D	On	GeoBase
Jarvis River	061018_0100_010719_17	2001/07/19	D	On	GeoBase
Whitehorse	058018_0102_010815_17	2001/08/15	D	On	GeoBase
McArthur	059016_0100_990801_17	1999/08/01	D	On	GeoBase
Whitehorse	059018_0100_990801_17	1999/08/01	D	On	GeoBase
Whitehorse	L71058018_01820020428	2002/04/28	D	On	Glovis
Whitehorse	L71058019_01920020428	2002/04/28	D	On	Glovis
Nash Creek	L71061015_01520010617	2001/06/17	D	On	Glovis
McArthur	L71059016_01620020318	2002-03-18	D	On	Glovis
Nash Creek	L71061015_01520020316	2002-03-16	D	On	Glovis
McArthur/Volcano Mountain	L71061016_01620020316	2002-03-16	D	On	Glovis
Jarvis River	L71061017_01720020316	2002-03-16	D	On	Glovis
Jarvis River	L71061018_01820000310	2000-03-10	D	On	Glovis
McArthur	L71058017_01720030517	2003-05-17	D	On	Glovis
Whitehorse	L71058018_01820000508	2000-05-08	D	On	Glovis
Whitehorse	L71058018_01820030517	2003-05-17	D	On	Glovis
McArthur	L71059016_01620020521	2002-05-21	D	On	Glovis
Whitehorse	L71059018_01820020521	2002-05-21	D	On	Glovis
Nash Creek	L71061015_01520020519	2002-05-19	D	On	Glovis
McArthur/Volcano Mountain	L71061016_01620030522	2003-05-22	D	On	Glovis
Jarvis River	L71061017_01720030522	2003-05-22	D	On	Glovis
McArthur/Volcano Mountain	L71061016_01620011124	2001-11-24	D	On	Glovis
McArthur	L71058017_01720011002	2001-10-02	D	On	Glovis
Nash Creek	L71061015_01520001004	2000-10-04	D	On	Glovis
McArthur	L71058017_01720000913	2000-09-13	D	On	Glovis
Whitehorse	L71058018_01820011002	2001-10-02	D	On	Glovis
McArthur	L71059016_01619990918	1999-09-18	D	On	Glovis
Whitehorse	L71060017_01720020917	2002-09-17	D	On	Glovis
McArthur/Volcano Mountain	L71061016_01620020908	2002-09-08	D	On	Glovis
Jarvis River	L71061017_01719990916	1999-09-16	D	On	Glovis
Jarvis River	L71061018_01820010921	2001-09-21	D	On	Glovis
Whitehorse	L71059018_01820020926	2002-09-26	D	On	Glovis

STUDY AREA	LANDSAT SCENE ID	DATE	NIGHT/DAY	SLC ON/OFF	SOURCE
Beaver Creek/Larson River	L71053018_01820020409	2002-04-09	D	On	Glovis
Beaver Creek/Larson River	L71053018_01820030428	2003-04-28	D	On	Glovis
Jarvis River	L71146226_22620020405	2002-04-05	N	On	WIST
Jarvis River	L71146227_22720020405	2002-04-05	N	On	WIST
N/A	L71146228_22820020405	2002-04-05	N	On	WIST
N/A	L71133227_22719990723	1999-07-23	N	On	WIST
Larsen Creek	L71135227_22719990721	1999-07-21	N	On	WIST
McArthur	L71140227_22719990724	1999-07-24	N	On	WIST
Jarvis River/Whitehorse	L71144227_22719990720	1999-07-20	N	On	WIST
Nash Creek/McArthur	L71141229_22920020301	2002-03-01	N	On	WIST
Whitehorse/McArthur	L71142227_22720020308	2002-03-08	N	On	WIST
McArthur/Volcano Mountain	L71142228_22820020308	2002-03-08	N	On	WIST
Nash Creek/McArthur/Volcano Mountain	L71142229_22920020308	2002-03-08	N	On	WIST
N/A	L71142230_23020020308	2002-03-08	N	On	WIST
Whitehorse	L71143225_22520020315	2002-03-15	N	On	WIST
Whitehorse/Jarvis River	L71143226_22620020315	2002-03-15	N	On	WIST
Whitehorse/Jarvis River	L71143227_22720020315	2002-03-15	N	On	WIST
McArthur/Volcano Mountain	L71143228_22820020315	2002-03-15	N	On	WIST
N/A	L71143229_22920020315	2002-03-15	N	On	WIST
N/A	L71143230_23020020315	2002-03-15	N	On	WIST
Whitehorse/Jarvis River	L71144226_22620020322	2002-03-22	N	On	WIST
Whitehorse/Jarvis River	L71144227_22720020322	2002-03-22	N	On	WIST
McArthur/Volcano Mountain	L71144228_22820020322	2002-03-22	N	On	WIST
N/A	L71144229_22920020322	2002-03-22	N	On	WIST
Jarvis River	L71145226_22620020329	2002-03-29	N	On	WIST
Jarvis River	L71145227_22720020329	2002-03-29	N	On	WIST
N/A	L71133228_22820021003	2002-10-03	N	On	WIST
N/A	L71134228_22820001004	2000-10-04	N	On	WIST
N/A	L71142230_23019991010	1999-10-10	N	On	WIST
N/A	L71144229_22919991008	1999-10-08	N	On	WIST
N/A	L71144230_23019991008	1999-10-08	N	On	WIST
N/A	L71133227_22720000927	2000-09-27	N	On	WIST
N/A	L71133228_22820000927	2000-09-27	N	On	WIST

STUDY AREA	LANDSAT SCENE ID	DATE	NIGHT/DAY	SLC ON/OFF	SOURCE
Nash Creek	L71061015_01520060514	2006-05-14	D	Off	WIST
N/A	L71135225_22520070406	2007-04-06	N	Off	WIST
N/A	L71137225_22520080913	2008-09-13	N	Off	WIST
Beaver Creek/Larson River	L71137226_22620080913	2008-09-13	N	Off	WIST
N/A	L71137227_22720080913	2008-09-13	N	Off	WIST

3.2 ASTER DATA SEARCH

Glovis was used to search for and order suitable archived day and night scenes of ASTER imagery for the Nash Creek and McArthur study areas. These areas were selected to evaluate the suitability of ASTER imagery for our application. If the imagery proved to be useful and provided better identification of potential thermal anomalies, we would acquire additional imagery for the other study areas. Both the raw data (all bands) and a derived surface kinetic temperature image were ordered for each scene shown in the table below. Once the parameters for cloud cover and time of year were applied to the archived data, it was not possible to achieve full coverage of either study area chosen for the ASTER analysis. Approximately 50% coverage of day/night pairs of the McArthur study area was achieved and approximately 90% coverage of day/night pairs for the Nash Creek study area was achieved.

An application of ASTER imagery to identify altered surface mineralization indicative of geothermal activity has been successful in desert regions of the United States. To insure complete utilization of the imagery and assess the potential of this application in the Yukon, we applied the technique to the ASTER data sets. For the alteration mapping application, which used only day scenes, approximately 75% coverage of McArthur, and approximately 90% coverage of Nash Creek was achieved.

STUDY AREA	ASTER SCENE ID	DATE	NIGHT/DAY	SOURCE
McArthur	SC:AST_L1A.003:2016704785	2003-08-26	Day	Glovis
McArthur	SC:AST_L1A.003:2016704788	2003-08-26	Day	Glovis
McArthur	SC:AST_L1A.003:2030408810	2005-08-10	Day	Glovis
Nash Creek	SC:AST_L1A.003:2013409639	2003-05-06	Day	Glovis
McArthur	SC:AST_L1A.003:2030408809	2005-08-10	Day	Glovis
McArthur	SC:AST_L1A.003:2046211092	2007-08-16	Day	Glovis
McArthur	SC:AST_L1A.003:2024358609	2004-06-10	Night	Glovis
McArthur	SC:AST_L1A.003:2024358611	2004-06-10	Night	Glovis
McArthur	SC:AST_L1A.003:2014704314	2003-06-15	Night	Glovis
McArthur	SC:AST_L1A.003:2014704309	2003-06-15	Night	Glovis
McArthur	SC:AST_L1A.003:2025003731	2004-07-12	Night	Glovis
Nash Creek	SC:AST_L1A.003:2024358624	2004-06-10	Night	Glovis

4.0 ANALYSIS AND RESULTS

Two separate approaches were used to utilize the Landsat and ASTER data. 1) Thermal data from both Landsat and ASTER satellites were assessed in an attempt to identify anomalous pixels related to geothermal heat. 2) The visible and short-wave infrared ASTER bands were also manipulated to highlight zones of alteration related to geothermal fluids. Even if alteration zones have long since been inactive, they may still provide clues about structures that may control geothermal fluids and/or where geothermal fluids may be near by. The image processing steps are described below in further detail.

4.1 LANDSAT ANALYSIS

Two approaches to the data analysis were tested using the Landsat 7 ETM + thermal band 6l (low gain) data. Band 6l was chosen over 6h (high gain) for both attempted methods because of its expanded dynamic range.

The first approach was to use known locations of hot or warm springs, determined through previous field work, as training sites in a supervised classification². This method was tested using the day scene covering most of the McArthur study area (scene # L71061016_01620020316). The results of the classification were noisy and not helpful in determining possible hot spots. This method was tested in all four seasons to ensure that seasonal effects were not impeding results. The failure of the McArthur hot springs to be easily identified by satellite thermal data is due to both the size and strength of the anomaly relative to scene complexities. Steep topography combined with elevation differences of more than several thousand feet between the valley floor and mountain tops substantially increases the variability of the encountered surface temperatures. Thermal inertia also adds to scene variability, as an example, vegetation and water appear cooler than rock outcrops during the day. Due to the effects of topography and thermal inertia, McArthur Hot Spring is not statistically unique; however, similar anomalies may be more easily recognized in areas of lower relief or in spatial subsets with fewer pixels.

The next approach was to average day and night image pairs and apply a classification to the resulting image. The averaging of day and night images works to reduce the effects of thermal inertia (Coolbaugh, et al, 2007) and reduces noise in the resulting image. It was initially proposed that the most useful data would be from spring, just after snow melt or fall just before snow fall. This approach has the most potential to reduce the effects of thermal inertia and reveal true thermal anomalies. Due to limitations in available night scenes, this analysis was performed on data from March, April, and September. Every effort was made to use SLC-ON images to avoid data gaps; however, for Beaver Creek and Larson River, this was not possible due to limitations in the available night scenes for those areas. The averaging was completed on subsets of image pairs that were clipped to the study area boundaries. For some study areas it was necessary to mosaic images together to

² Supervised Classification involves an analyst choosing representative sample locations from an image that are then used by an algorithm in remote sensing software to identify similar areas on the image (Lilles and Kiefer, 2000).

gain better coverage of the area before performing the averaging. Once the averaging was completed, a classification that grouped pixel values together into subsets was applied to the resulting image.

The results of this analysis proved much more promising than the supervised classification. Clusters of the highest pixel values formed areas on the images with less noise than the supervised classification. When the clusters of the highest (warmest) valued pixels were compared to hydrological and geological vector layers, they appeared to make sense geologically as possible locations of “hot spots” or thermal anomalies. Figures 2 – 13 show the resulting potential thermal anomalies for each of the study areas. Figures 2 – 6 present the results of the day/night averaging and classification for each study area. Figure 7 shows a classified day image over Nash Creek where there was no available night time image for use in the analysis. Figures 8 – 13 show the day, night, and resulting averaged image side-by-side for comparison. These figures illustrate the effectiveness of the averaging technique for each study area where suitable data was available. This information will be reviewed with the geologic team to determine if the results ‘make sense’ and if it can be used for the next level of effort, to focus the field work and low-level TIR survey on a finer scale.

It is important to note the possible limitations of the averaged results. In the ideal situation, the day/night image pairs would be from the same date and year. Due to limitations in available data, this was not the case for our analysis. The effects of changes in weather from day to day and year to year cannot be accounted for in the results of this analysis.

4.2 ASTER ANALYSIS

Two approaches to data analysis were taken for the ASTER imagery for the McArthur and Nash Creek study areas. McArthur was chosen as a test location for the ASTER analysis because the hottest recorded temperatures from previous field work were recorded at the McArthur Hot Springs, making it an ideal location to test the effectiveness of the ASTER analysis. Nash Creek was chosen as the second test site because it is completely above the tree line, meaning that the effects of heavy vegetation on cell values will be less than in heavily treed areas.

The first approach was to average day and night pairs of the kinetic temperature images³ (Figures 14 - 15). This is the same technique that was applied to the Landsat thermal band outlined in the previous section. The same confounding factors that are described for processing results with Landsat in the previous section also were a challenge to detecting thermal anomalies with ASTER kinetic surface temperature data. Moreover, the Landsat thermal band (band 6) offers 60 m spatial resolution while the ASTER spatial resolution in the thermal portion of the spectrum is 90 m. The motivation for acquiring ASTER

³ This validated version of the surface temperature product provides an estimate of the surface temperature for each of the five ASTER TIR bands (Asterweb, 2009)

day/night pairs despite coarsening of the spatial resolution was to provide the opportunity for data coverage where no available or inadequate data from Landsat existed. Lack of adequate night time data is most likely due to the sensor being turned off at the time the satellite is over the area of interest. Landsat and ASTER are only 15 minutes apart in their orbital path; serendipitous changes in cloud cover during that time may be possible but are unlikely.

The second approach was to use the visible and short-wave infrared bands of each ASTER scene for alteration mapping of silicate minerals. Basic band math described by Borstad (2008) uses band ratios that target spectral absorption features to highlight zones of alteration. Histograms from the 8-bit greyscale (0-255) images that result from the band math can be adjusted to highlight pixels with higher to highest values. For image context a color-infrared (CIR) approximate composite image can be linked to the band math result in the image display. The CIR allows the analyst to easily differentiate vegetation, as it will be rendered red. Linking the CIR with the band math result helps the analyst to identify false-positives such as high pixel values that occur over thick canopy cover or water. High pixel values that occur over bedrock outcrop or where canopy cover appears to be thin may be good candidates for closer investigation (i.e., Google Earth hi-res imagery, structural setting, field visit, or other relevant existing geologic data). Of the ASTER scenes that were acquired for the study area most displayed at least partial cloud cover or snow cover. While examining the band math results, particular attention was paid to areas of thin canopy cover and rock outcrop, however, no clusters of high value pixels occurred in these areas, thus no zones of alteration were apparent.

5.0 RECOMMENDATIONS FOR HELICOPTER-BASED THERMAL INFRARED (TIR) ASSESSMENT

The results of this phase were provided to the project geologist, Jack Dennett, for analysis and correlation with available geologic data to select satellite anomalies as specific targets for the helicopter-based thermal infrared (TIR) assessment. Additionally, 'open-water' areas identified during a late winter survey and known hot springs too small to be identified on the satellite data will be surveyed during the TIR flights. The TIR assessment was proposed as a separate project phase (12) to ground-truth the satellite imagery analysis, test the effectiveness of the technology for application to regional surveys for potential hot geothermal resources, and confirm the thermal signature of other features (e.g., open water areas).

Figures 16-20 show the areas selected and prioritized by the project geologist for TIR assessment. The TIR surveys are scheduled to begin the second week of June 2009. The results of the TIR surveys will be documented in a separate Tech Memo for Phase 12.

6.0 CONCLUSIONS

Based on the results of the studies conducted for this Phase, our conclusions are as follows:

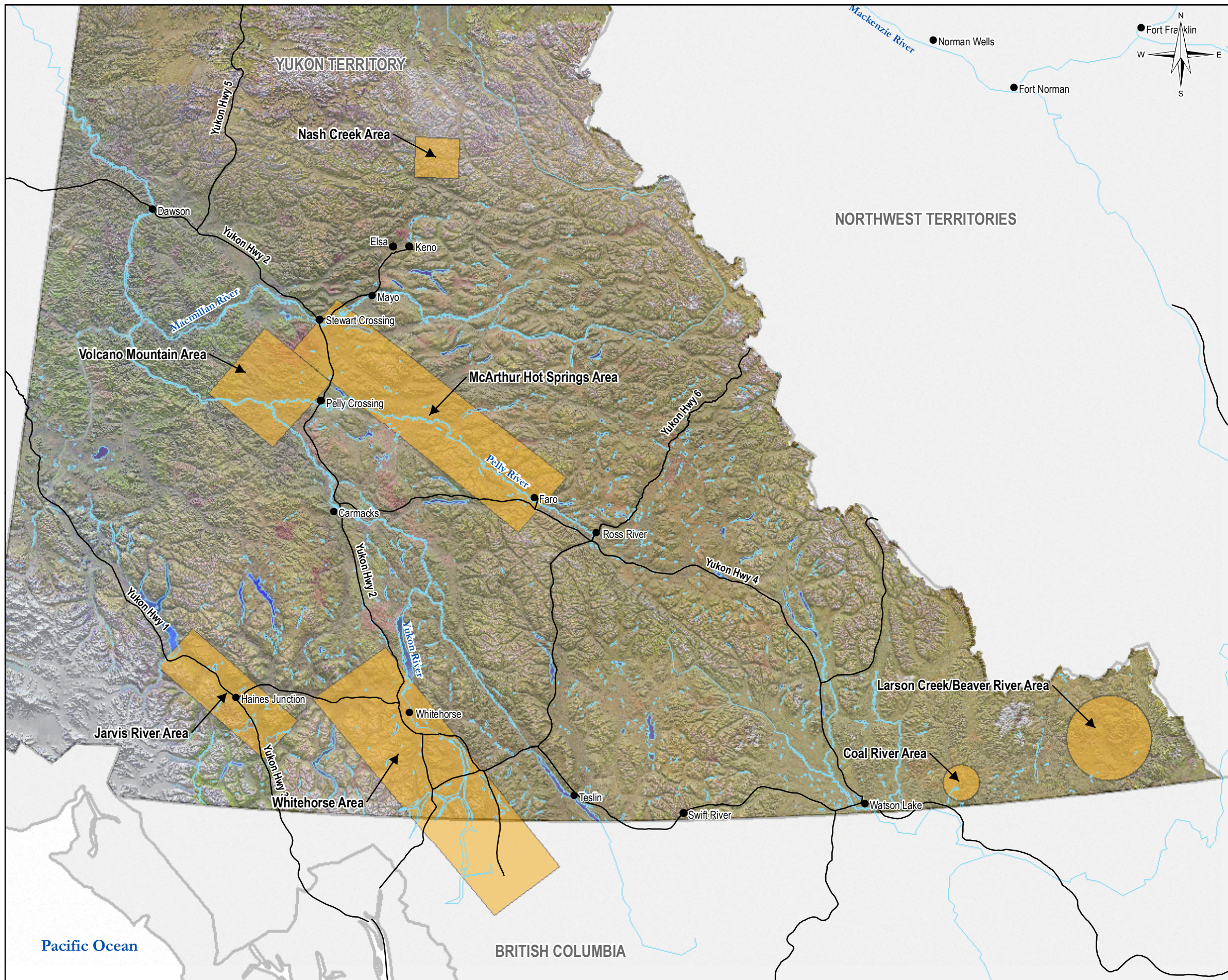
- The day/night averaging process revealed regional thermal anomalies, areas warmer than surrounding areas. The thermal anomalies detected coincided with sample sites on the ground where higher temperatures were recorded, e.g. hot springs.
- The results have provided potential thermal 'targets' for further study. The information will be reviewed and analyzed with the geologic team to identify the more likely candidates or targets for low-level thermal infrared field surveys.

Given the low cost to no cost of satellite data, some general analyses may be useful when data are available, especially in the earliest stages of exploration. EBA recommends that further inquiry into the logistics and cost effectiveness of tasking satellites be considered. Results of the analysis reported here point to promising information; the same processing techniques applied in remote areas that have received little study have the most potential utility. Whenever possible, known areas of alteration or thermal anomalies within a scene should be spatially recorded and used as a proxy to assess any potential anomalies. Masking out vegetation and working with spatial subsets of the data can also help call attention to subtle anomalies.

REFERENCES

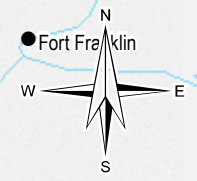
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- Attachments:
- Figure 1 Study Areas
 - Figure 2 Jarvis River Area Landsat Imagery Analysis
 - Figure 3 Whitehorse Area Landsat Imagery Analysis
 - Figure 4 Volcano Mountain Area Landsat Imagery Analysis
 - Figure 5 McArthur Hot Springs Area Landsat Imagery Analysis
 - Figure 6 Coal River and Larson Creek/Beaver River Area Landsat Imagery Analysis
 - Figure 7 Nash Creek Area Landsat Imagery Analysis
 - Figure 8 Comparison of Day, Night, and Averaged Landsat Scenes - Jarvis River Study Area
 - Figure 9 Comparison of Day, Night, and Averaged Landsat Scenes - Whitehorse Study Area
 - Figure 10 Comparison of Day, Night, and Averaged Landsat Scenes - Volcano Mountain Study Area
 - Figure 11 Comparison of Day, Night, and Averaged Landsat Scenes - McArthur Study Area
 - Figure 12 Comparison of Day, Night, and Averaged Landsat Scenes - Coal River Study Area
 - Figure 13 Comparison of Day, Night, and Averaged Landsat Scenes - Larson Creek/Beaver River Study Area
 - Figure 14 McArthur Area ASTER Imagery Analysis
 - Figure 15 Nash Creek Area ASTER Imagery Analysis
 - Figure 16 Jarvis River Area Satellite Derived Thermal Anomalies Selected for Low-Level TIR Analysis
 - Figure 17 Whitehorse Area Satellite Derived Thermal Anomalies Selected for Low-Level TIR Analysis
 - Figure 18 Volcano Mountain Area Satellite Derived Thermal Anomalies Selected for Low-Level TIR Analysis
 - Figure 19 McArthur Hot Springs Area Satellite Derived Thermal Anomalies Selected for Low-Level TIR Analysis
 - Figure 20 Nash Creek Area Satellite Derived Thermal Anomalies Selected for Low-Level TIR Analysis



LEGEND

- Study Areas
- Communities
- Roads
- Water



NOTES
Base data source: Geomatics Yukon

YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

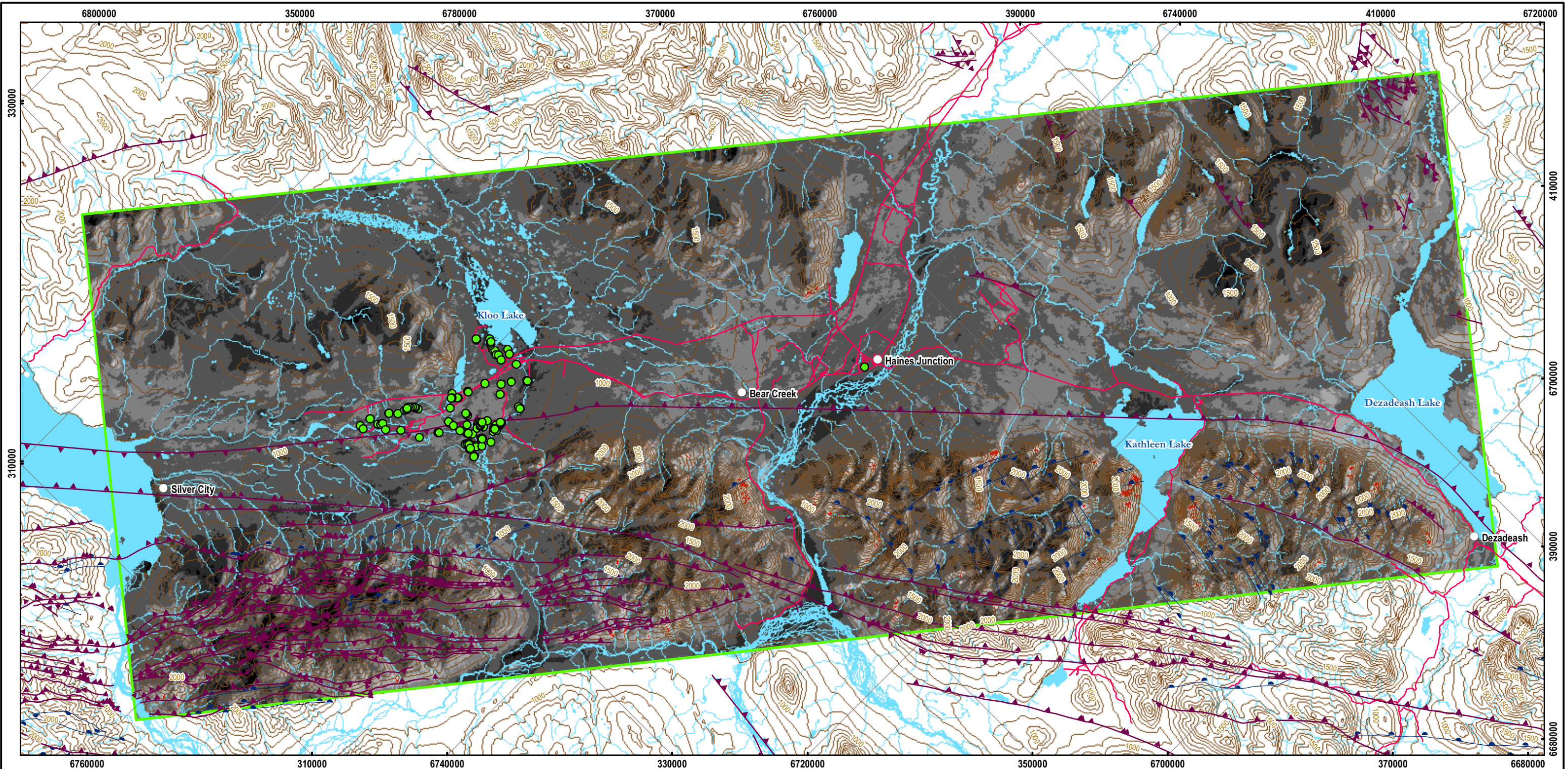
Study Areas

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OFFICE EBA-VANC	DATE April 22, 2009		



Figure 1

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LEGEND

- Jarvis River Warm Springs - Previously Sampled Location
 - Populated Place
 - Study Area
 - Roads
 - Watercourse
 - Waterbody
- Contours**
- Index (500m)
 - Intermediate (100m)
- Geological Features**
- ▲ Fault
 - ▲ Fold
- Landsat Averaged Day/Night Pair**
- Pixel Value¹**
- 58 - 63
 - 63 - 67
 - 67 - 73
 - 73 - 77
 - 77 - 83
 - 83 - 87
 - 87 - 97
- } Potential Thermal Anomalies



NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Geological data from Geomatics Yukon
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

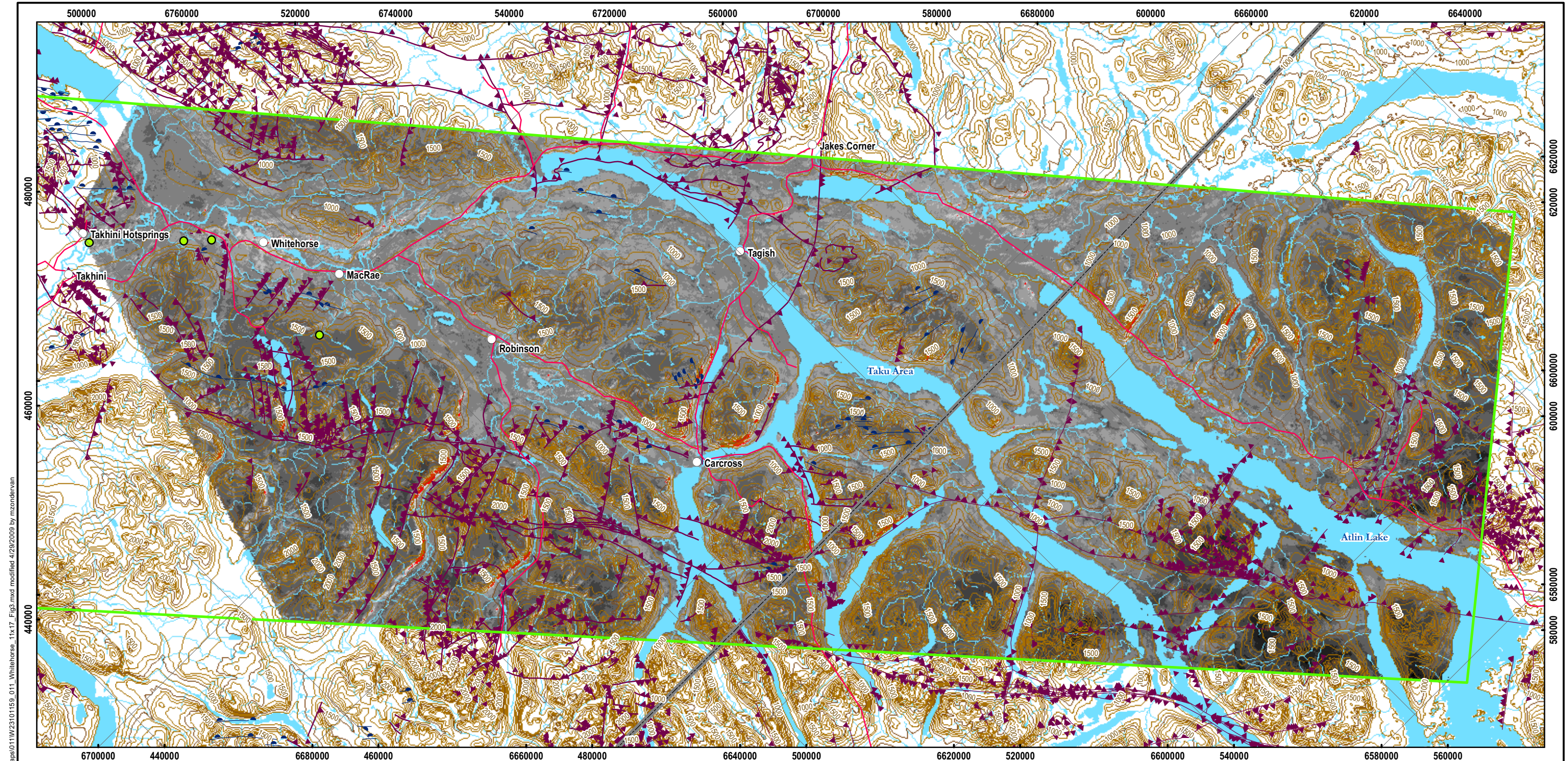
YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

**Jarvis River Area
Landsat Imagery Analysis**

PROJECTION UTM Zone 8		DATUM NAD83	
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OFFICE EBA-VANC	DATE April 29, 2009		

Figure 2

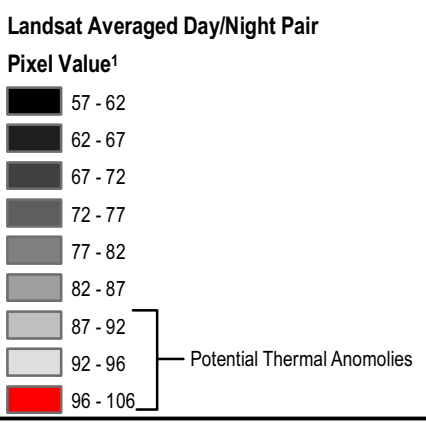
ISSUED FOR USE



G:\Vancouver\GIS\ENVIRONMENTAL\W231W23101159_011_Whitehorse_11x17_Fig3.mxd modified 4/29/2009 by mzondevan

- LEGEND**
- Approximate Locations of Known Hot Springs
 - Populated Place
 - Study Area
 - Road
 - Watercourse
 - Waterbody
 - Yukon-BC Border

- Contours**
- Index (500m)
 - Intermediate (100m)
- Geological Features**
- ▲ Fault
 - ▲ Fold



NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Yukon Geological data from Geomatics Yukon
 BC Geological data from ILMB
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

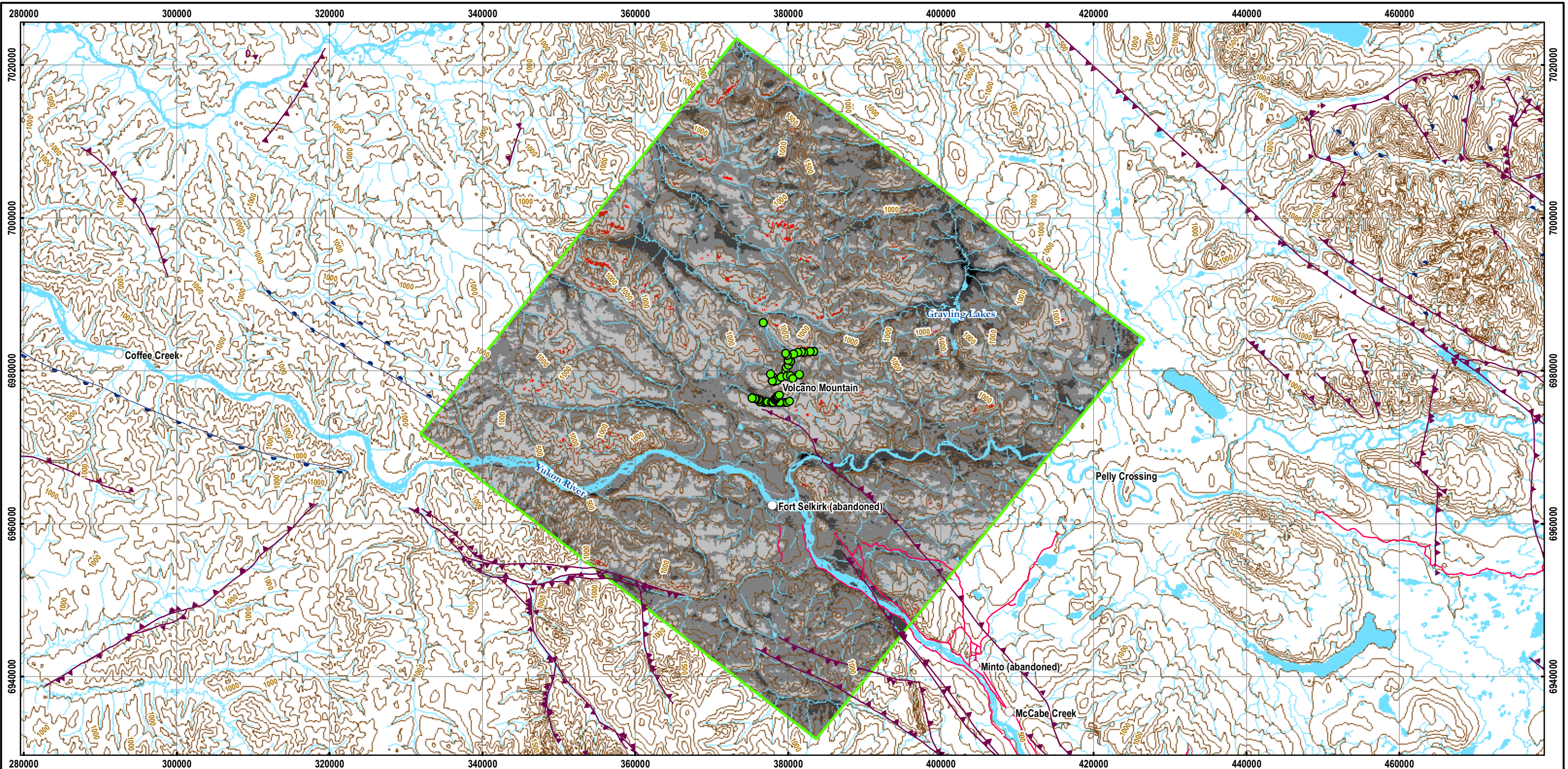
ISSUED FOR USE

YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

**Whitehorse Area
Landsat Imagery Analysis**

PROJECTION UTM Zone 8	DATUM NAD83			
Scale: 1:500,000				
FILE NO. W23101159_011_Whitehorse_11x17_Fig3.mxd	 			
PROJECT NO. W23101159.011	<table border="1" style="font-size: small;"> <tr> <td>DWN MEZ</td> <td>CKD GC</td> <td>REV 0</td> </tr> </table>	DWN MEZ	CKD GC	REV 0
DWN MEZ	CKD GC	REV 0		
OFFICE EBA-VANC	DATE April 29, 2009			

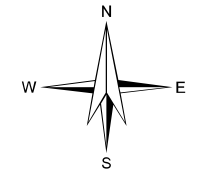
Figure 3



G:\Vancouver\GIS\ENVIRONMENTAL\W231W23101159_011_Volcano_11x17_Fig4.mxd modified 4/29/2009 by mzondevran

LEGEND

- Volcano Mountain - Previously Sampled Location
 - Populated Place
 - Study Area
 - Roads
 - Watercourse
 - Waterbody
- Contour**
 - Index (500m)
 - Intermediate (100m)
 - Geological Features**
 - Fault
 - Fold
- Landsat Averaged Day/Night Pair**
 - Pixel Value ¹**
 - 51 - 56
 - 56 - 61
 - 61 - 66
 - 66 - 71
 - 71 - 79
- } Potential Thermal Anomalies



NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Geological data from Geomatics Yukon
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

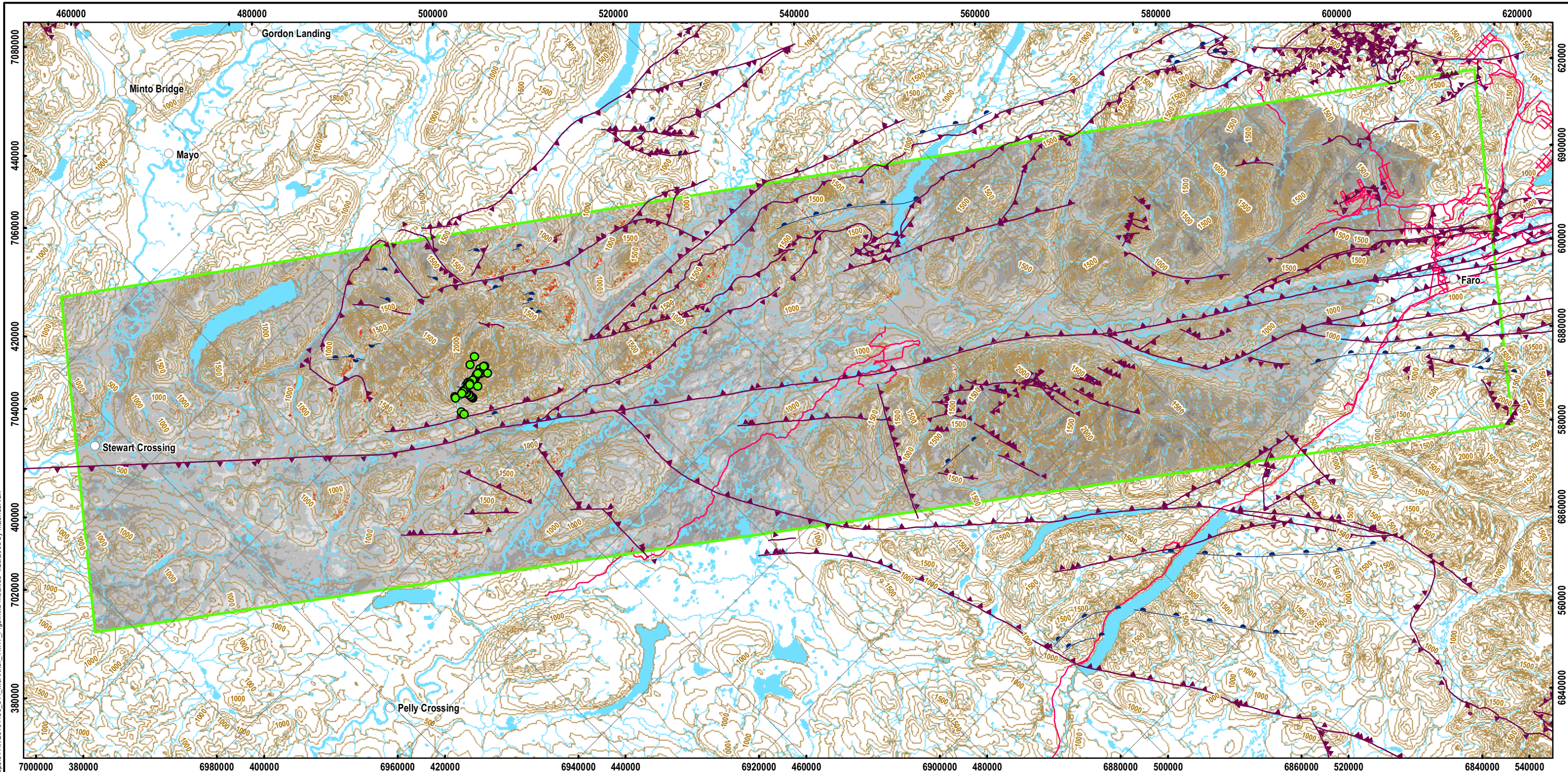
ISSUED FOR USE

YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

Volcano Mountain Area Landsat Imagery Analysis

PROJECTION UTM Zone 8		DATUM NAD83	
Scale: 1:500,000			
FILE NO. W23101159_011_Volcano_11x17_Fig4.mxd			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE April 29, 2009		

Figure 4



G:\Vancouver\GIS\ENVIRONMENTAL\W23101159_011_McArthur_11x17_Fig5.mxd modified: 4/29/2009 by mzdobner

LEGEND

- McArthur Hot Springs - Previously Sampled Location
 - Populated Place
 - Study Area
 - Roads
 - Watercourse
 - Waterbody
-
- Contour**
 - Index (500m)
 - Intermediate (100m)
 - Geological Features**
 - Fault
 - Fold
-
- Landsat Averaged Day/Night Pair**
 - Pixel Value ¹**
 - 31 - 36
 - 36 - 41
 - 41 - 46
 - 46 - 51
 - 51 - 56
 - 56 - 61
 - 61 - 66
 - 66 - 71
 - 71 - 76
- } Potential Thermal Anomalies



NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Geological data from Geomatics Yukon
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

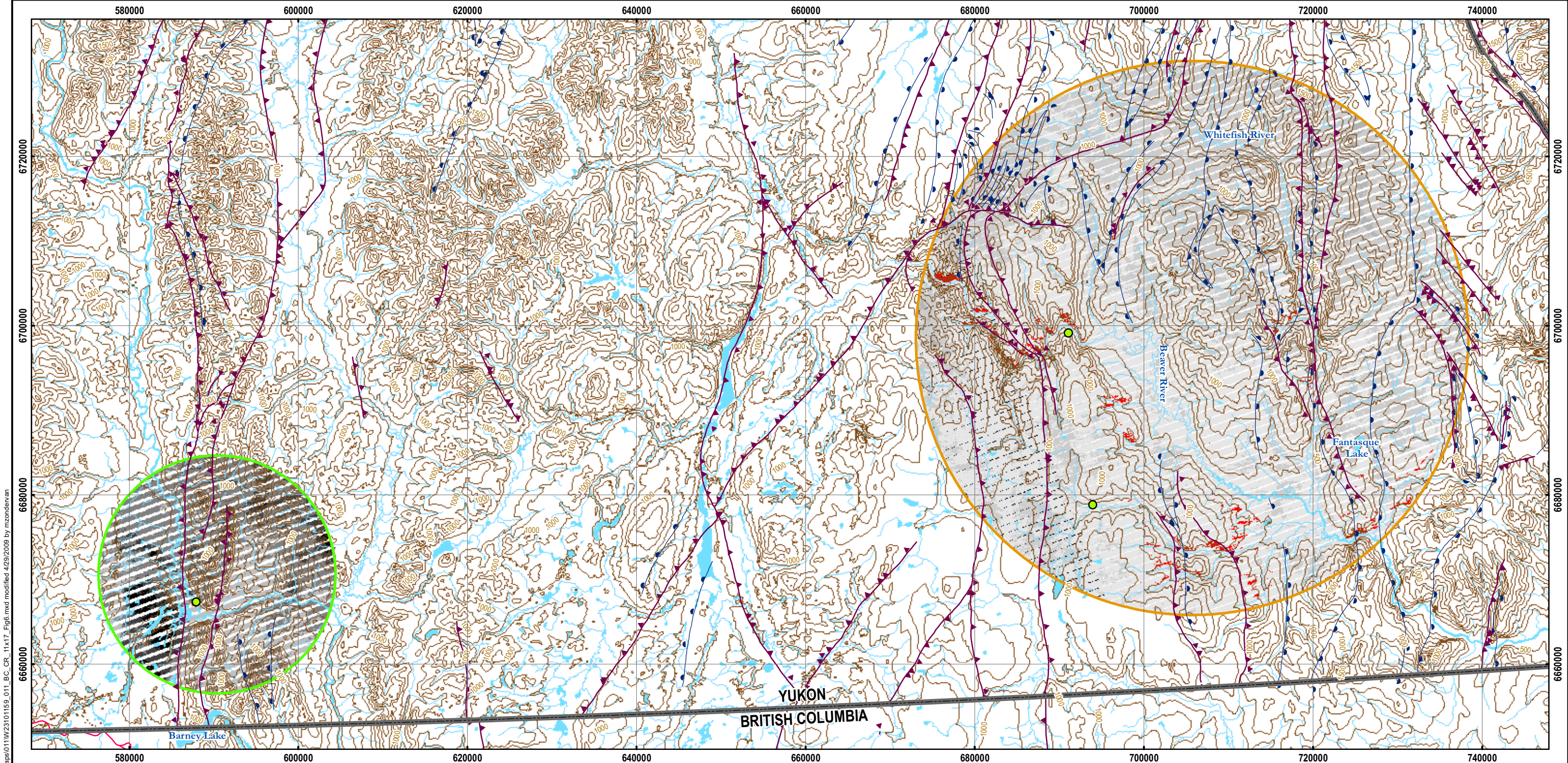
ISSUED FOR USE

YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

McArthur Hot Springs Area Landsat Imagery Analysis

PROJECTION UTM Zone 8		DATUM NAD83	
Scale: 1:600,000			
FILE NO. W23101159_011_McArthur_11x17_Fig5.mxd			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE April 29, 2009		

Figure 5

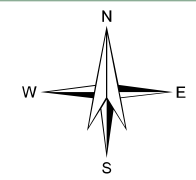


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LEGEND

- Approximate Locations of Known Hot Springs
 - Coal River Warm Springs Study Area
 - Larson Creek/Beaver River Study Area
 - Road
 - Watercourse
 - Waterbody
 - Yukon-BC Border
- | | | | | | | | | | | | | | | | | | | | | | |
|--|---|--|---------|---------|---------|---------|---------|---------|--|---------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|
| <p>Contours</p> <ul style="list-style-type: none"> — Index (500m) — Intermediate (100m) | <p>Geological Features</p> <ul style="list-style-type: none"> —▲ Fault —▲ Fold | <p>Coal River Landsat Averaged Day/Night Pair</p> <p>Pixel Value¹</p> <table border="0" style="width: 100%;"> <tr> <td style="background-color: black; width: 20px; height: 10px;"></td> <td style="width: 20px;">75 - 80</td> <td style="width: 20px;">80 - 85</td> <td style="width: 20px;">85 - 90</td> <td style="width: 20px;">90 - 95</td> <td style="width: 20px;">95 - 99</td> </tr> </table> | | 75 - 80 | 80 - 85 | 85 - 90 | 90 - 95 | 95 - 99 | <p>Larson Creek/Beaver River Landsat Averaged Day/Night Pair</p> <p>Pixel Value¹</p> <table border="0" style="width: 100%;"> <tr> <td style="background-color: black; width: 20px; height: 10px;"></td> <td style="width: 20px;">44 - 49</td> <td style="width: 20px;">49 - 54</td> <td style="width: 20px;">54 - 59</td> <td style="width: 20px;">59 - 64</td> <td style="width: 20px;">64 - 69</td> <td style="width: 20px;">69 - 74</td> <td style="width: 20px;">74 - 79</td> <td style="width: 20px;">79 - 84</td> <td style="width: 20px;">84 - 89</td> <td style="width: 20px;">89 - 94</td> <td style="width: 20px;">94 - 100</td> </tr> </table> | | 44 - 49 | 49 - 54 | 54 - 59 | 59 - 64 | 64 - 69 | 69 - 74 | 74 - 79 | 79 - 84 | 84 - 89 | 89 - 94 | 94 - 100 |
| | 75 - 80 | 80 - 85 | 85 - 90 | 90 - 95 | 95 - 99 | | | | | | | | | | | | | | | | |
| | 44 - 49 | 49 - 54 | 54 - 59 | 59 - 64 | 64 - 69 | 69 - 74 | 74 - 79 | 79 - 84 | 84 - 89 | 89 - 94 | 94 - 100 | | | | | | | | | | |

ISSUED FOR USE

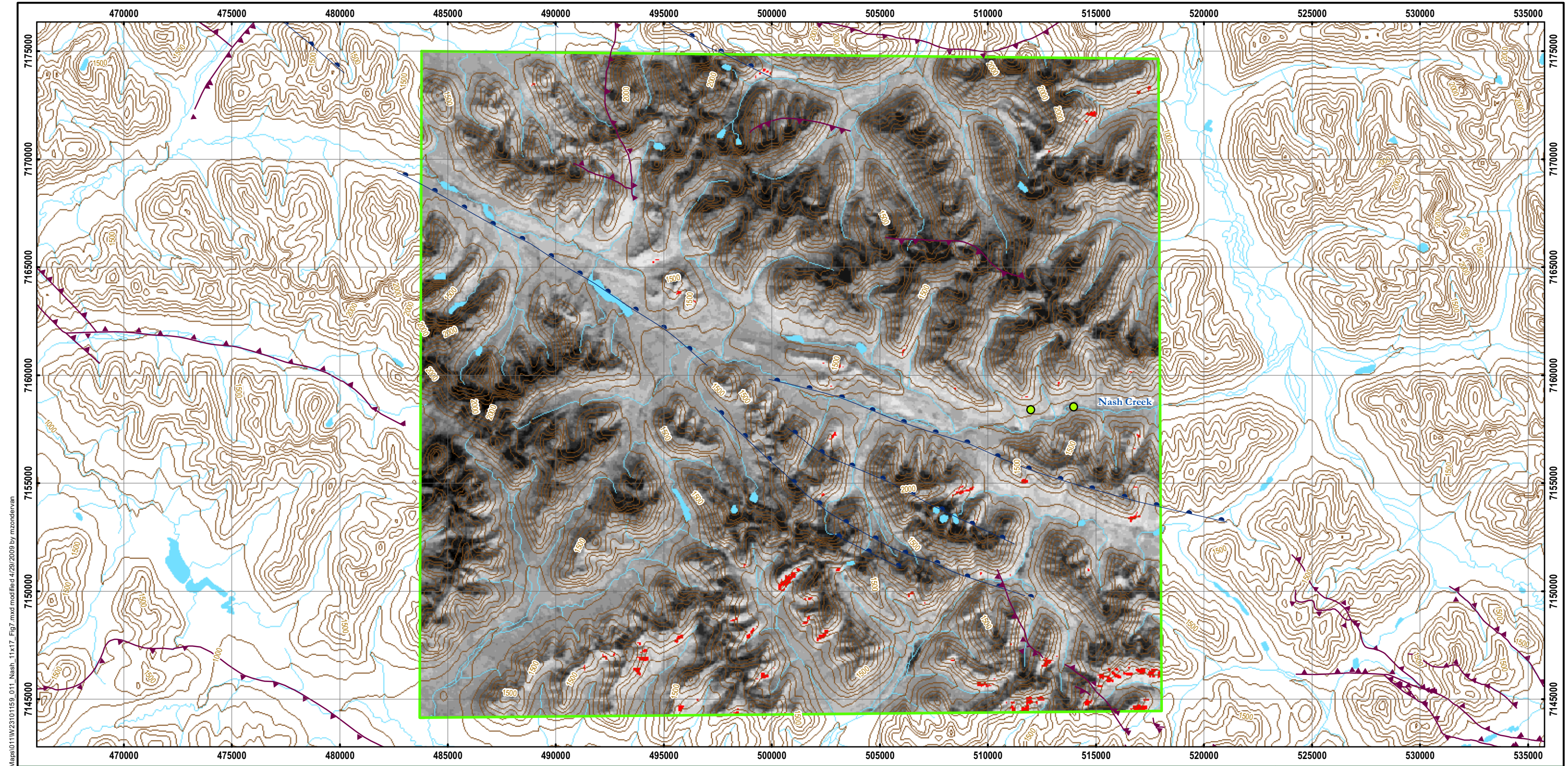


NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)
2. The striping effect seen in the night and averaged images is caused by the use of SLC-OFF data. Imagery available after the SLC sensor malfunctioned contains gaps and overlaps at the edges of swaths.

Base data sources:
 Yukon Geological data from Geomatics Yukon
 BC Geological data from ILMB
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM			
Coal River and Larson Creek/Beaver River Area Landsat Imagery Analysis			
PROJECTION UTM Zone 9	DATUM NAD83	Scale: 1:450,000	
<p>FILE NO. W23101159_011_BC_CR_11x17_Fig6.mxd</p>			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE April 29, 2009		
			Figure 6



G:\Vancouver\GIS\ENVIRONMENTAL\W231W23101159_YU_Geothermal\Maps\011W23101159_011_Nash_11x17_Fig7.mxd modified 4/29/2009 by mzordevan

LEGEND

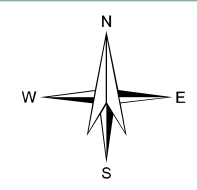
- Approximate Locations of Known Hot Springs
- Study Area
- Watercourse
- Waterbody
- Contours**
- Index (500m)
- Intermediate (100m)
- Geological Features**
- ▲ Fault
- Fold

Nash Creek Landsat Day Scene

Pixel Value¹

	86 - 90		115 - 120
	90 - 95		120 - 125
	95 - 100		125 - 130
	100 - 105		130 - 135
	105 - 110		135 - 140
	110 - 115		140 - 145
	145 - 155		

} Potential Thermal Anomalies



NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Geological data from Geomatics Yukon
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

ISSUED FOR USE

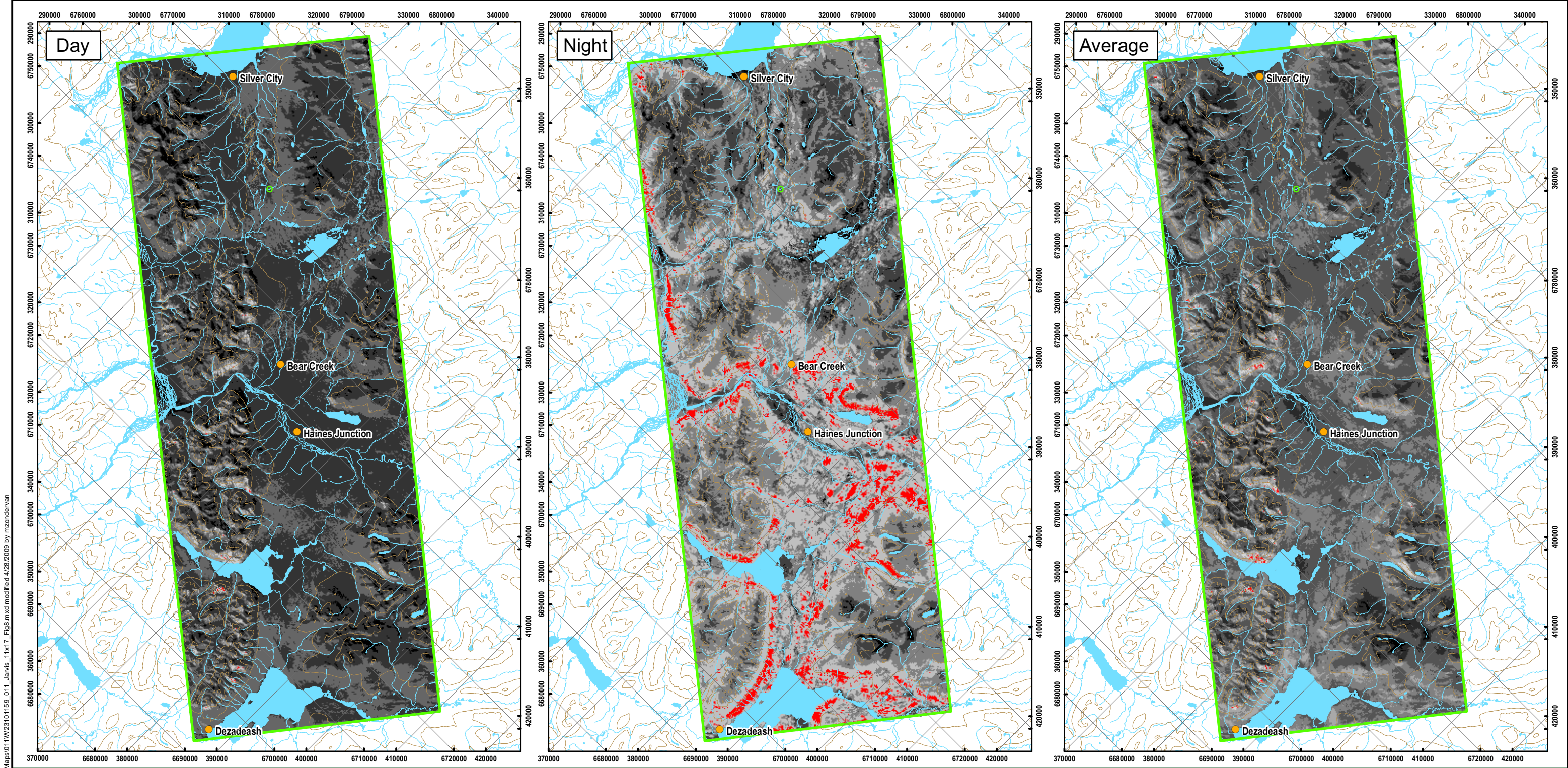
YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

**Nash Creek Area
Landsat Imagery Analysis**

PROJECTION UTM Zone 8		DATUM NAD83	
Scale: 1:175,000			
FILE NO. W23101159_011_Nash_11x17_Fig7.mxd			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE April 29, 2009		

EBA Engineering Consultants Ltd.

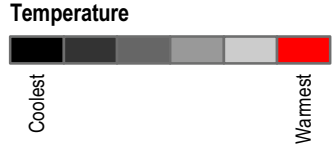
Figure 7



G:\Vancouver\GIS\ENVIRONMENTAL\W231W23101159_YU_Geothermal\Maps\011W23101159_011_Jarvis_11x17_Fig8.mxd modified 4/28/2009 by m.zonderman

LEGEND

- Populated Place
- Study Area
- Location of Previous Field Work
- Contour (500m)
- Watercourse
- Waterbody

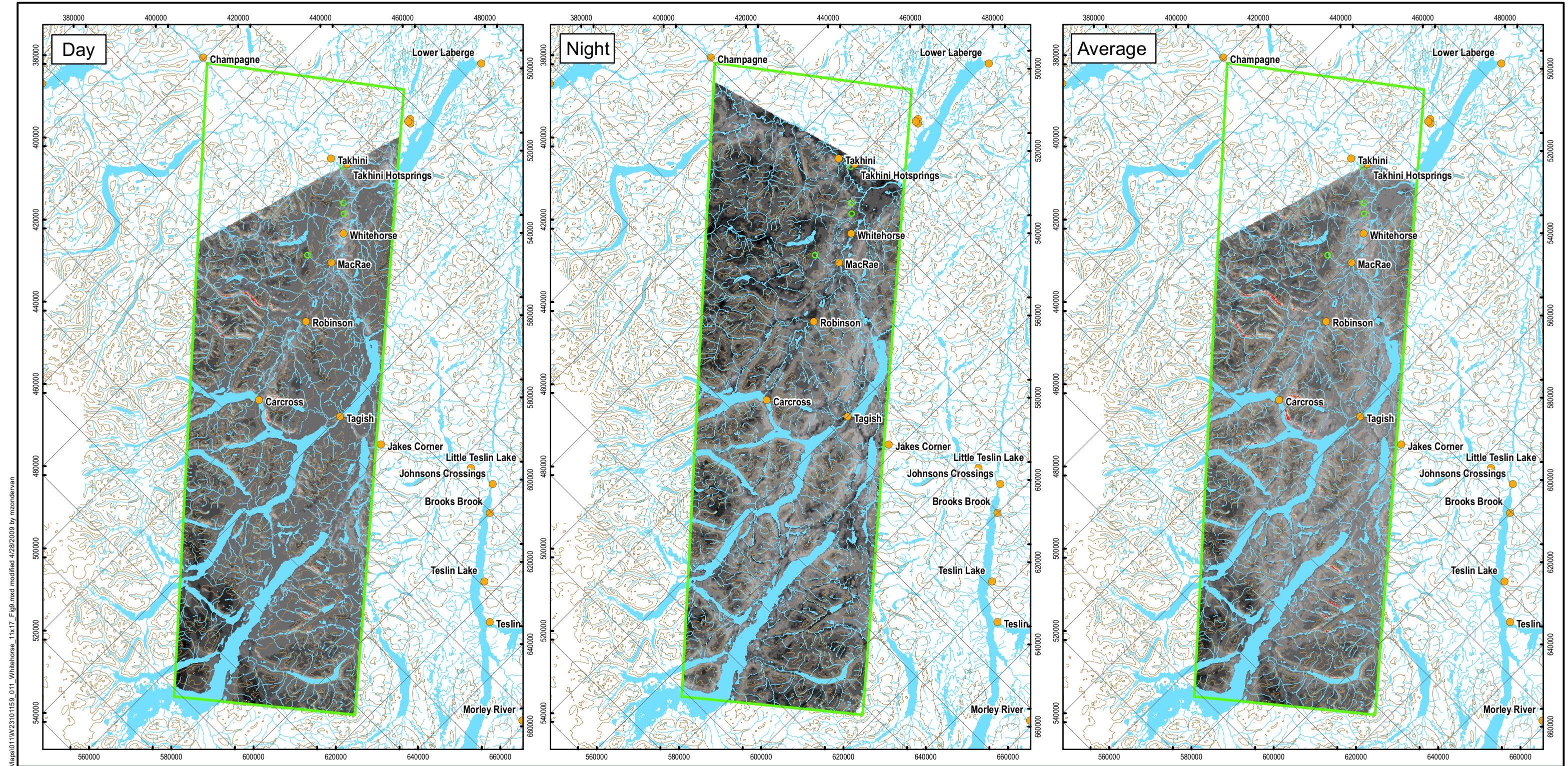


NOTES
Base data source: USGS, NTDB 1:250K



YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM			
Comparison of Day, Night, and Averaged Landsat Scenes - Jarvis River Study Area			
PROJECTION UTM Zone 8	DATUM NAD83		
Scale: 1:600,000 			
FILE NO. W23101159_011_Jarvis_11x17_Fig8.mxd			
EBA Engineering Consultants Ltd.			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE April 28, 2009		
			Figure 8

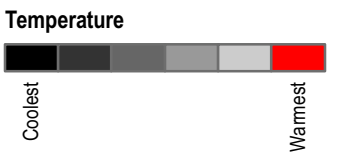
ISSUED FOR USE



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LEGEND

- Populated Place
- Study Area
- Approximate Locations of Known Hot Springs
- Contour (500m)
- Watercourse
- Waterbody

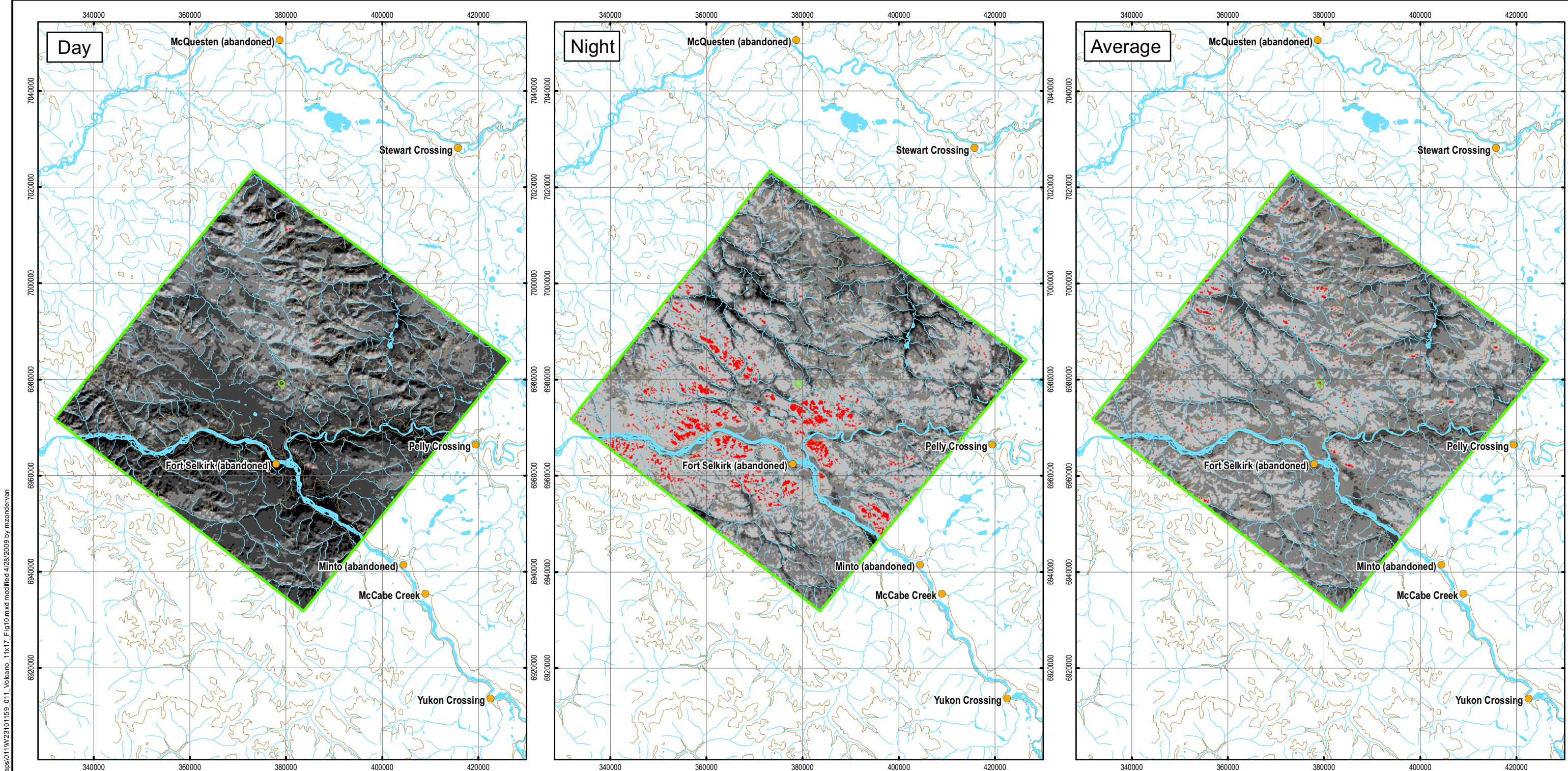


NOTES
Base data source: USGS, NTDB 1:250K



YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM			
Comparison of Day, Night, and Averaged Landsat Scenes - Whitehorse Study Area			
PROJECTION UTM Zone 8	DATUM NAD83		
Scale: 1:1,300,000 			
FILE NO. W23101159_011_Whitehorse_11x17_Fig9.mxd			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE April 28, 2009		
			Figure 9

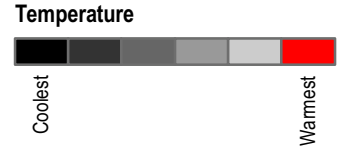
ISSUED FOR USE



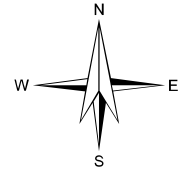
G:\Vancouver\GIS\ENVIRONMENTAL\W231W23101159_011_Volcano_11x17_Fig10.mxd modified 4/28/2009 by mzondevan

LEGEND

- Populated Place
- Study Area
- Location of Previous Field Work
- Contour (500m)
- Watercourse
- Waterbody



NOTES
Base data source: USGS, NTDB 1:250K



YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

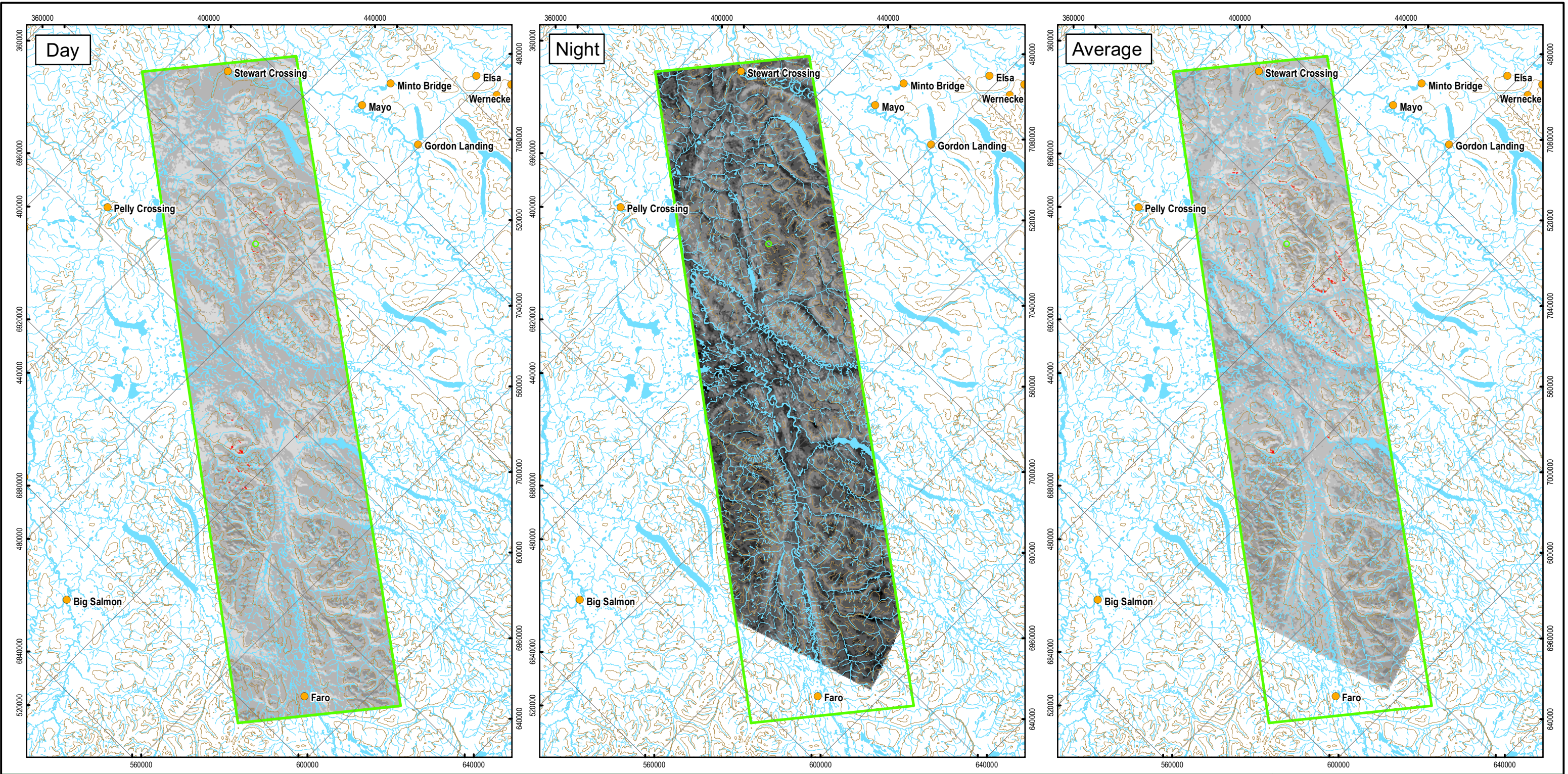
Comparison of Day, Night, and Averaged Landsat Scenes - Volcano Mountain Study Area

PROJECTION UTM Zone 8	DATUM NAD83	
Scale: 1:800,000 		
FILE NO. W23101159_011_Volcano_11x17_Fig10.mxd		
EBA Engineering Consultants Ltd.		
PROJECT NO. W23101159.011	DWN MEZ	CKD GC
OFFICE EBA-VANC	DATE April 28, 2009	REV 0

Figure 10

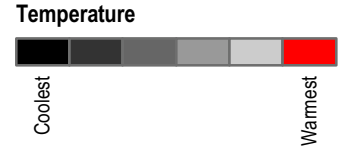
ISSUED FOR USE

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LEGEND

- Populated Place
- Study Area
- Location of Previous Field Work
- Contour (500m)
- Watercourse
- Waterbody



NOTES
Base data source: USGS, NTDB 1:250K



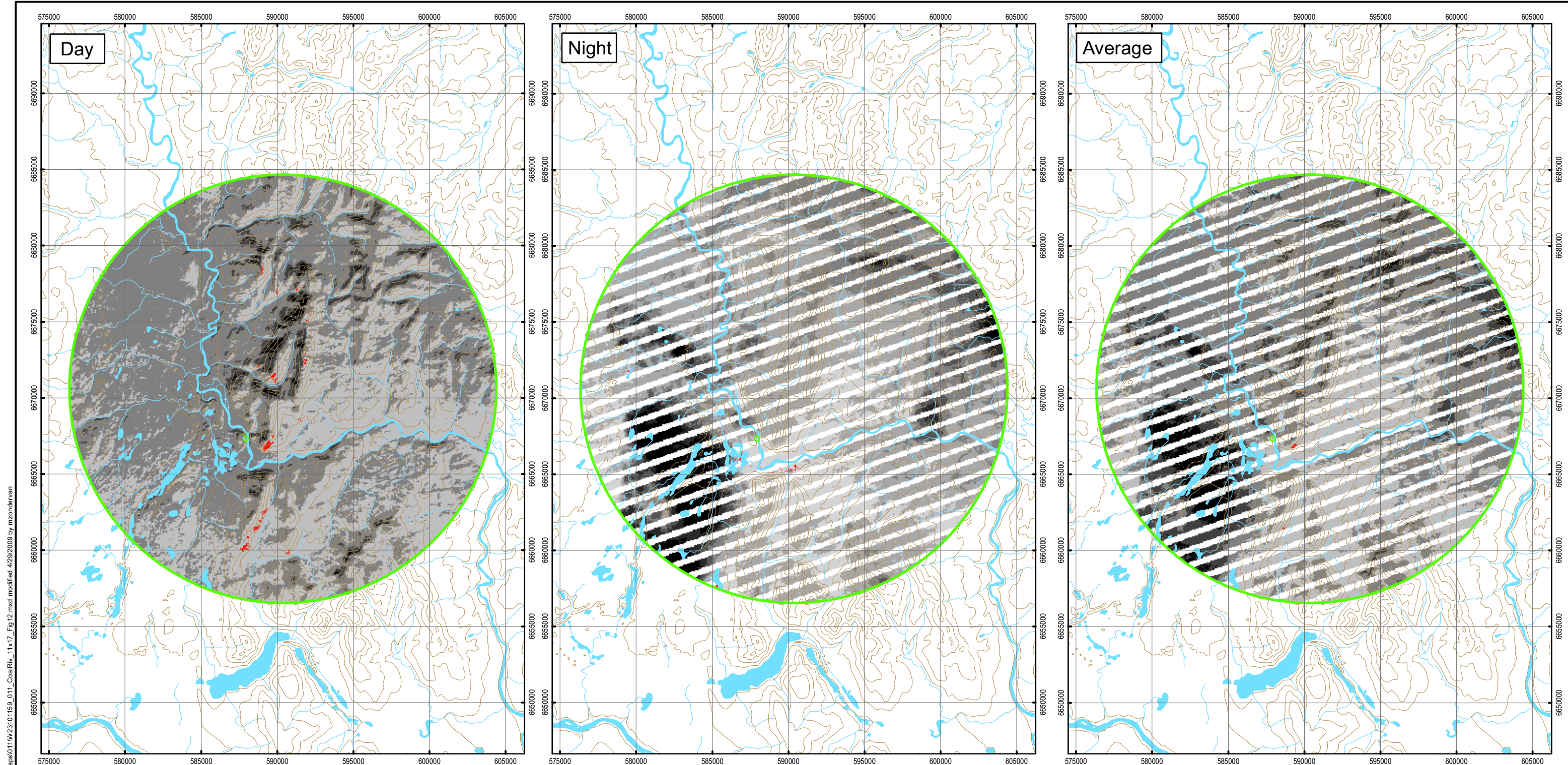
YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

Comparison of Day, Night, and Averaged Landsat Scenes - McArthur Study Area

PROJECTION UTM Zone 8	DATUM NAD83			
Scale: 1:1,300,000 Kilometres				
FILE NO. W23101159_011_McArthur_11x17_Fig11.mxd				
PROJECT NO. W23101159.011	DWN MEZ		CKD GC	REV 0
OFFICE EBA-VANC	DATE April 27, 2009			

Figure 11

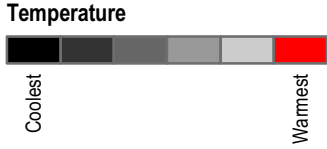
ISSUED FOR USE



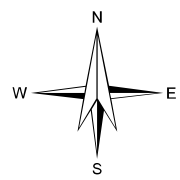
G:\Vancouver\GIS\ENVIRONMENTAL\W231W23101159_YU_Geothermal\Maps\011W23101159_011_CoalRiv_11x17_Fig12.mxd modified: 4/29/2009 by mzondevan

LEGEND

- Study Area
- Approximate Locations of Known Hot Springs
- Contour (100m)
- Watercourse
- Waterbody



NOTES
 1. The striping in the night and averaged images is due to the use of SLC-OFF data. Imagery available after the SLC sensor malfunctioned contains gaps and overlaps at the edges of swaths.
 Base data source: USGS, NTDB 1:250K



YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

Comparison of Day, Night, and Averaged Landsat Scenes - Coal River Study Area

PROJECTION UTM Zone 9	DATUM NAD83
Scale: 1:250,000	

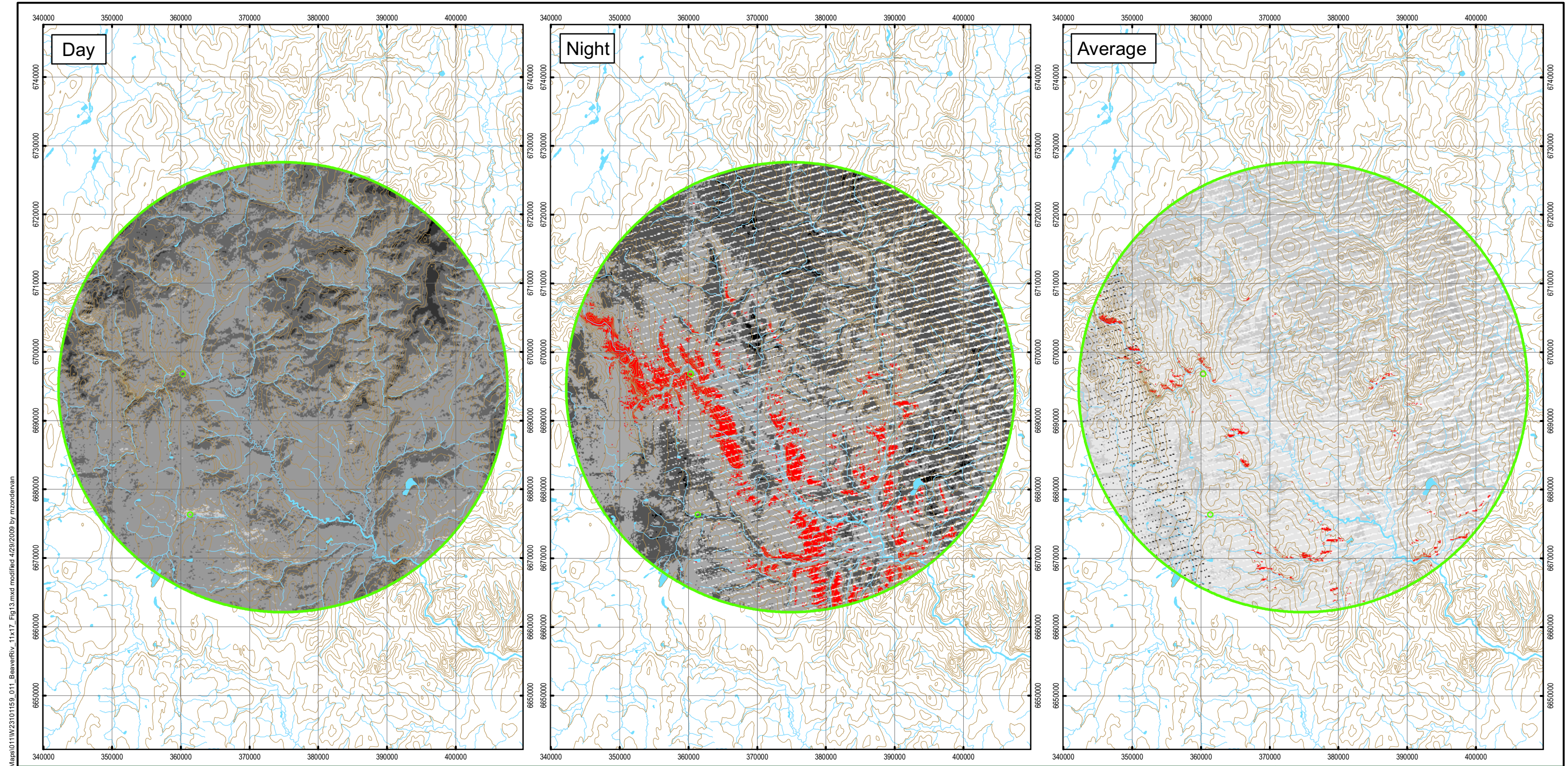


FILE NO. W23101159_011_CoalRiv_11x17_Fig12.mxd			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE April 27, 2009		

EBA Engineering Consultants Ltd.

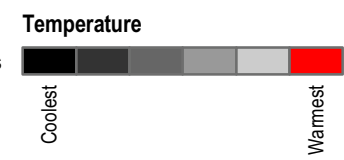
Figure 12

ISSUED FOR USE



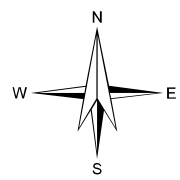
G:\Vancouver\GIS\ENVIRONMENTAL\W231W23101159_YU_Geothermal\Maps\011W23101159_011_BeaverRiv_11x17_Fig13.mxd modified 4/29/2009 by mzdandevan

- LEGEND**
- Study Area
 - Approximate Locations of Known Hot Springs
 - Contour (100m)
 - Watercourse
 - Waterbody



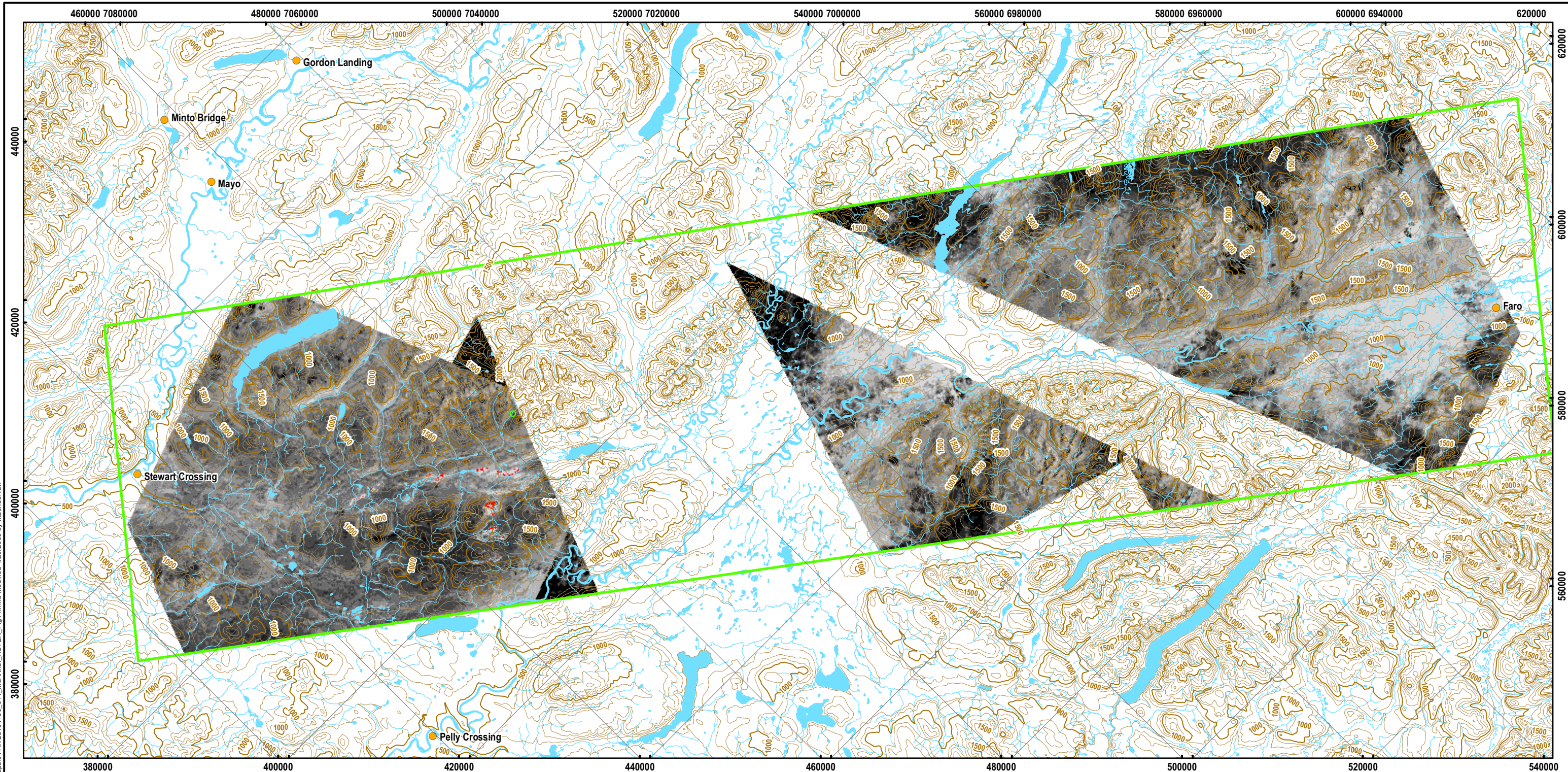
NOTES

1. The striping in the night and averaged images is due to the use of SLC-OFF data. Imagery available after the SLC sensor malfunctioned contains gaps and overlaps at the edges of swaths. Base data source: USGS, NTDB 1:250K



ISSUED FOR USE

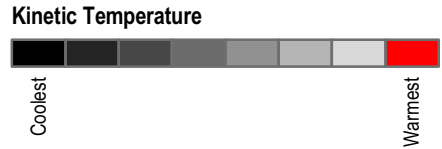
YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM			
Comparison of Day, Night, and Averaged Landsat Scenes - Larson Creek/Beaver River Study Area			
PROJECTION UTM Zone 10	DATUM NAD83		
Scale: 1:550,000			
FILE NO. W23101159_011_BeaverRiv_11x17_Fig13.mxd			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC		DATE April 27, 2009	
			Figure 13



G:\Vancouver\GIS\ENVIRONMENTAL\W23101159_011_McArthur_ASTER_Fig14.mxd modified: 4/29/2009 by mzcandevan

LEGEND

- Populated Place
- Location of Previous Field Work
- Study Area
- Contour**
- Index (500m)
- Intermediate (100m)
- Watercourse
- Waterbody



Scene List

Scene ID	Date
SC:AST_L1A.003:2016704785	2003-08-26
SC:AST_L1A.003:2016704788	2003-08-26
SC:AST_L1A.003:2030408810	2005-08-10
SC:AST_L1A.003:2030408809	2005-08-10
SC:AST_L1A.003:2046211092	2007-08-16
SC:AST_L1A.003:2024358609	2004-06-10
SC:AST_L1A.003:2024358611	2004-06-10
SC:AST_L1A.003:2014704314	2003-06-15
SC:AST_L1A.003:2014704309	2003-06-15
SC:AST_L1A.003:2025003731	2004-07-12

NOTES
Base data source: USGS, NTDB 1:250K



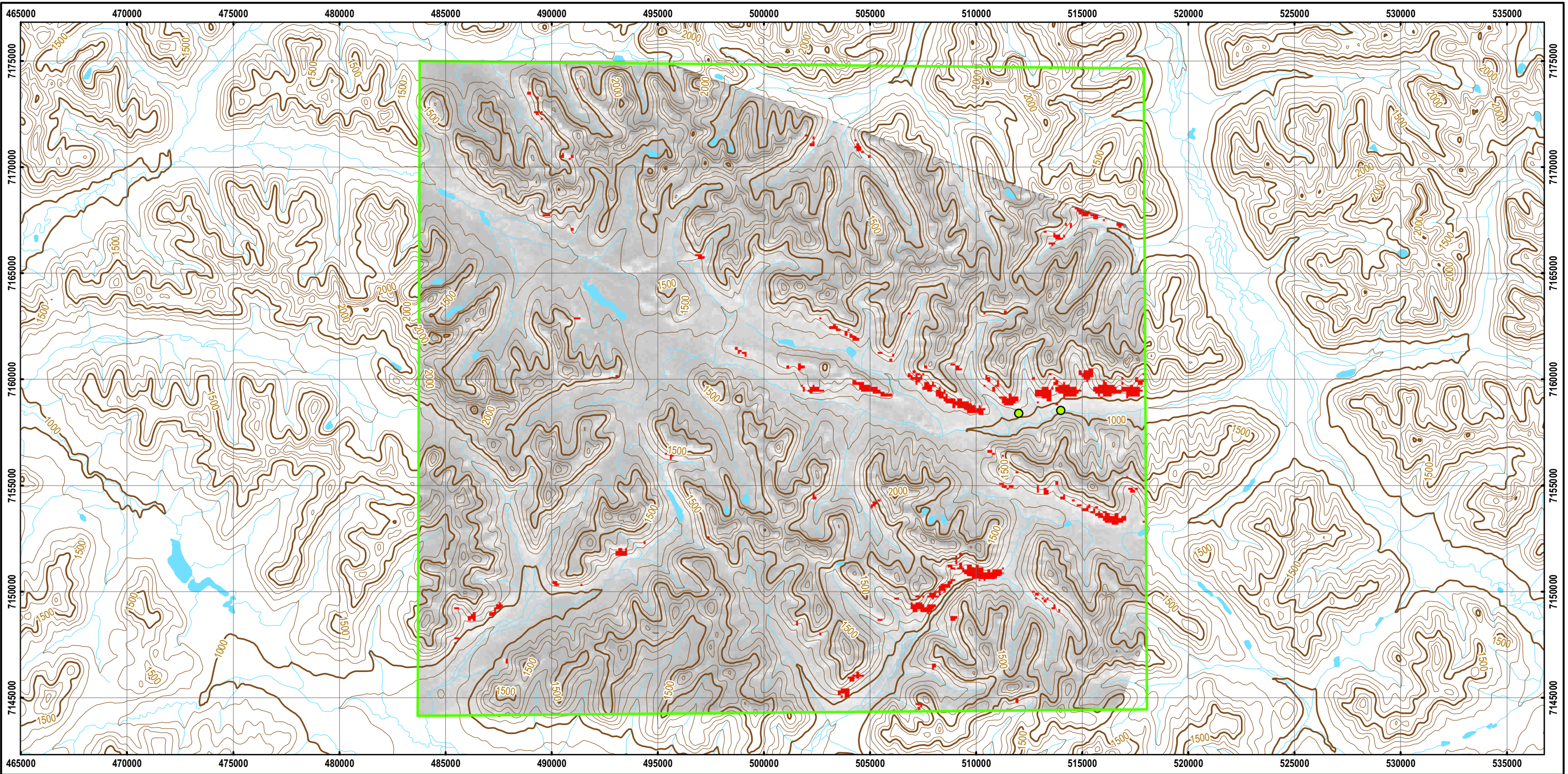
YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

**McArthur Area
ASTER Imagery Analysis**

PROJECTION UTM Zone 8	DATUM NAD83
Scale: 1:600,000 	
FILE NO. W23101159_011_McArthur_ASTER_Fig14.mxd	PROJECT NO. W23101159.011
OFFICE EBA-VANC	DATE April 29, 2009

Figure 14

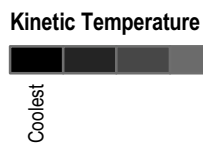
ISSUED FOR USE



G:\Vancouver\GIS\ENVIRONMENTAL\W23101159_YU_Geothermal\Maps\011W23101159_011_Nash_ASTER_Fig15.mxd modified 4/29/2009 by mzoandevan

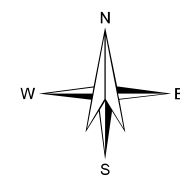
LEGEND

- Approximate Locations of Known Hot Springs
- Study Area
- Contours**
- Index (500m)
- Intermediate (100m)
- Watercourse
- Waterbody



Scene List

Scene ID	Date
SC:AST_L1A.003:2013409639	2003-05-06
SC:AST_L1A.003:2024358624	2004-06-10



YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

**Nash Creek Area
ASTER Imagery Analysis**

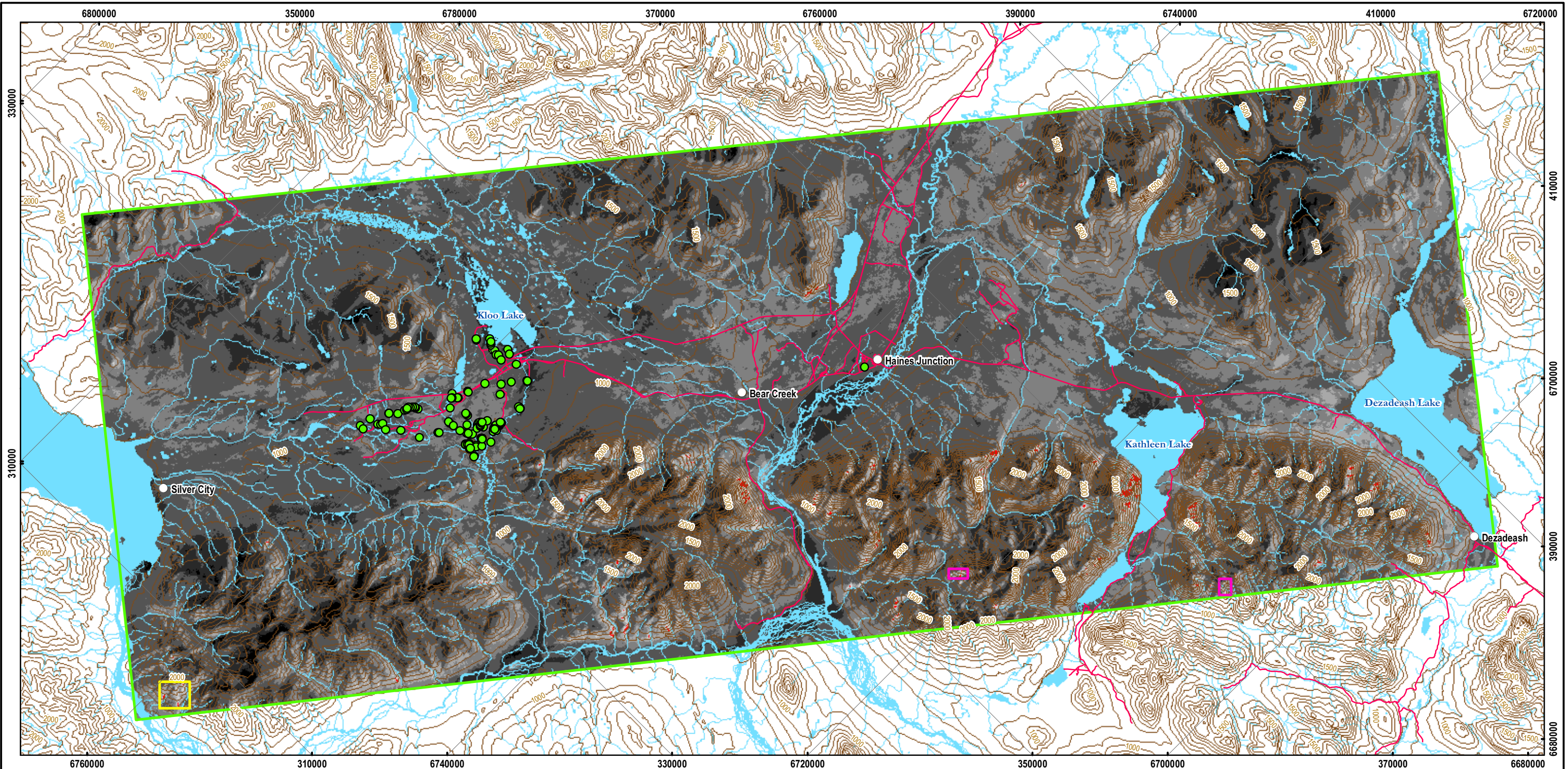
PROJECTION UTM Zone 8	DATUM NAD83		
Scale: 1:180,000			
FILE NO. W23101159_011_Nash_ASTER_Fig15.mxd			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE April 29, 2009		



NOTES
Base data source: USGS, NTDB 1:250K

ISSUED FOR USE

Figure 15



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LEGEND

Anomalies Selected for Low-level TIR Analysis		Contours	Landsat Averaged Day/Night Pair
Priority Level		— Index (500m)	Pixel Value¹
2		— Intermediate (100m)	58 - 63
3		— Watercourse	63 - 67
●	Jarvis River Warm Springs -	— Waterbody	67 - 73
○	Previously Sampled Location		73 - 77
○	Populated Place		77 - 83
—	Roads		83 - 87
□	Study Area		87 - 97

} Potential Thermal Anomalies

NOTES

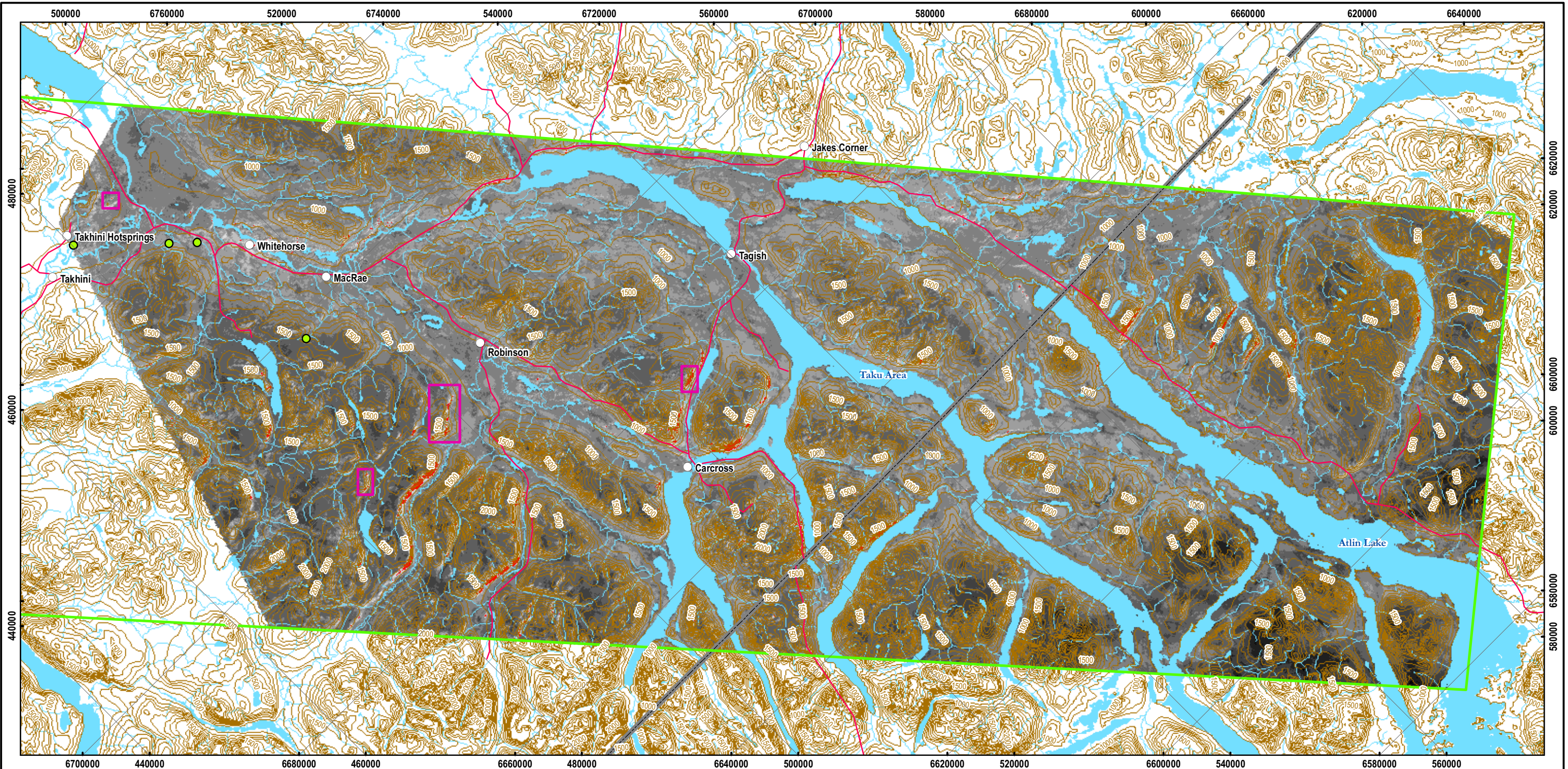
1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Geological data from Geomatics Yukon
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K



YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM			
Jarvis River Area			
Satellite Derived Thermal Anomalies Selected for Low-Level TIR Analysis			
PROJECTION	UTM Zone 8	DATUM	NAD83
Scale: 1:300,000		5 2.5 0 5	
Kilometres			
FILE NO.	W23101159_011_Jarvis_11x17_Fig16.mxd		
PROJECT NO.	DWN	CKD	REV
W23101159.011	MEZ	GC	0
OFFICE	DATE		
EBA-VANC	June 2, 2009		
Figure 16			

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LEGEND

Anomalies Selected for Low-level TIR Analysis		Contours	Landsat Averaged Day/Night Pair
Priority Level		— Index (500m)	Pixel Value¹
3		— Intermediate (100m)	57 - 62
	Approximate Locations of Known Hot Springs	— Watercourse	62 - 67
	Populated Place	Waterbody	67 - 72
	Study Area		72 - 77
	Road		77 - 82
	Yukon-BC Border		82 - 87
			87 - 92
			92 - 96
			96 - 106

Potential Thermal Anomalies



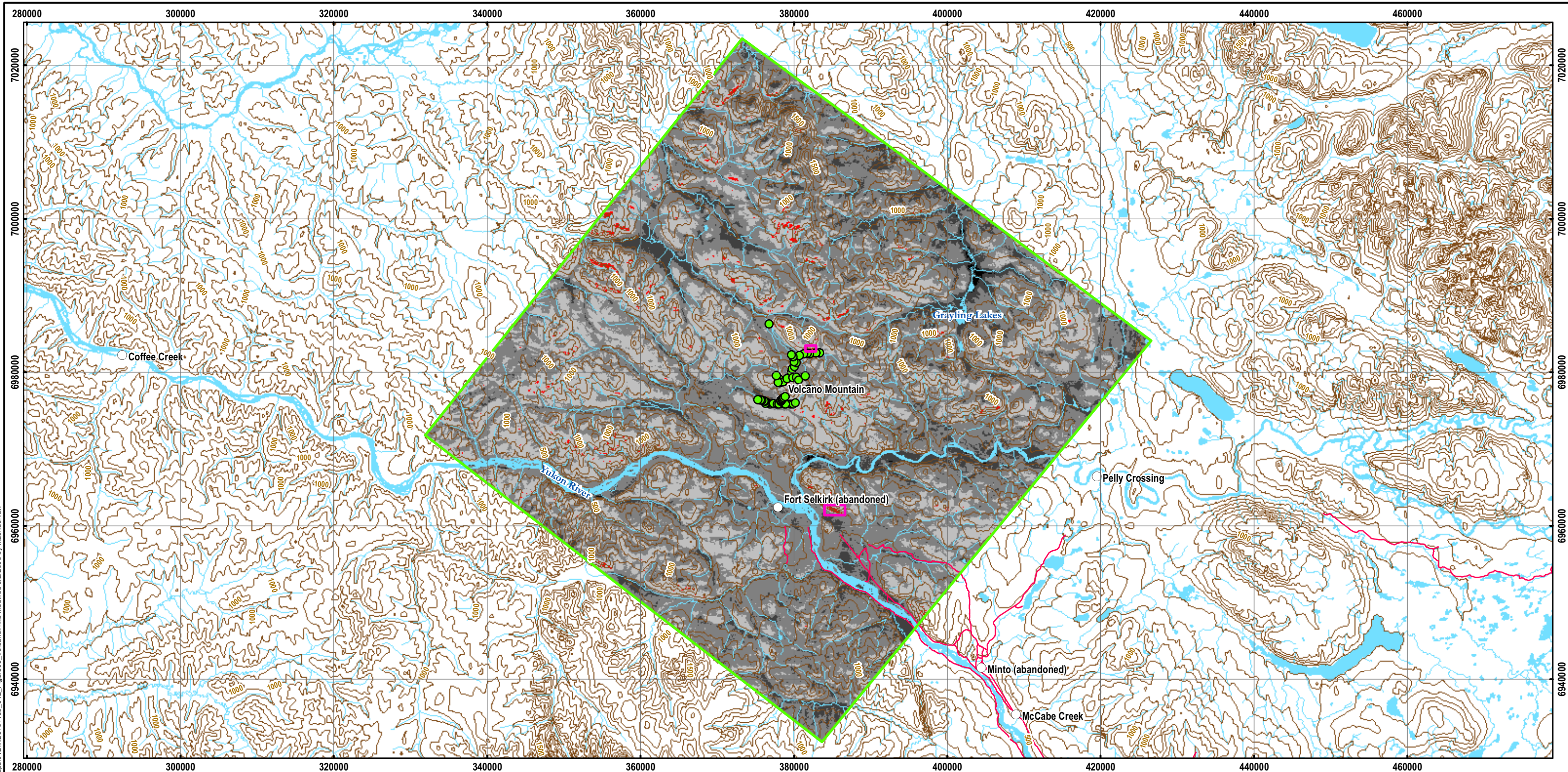
NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Yukon Geological data from Geomatics Yukon
 BC Geological data from ILMB
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

ISSUED FOR USE

YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM			
Whitehorse Area			
Satellite Derived Thermal Anomalies Selected for Low-Level TIR Analysis			
PROJECTION	UTM Zone 8	DATUM	NAD83
Scale: 1:500,000			
FILE NO.	W23101159_011_Whitehorse_11x17_Fig17.mxd		
PROJECT NO.	DWN	CKD	REV
W23101159.011	MEZ	GC	0
OFFICE	DATE		
EBA-VANC	June 2, 2009		
Figure 17			



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LEGEND

Anomalies Selected for Low-level TIR Analysis

- Priority Level**
- 3
 - Volcano Mountain - Previously Sampled Location
 - Populated Place
 - Study Area
 - Roads

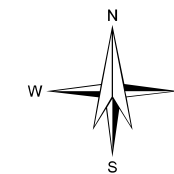
Contour

- Index (500m)
- Intermediate (100m)
- Watercourse
- Waterbody

Landsat Averaged Day/Night Pair

- Pixel Value ¹**
- 51 - 56
 - 56 - 61
 - 61 - 66
 - 66 - 71
 - 71 - 79

Potential Thermal Anomalies



NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Geological data from Geomatics Yukon
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

ISSUED FOR USE

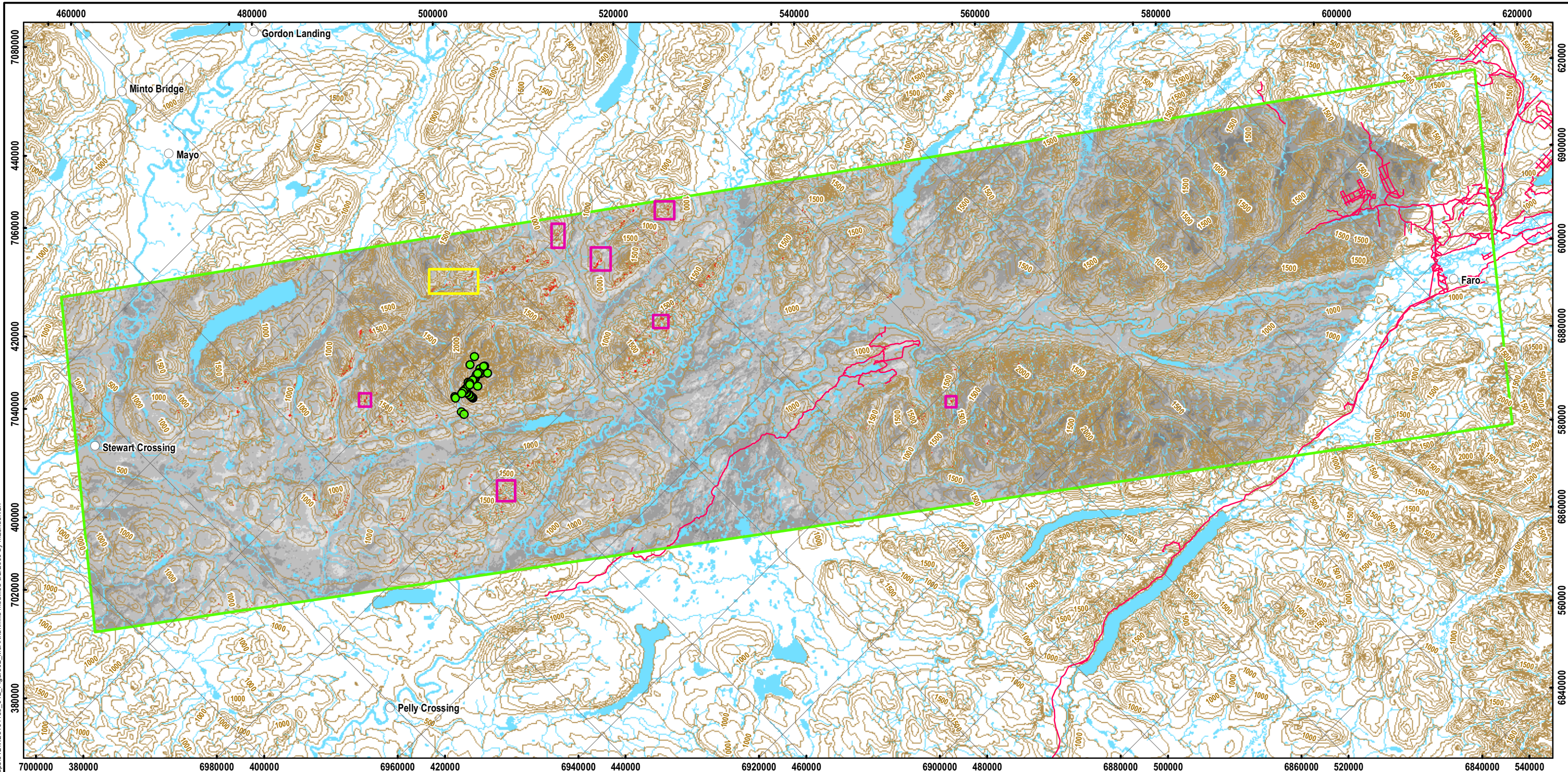
YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

**Volcano Mountain Area
 Satellite Derived Thermal Anomalies
 Selected for Low-Level TIR Analysis**

PROJECTION UTM Zone 8	DATUM NAD83		
Scale: 1:500,000			
FILE NO. W23101159_011_Volcano_11x17_Fig18.mxd	DWN MEZ	CKD GC	REV 0
PROJECT NO. W23101159.011	DATE June 2, 2009		
OFFICE EBA-VANC			



Figure 18



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LEGEND

Anomalies Selected for Low-level TIR Analysis

- Priority Level**
- 2
 - 3
 - McArthur Hot Springs - Previously Sampled Location
 - Populated Place
 - Study Area
 - Roads

Contour

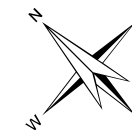
- Index (500m)
- Intermediate (100m)
- Watercourse
- Waterbody

Landsat Averaged Day/Night Pair

Pixel Value ¹

- 31 - 36
- 36 - 41
- 41 - 46
- 46 - 51
- 51 - 56
- 56 - 61
- 61 - 66
- 66 - 71
- 71 - 76

Potential Thermal Anomalies



NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Geological data from Geomatics Yukon
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

ISSUED FOR USE

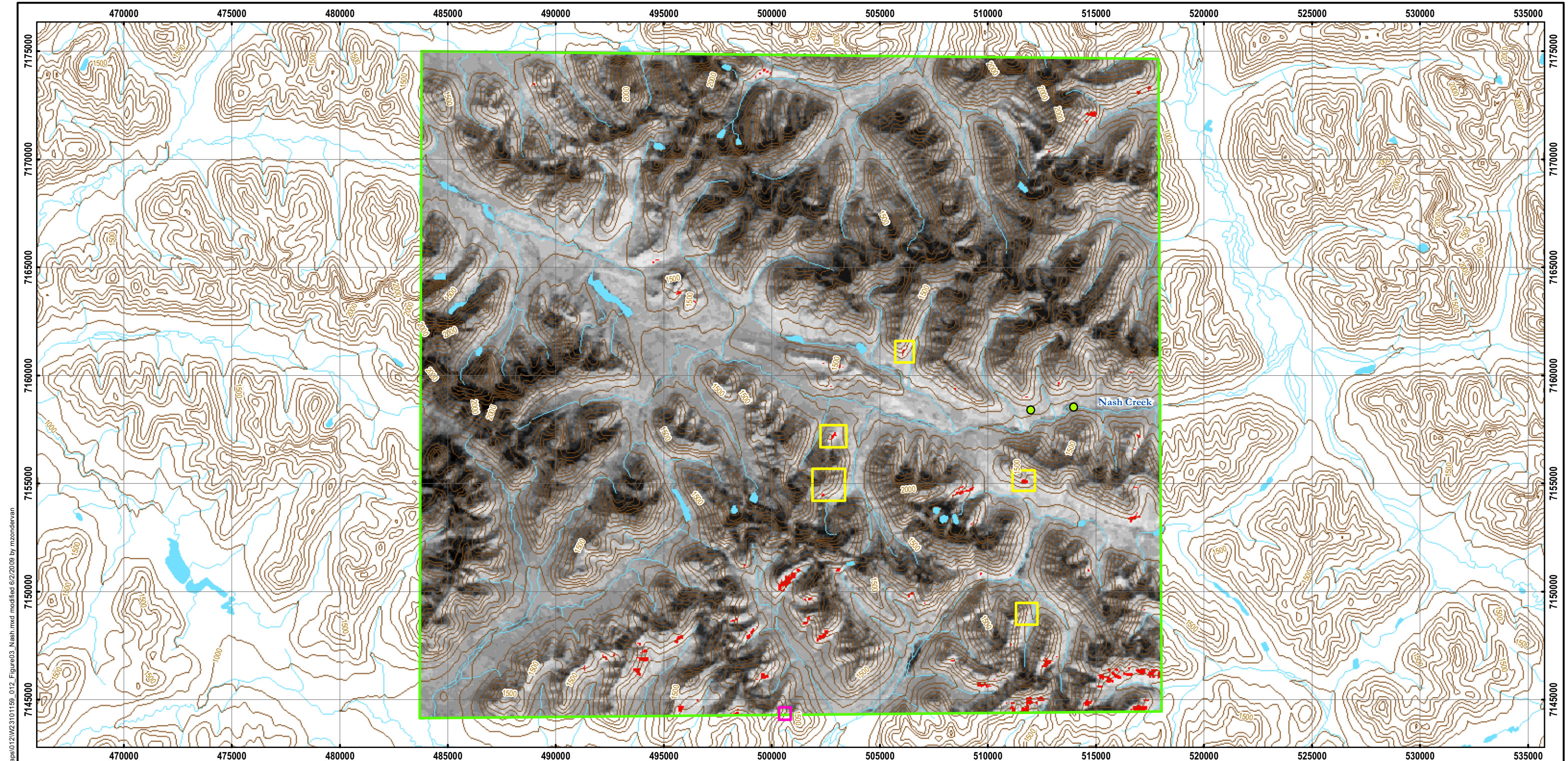
YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

**McArthur Hot Springs Area
 Satellite Derived Thermal Anomalies
 Selected for Low-Level TIR Analysis**

PROJECTION UTM Zone 8	DATUM NAD83		
Scale: 1:600,000			
FILE NO. W23101159_011_McArthur_11x17_Fig19r.mxd	DWN MEZ	CKD GC	REV 0
PROJECT NO. W23101159.011	DATE June 2, 2009		
OFFICE EBA-VANC			



Figure 19



G:\Vancouver\GIS\ENVIRONMENTAL\W231\W23101159_012_Figure03_Nash.mxd modified 6/2/2009 by mzondevan

LEGEND

Anomalies Selected for Low-level TIR Analysis

Priority Level

- 2
- 3
- Approximate Locations of Known Hot Springs
- Study Area

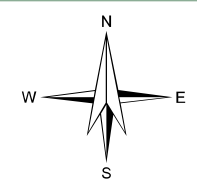
Contours

- Index (500m)
- Intermediate (100m)
- Watercourse
- Waterbody

Nash Creek Landsat Day Scene

Pixel Value¹

	86 - 90		115 - 120
	90 - 95		120 - 125
	95 - 100		125 - 130
	100 - 105		130 - 135
	105 - 110		135 - 140
	110 - 115		140 - 145
	145 - 155	} Potential Thermal Anomalies	



NOTES

1. The digital number (pixel value) of a band 6 Landsat pixel can range from 0 to 255. The digital number has a direct correlation to effective temperature (ie. A high digital number indicates a high effective temperature and low digital number indicates a low effective temperature)

Base data sources:
 Geological data from Geomatics Yukon
 Landsat data from USGS
 Water layers from NTDB 1:50K
 Contours from NTDB 1:250K

ISSUED FOR USE

YUKON-WIDE GEOTHERMAL EXPLORATION PROGRAM

Nash Creek Area
Satellite Derived Thermal Anomalies
Selected for Low-Level TIR Analysis

PROJECTION UTM Zone 8	DATUM NAD83		
Scale: 1:175,000			
FILE NO. W23101159_011_Nash_11x17_Fig20.mxd			
PROJECT NO. W23101159.011	DWN MEZ	CKD GC	REV 0
OFFICE EBA-VANC	DATE June 2, 2009		

EBA Engineering Consultants Ltd.

Figure 20