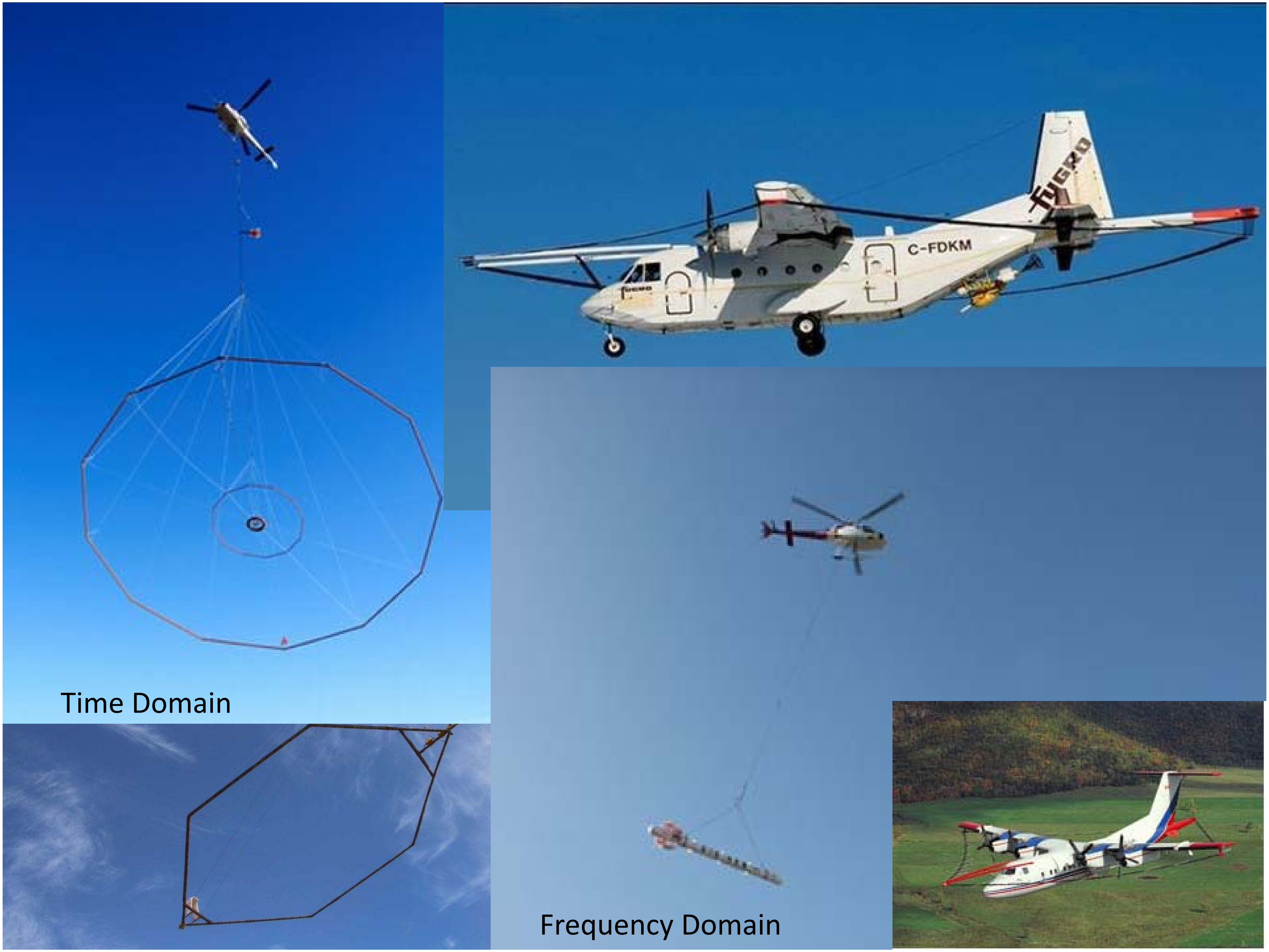
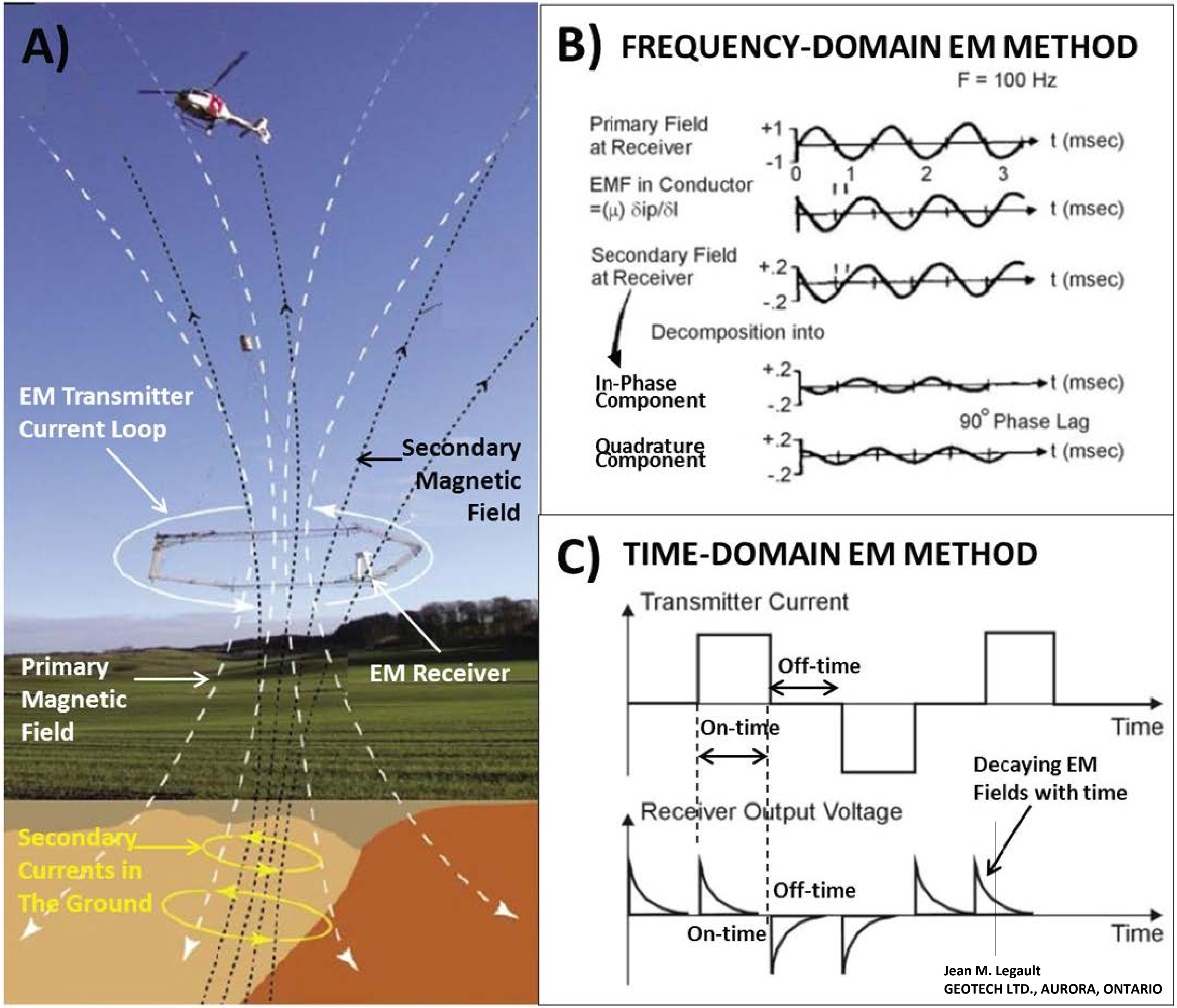
Permafrost Remote Sensing Through Airborne Electromagnetic Geophysics and Thermal Anomalies

Ronald Daanen, Abraham Emond, Jordi Cristobal,
Burke Minsley, Anupma Prakash, Gwen Holdmann,
Anna Liljedahl, Katey Walter Anthony,
Vladimir Romanovsky, Dave Barnes

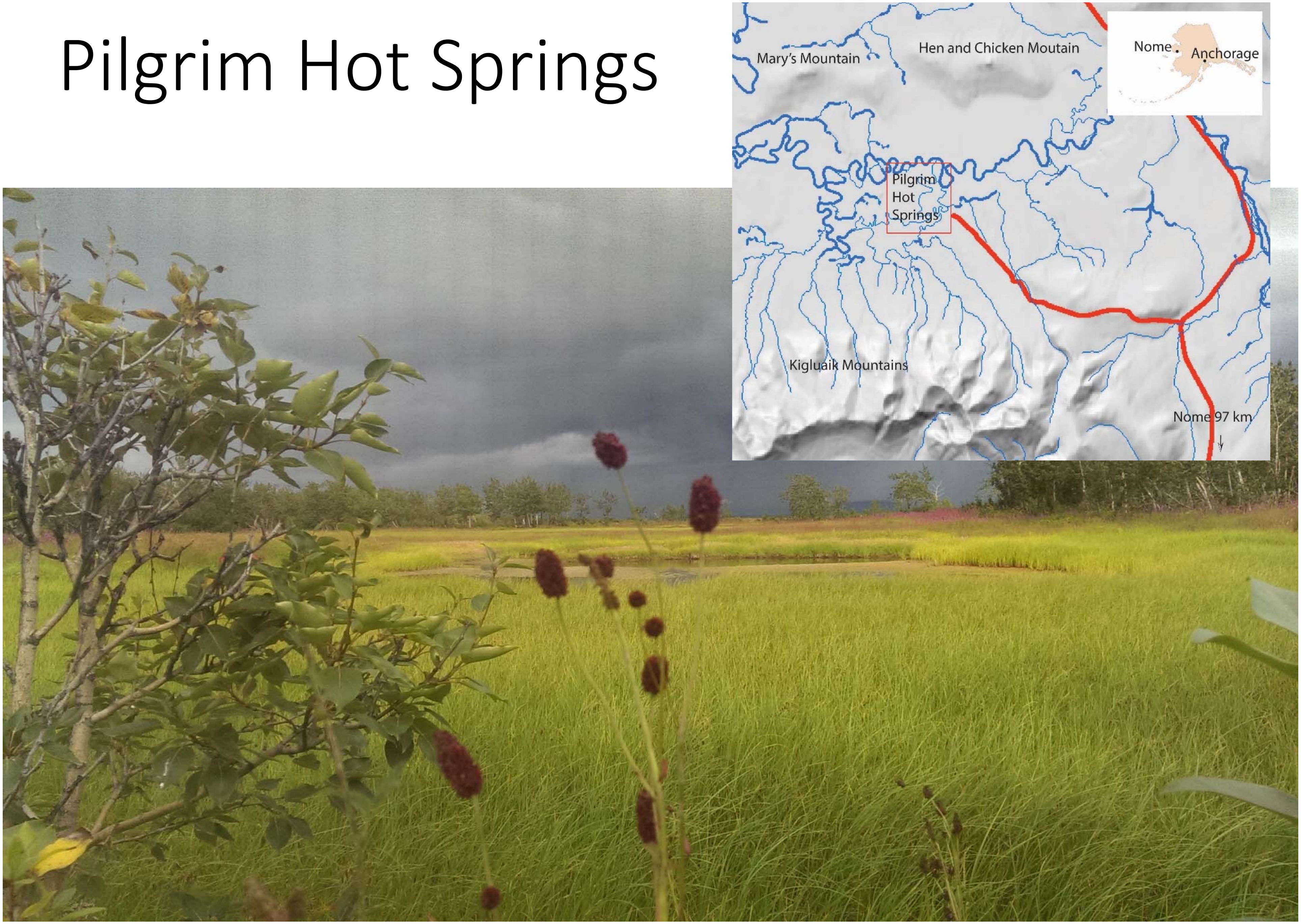
Goldstream Valley Watershed


C-FDKM
Time Domain
Frequency Domain



A)
EM Transmitter Current Loop
Secondary Magnetic Field
Primary Magnetic Field
EM Receiver
Secondary Currents in The Ground
B) FREQUENCY-DOMAIN EM METHOD
F = 100 Hz
Primary Field at Receiver
+1
-1
0
1
2
3
t (msec)
EMF in Conductor
=(μ) δip/δl
Secondary Field at Receiver
+.2
-.2
Decomposition into
In-Phase Component
90° Phase Lag
Quadrature Component
C) TIME-DOMAIN EM METHOD
Transmitter Current
Off-time
On-time
Time
Decaying EM Fields with time
Receiver Output Voltage
Off-time
On-time
Time
Jean M. Legault
GEOTECH LTD., AURORA, ONTARIO

Pilgrim Hot Springs

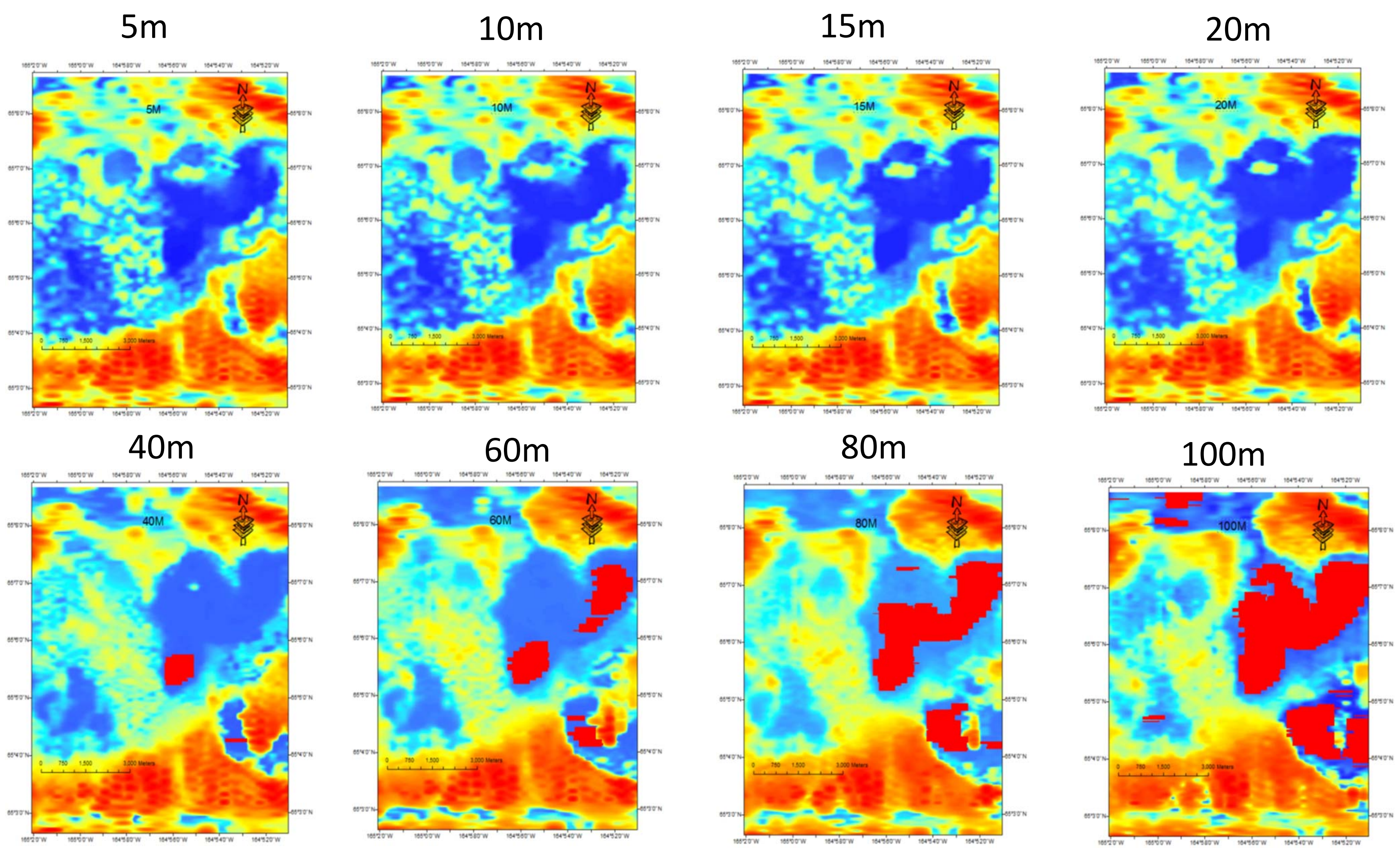


Pilgrim Hot Springs resistivity model

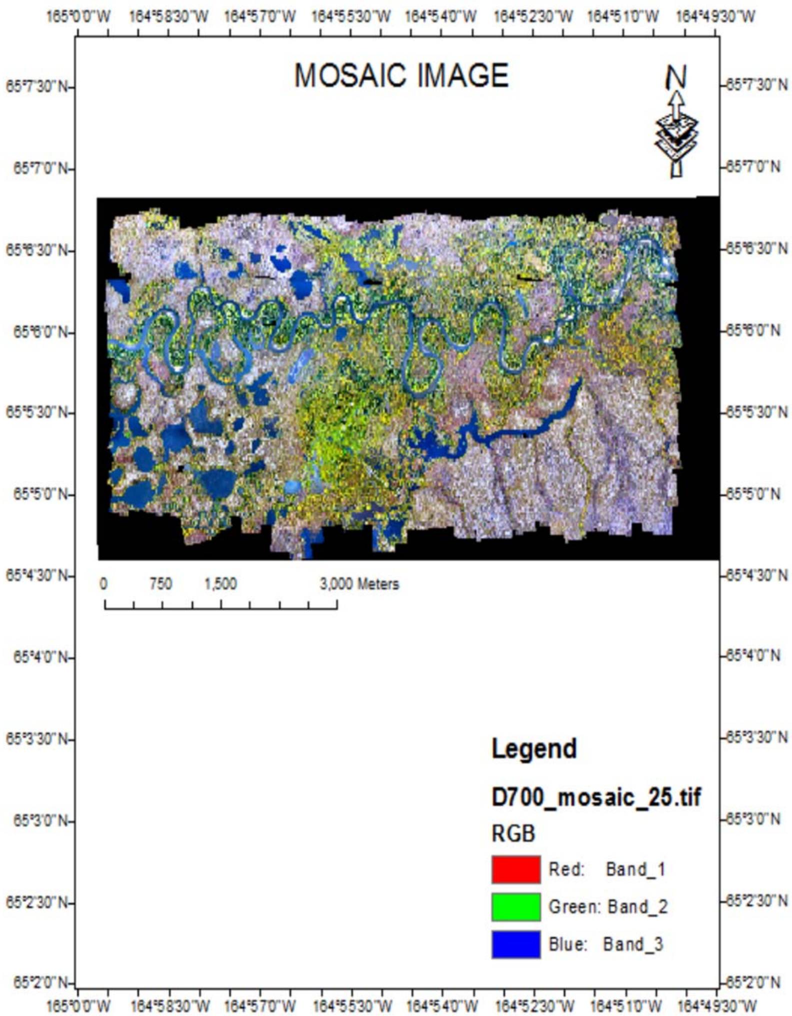
High : 41439.8
Low : -2396.77

Jonathan Glen

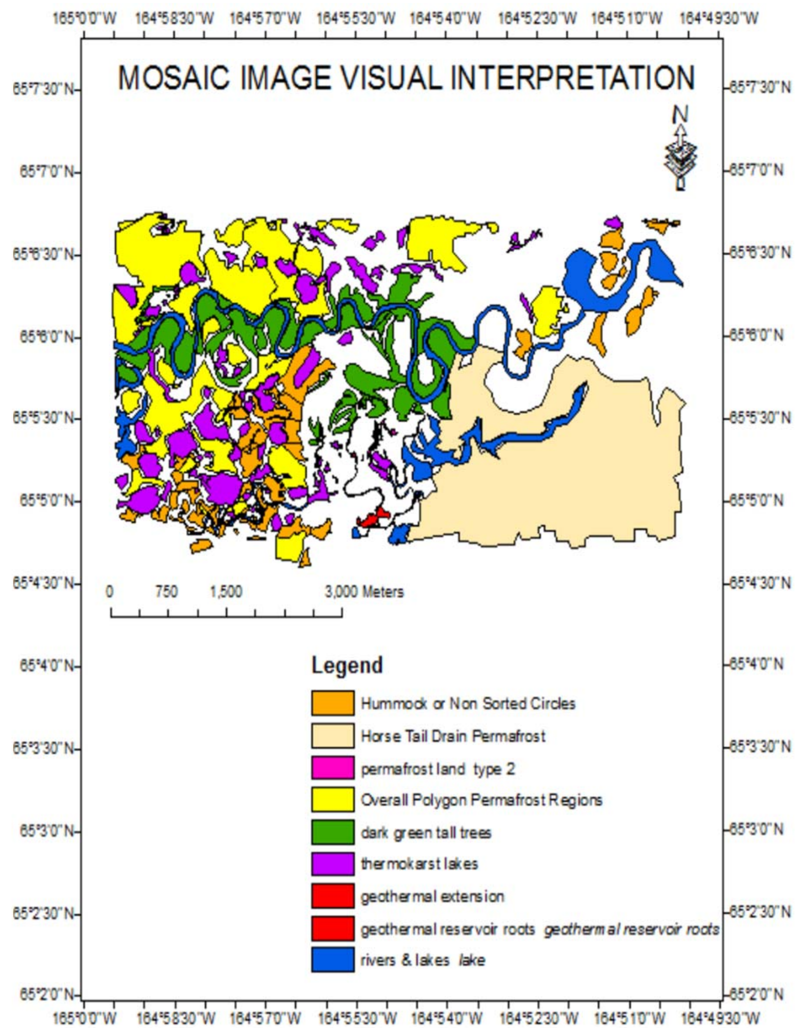
High : 41439.8
Low : -2396.77



Mosaic Image Visual Interpretation

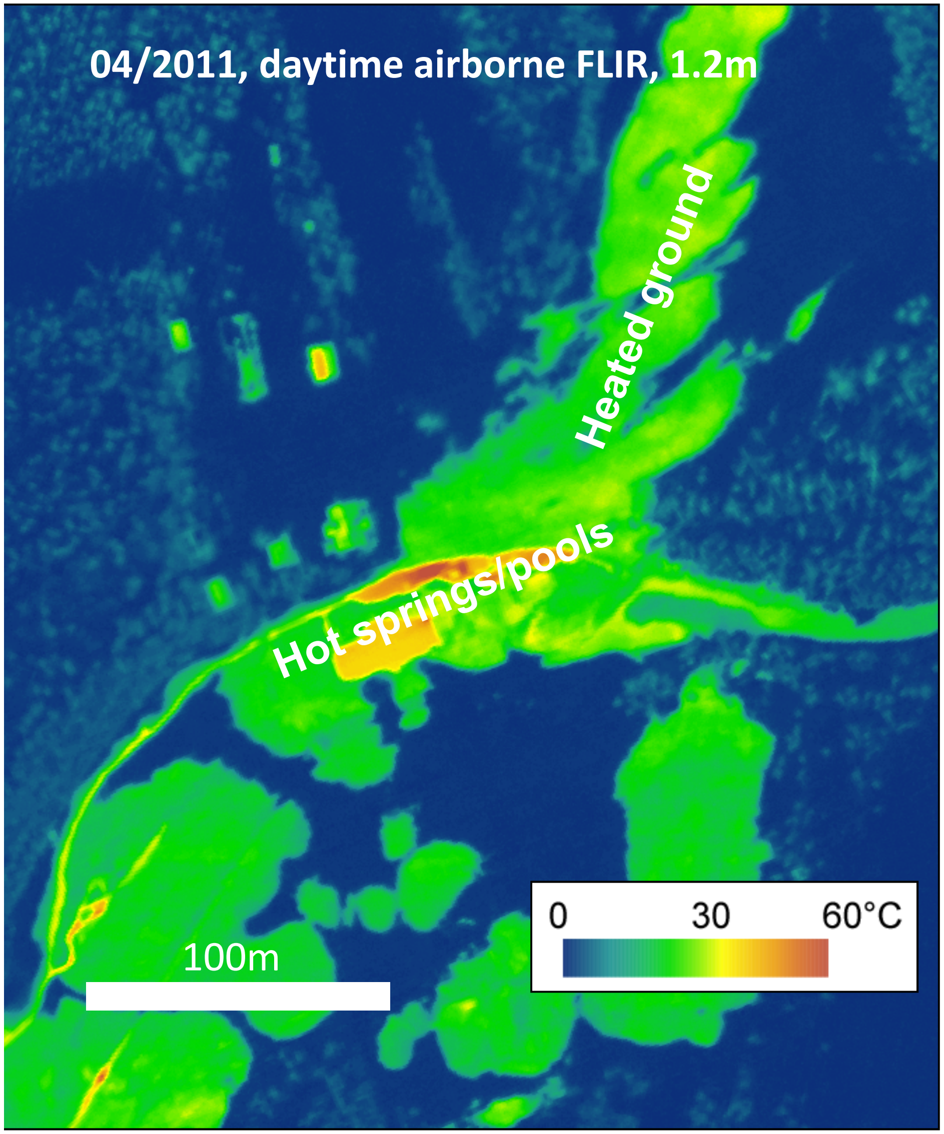


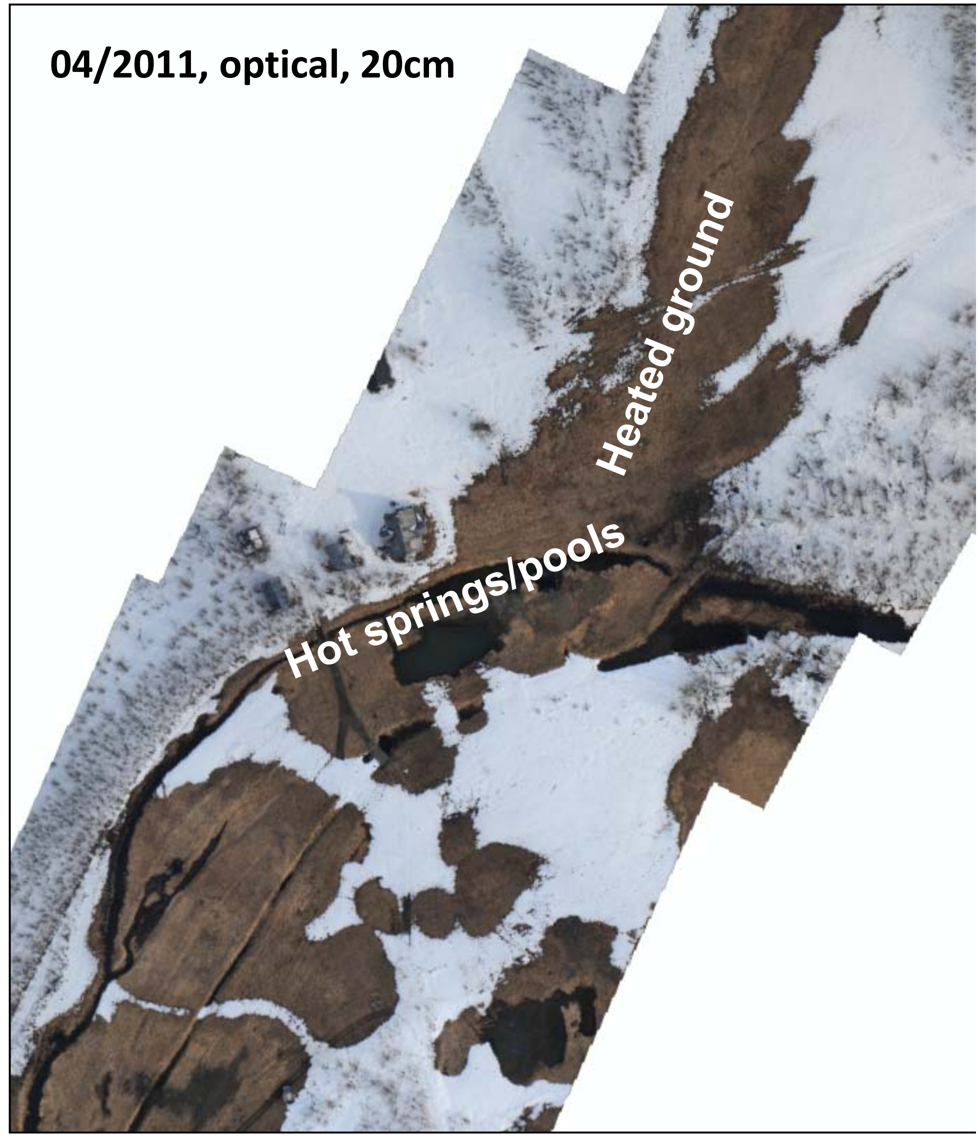
Christian Haselwimmer



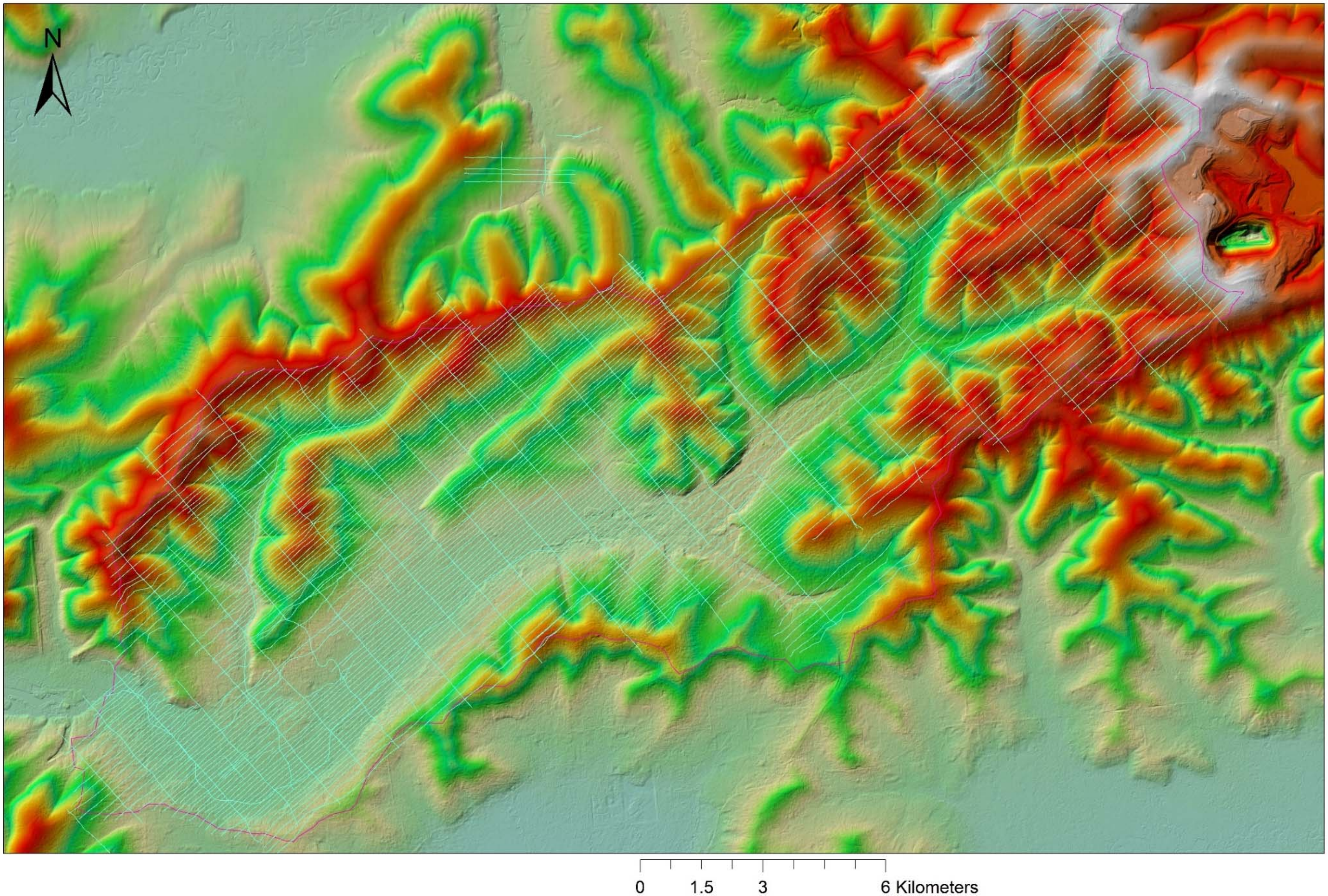
Arvind Chittambakkam

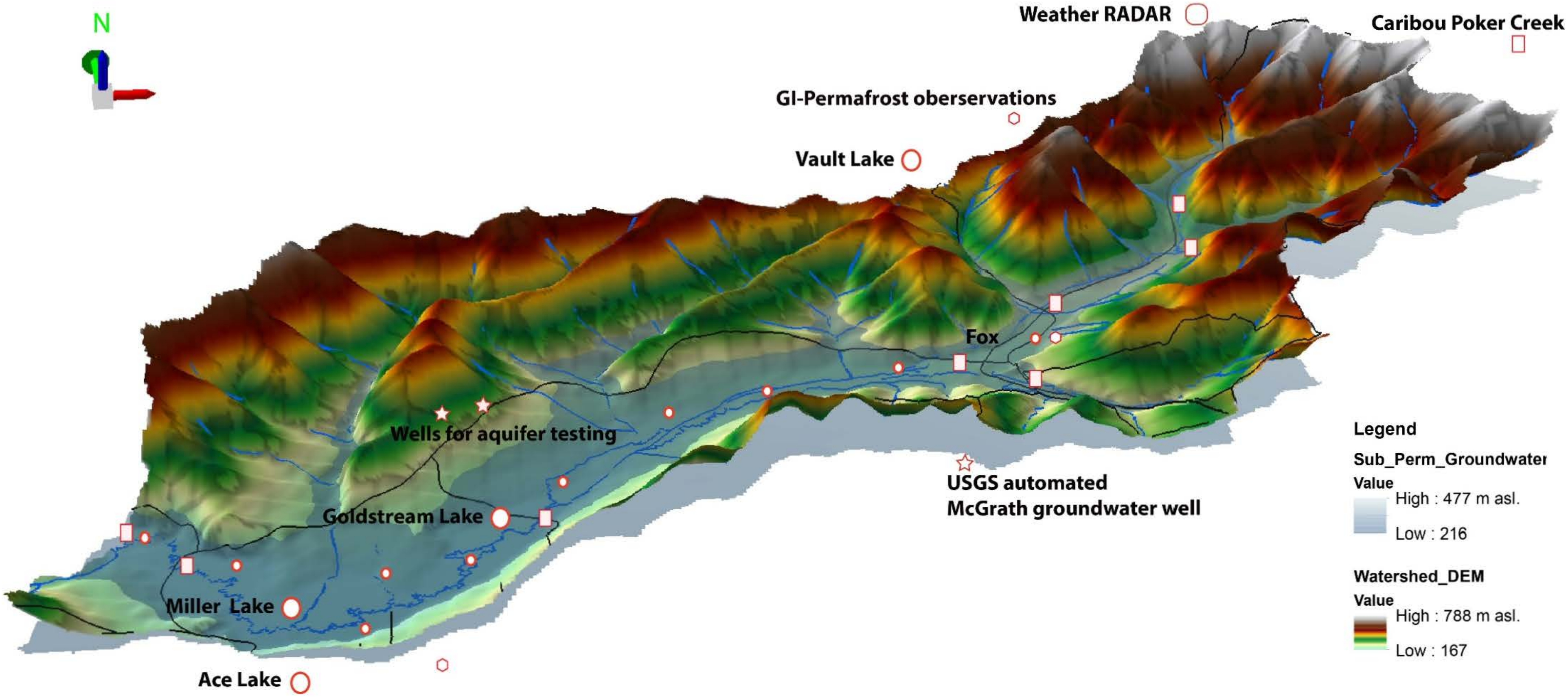
Spring thermal and optical imagery





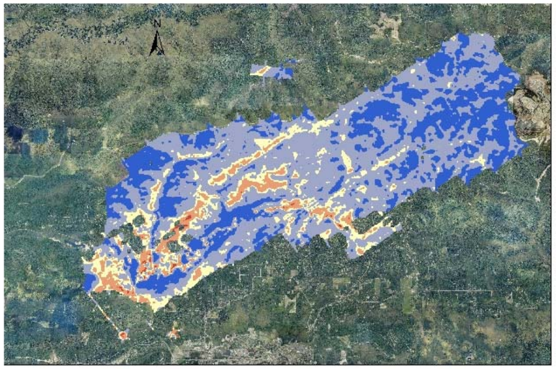
Goldstream Valley DEM and AEM lines



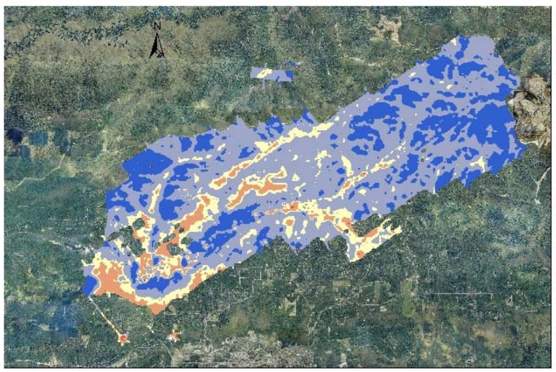

N
Weather RADAR
Caribou Poker Creek
GI-Permafrost oberservations
Vault Lake
Fox
Wells for aquifer testing
USGS automated
McGrath groundwater well
Goldstream Lake
Miller Lake
Ace Lake
Legend
Sub_Perm_Groundwater
Value
High : 477 m asl.
Low : 216
Watershed_DEM
Value
High : 788 m asl.
Low : 167

Apparent resistivity maps

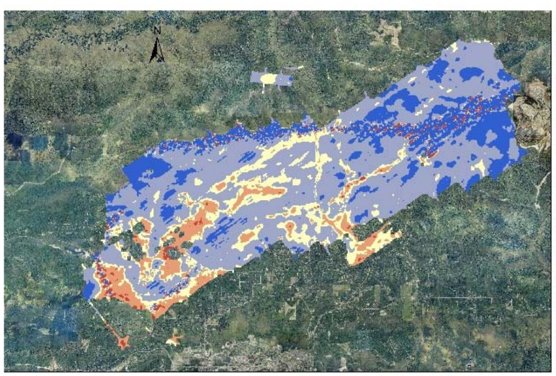
140KHz



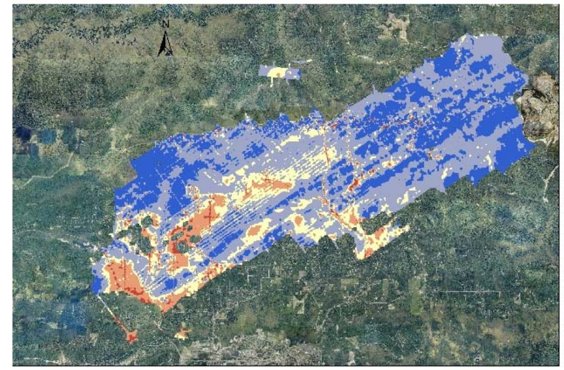
40KHz



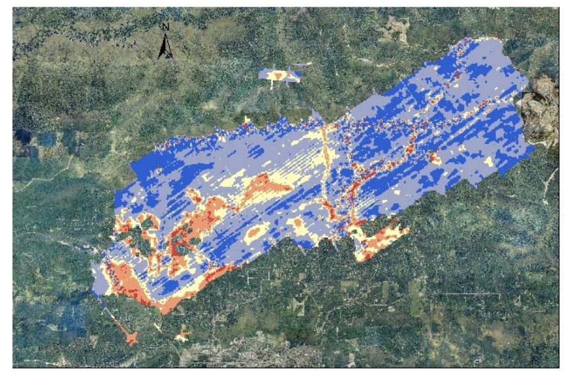
8200KHz



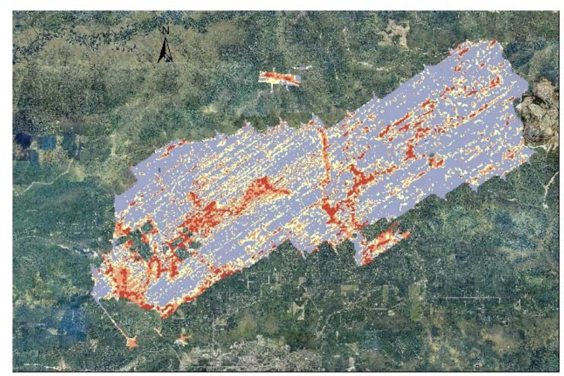
3300KHz



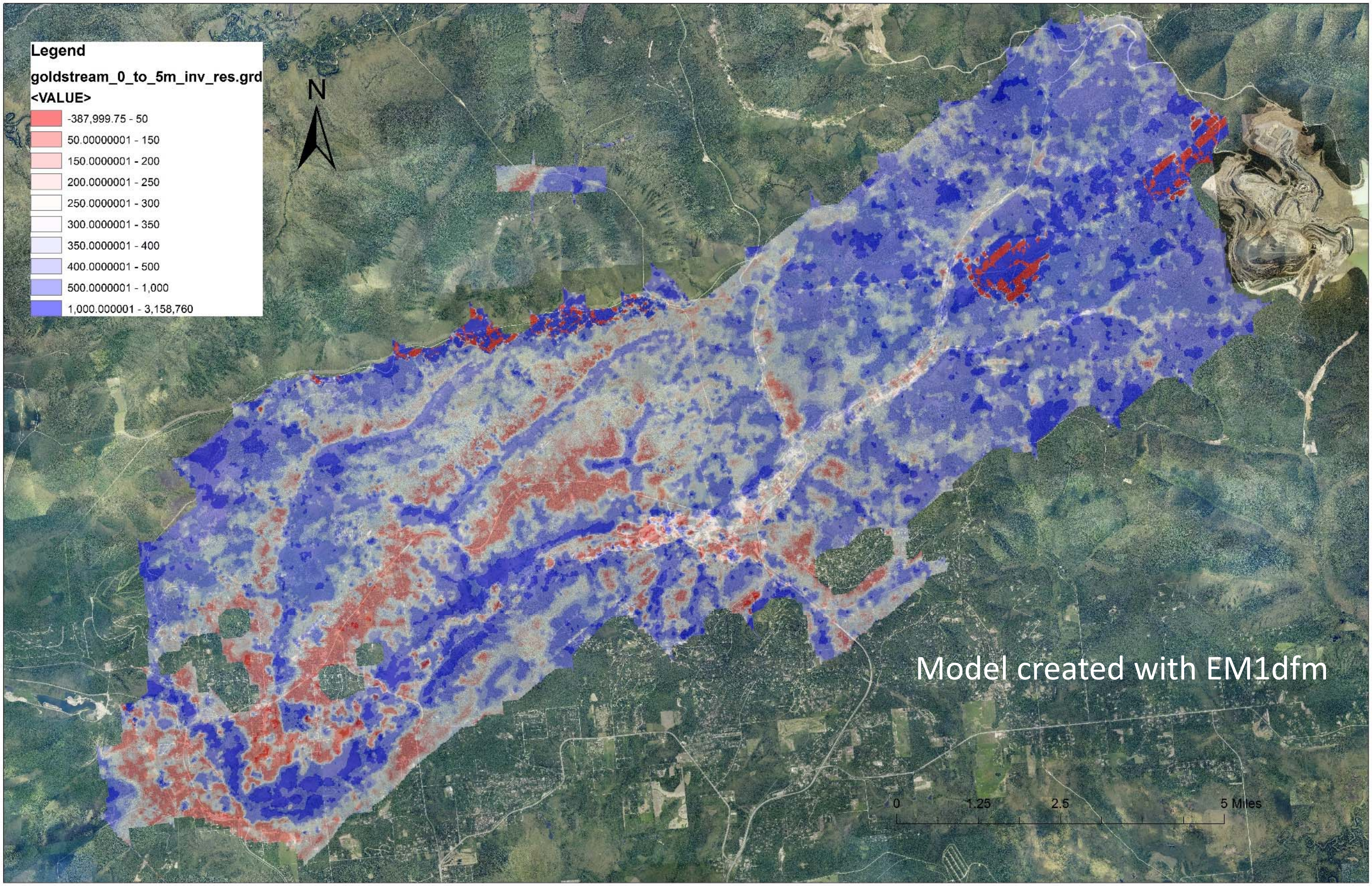
1800KHz



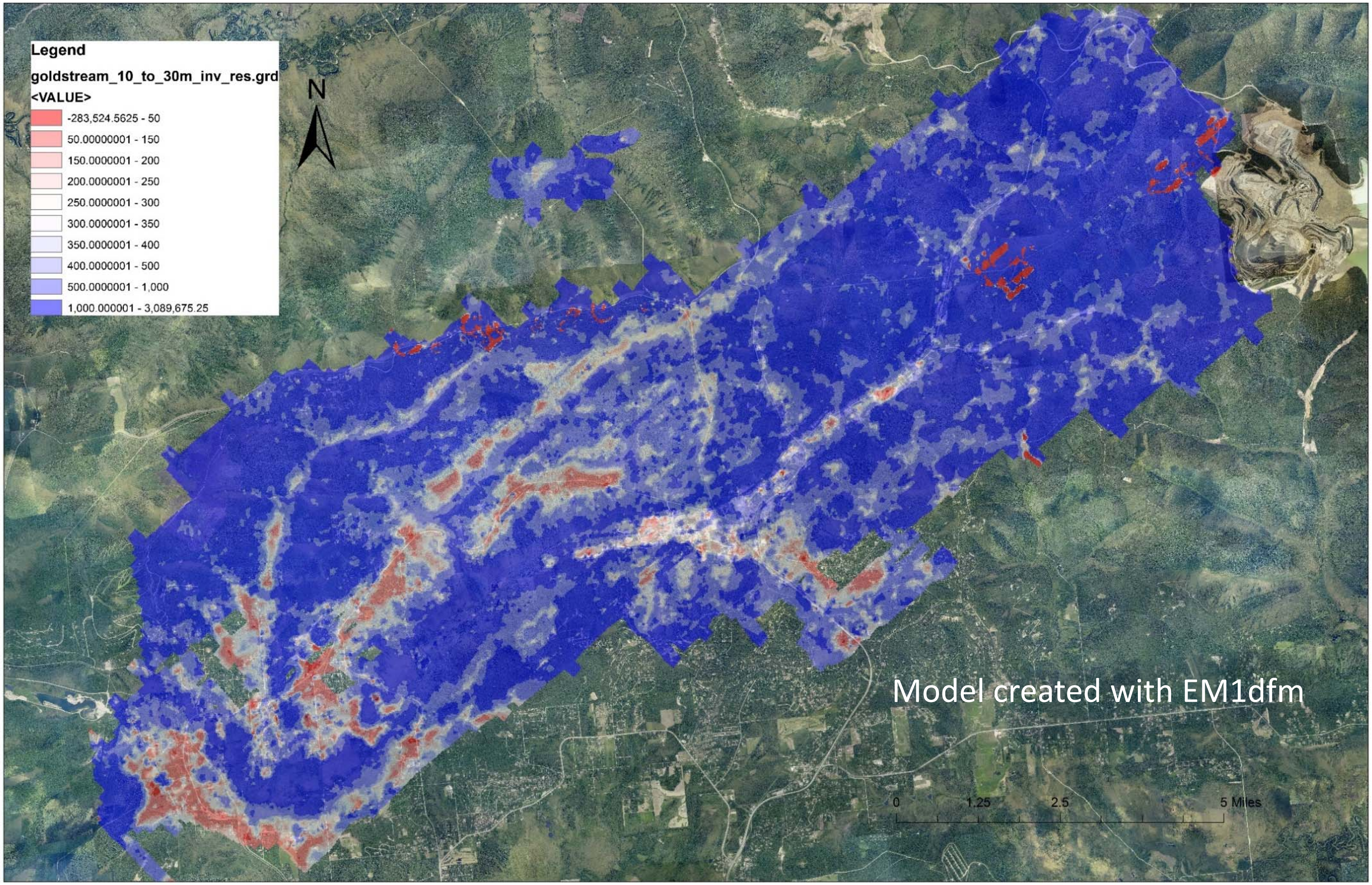
400KHz

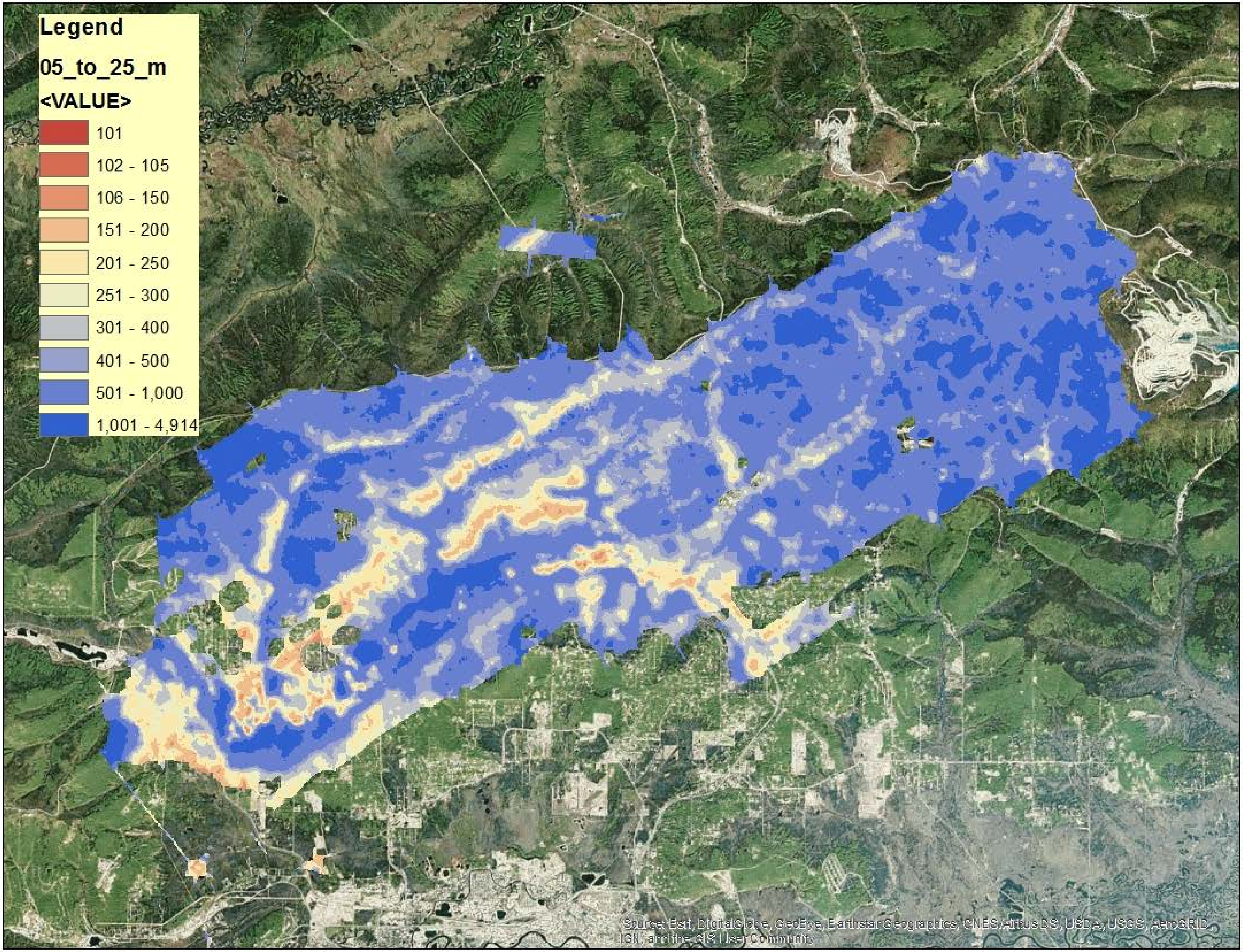


Goldstream Valley resistivity model 0-5m

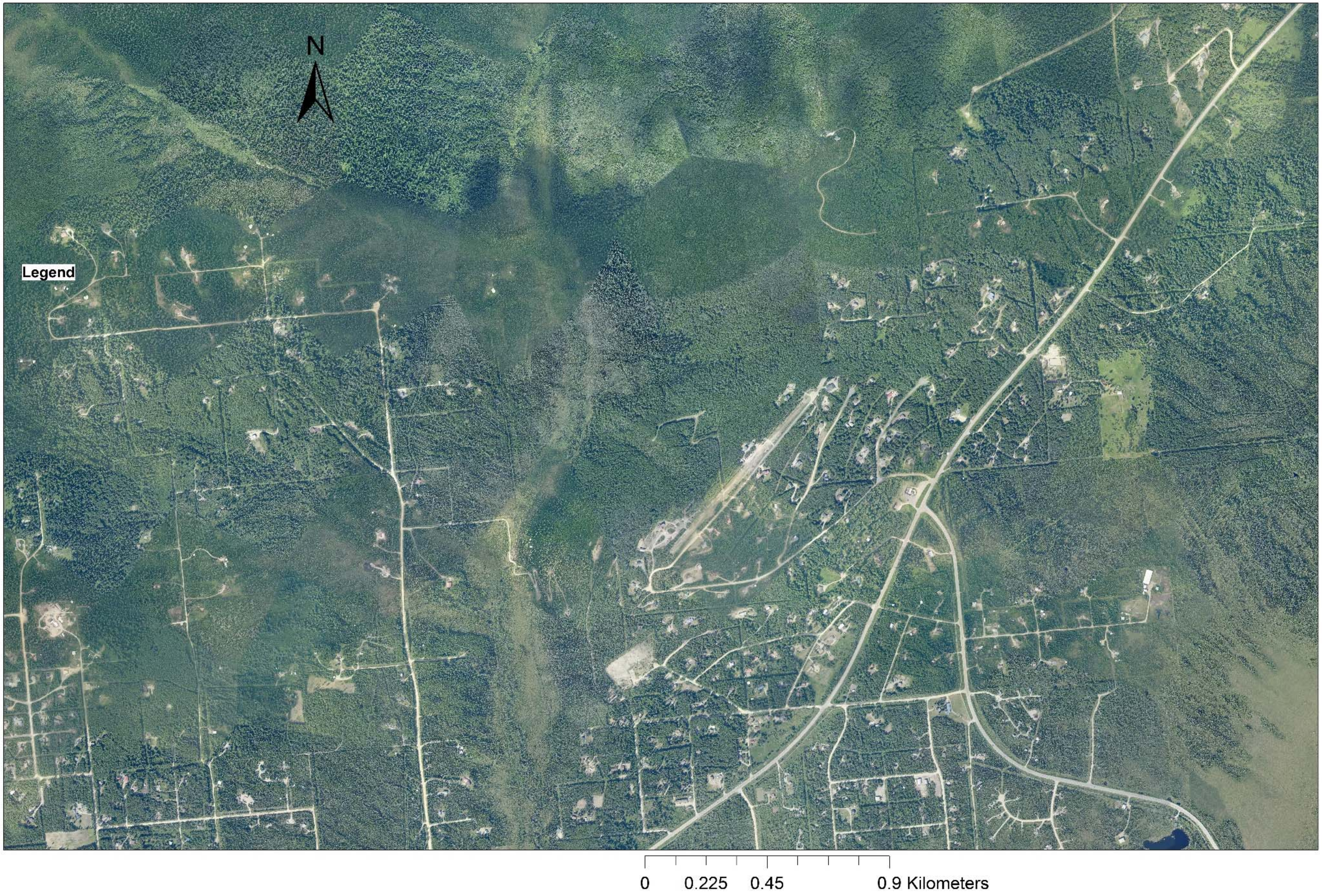


Goldstream Valley resistivity model 10-30m

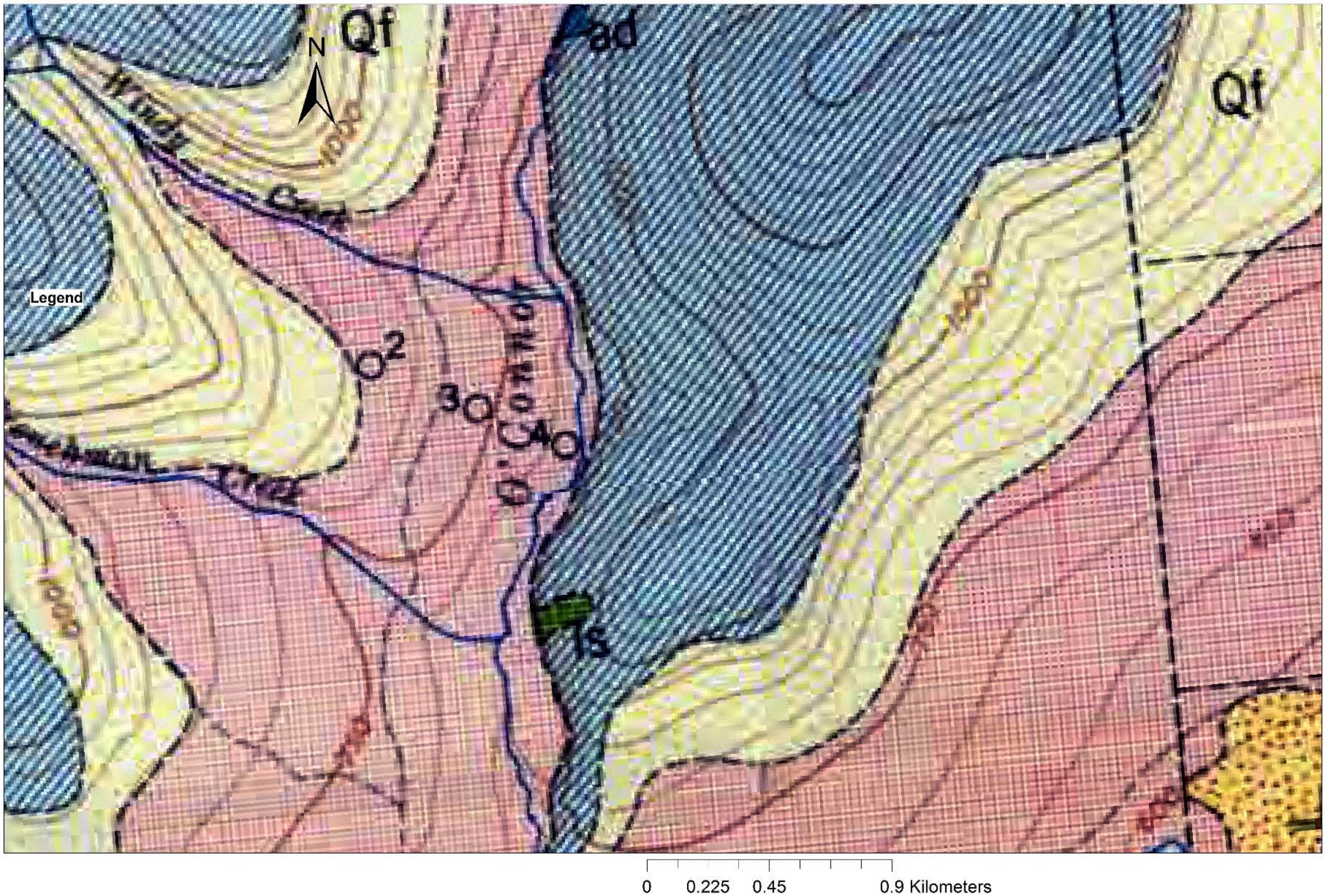



Legend
05_to_25_m
<VALUE>
101
102 - 105
106 - 150
151 - 200
201 - 250
251 - 300
301 - 400
401 - 500
501 - 1,000
1,001 - 4,914
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

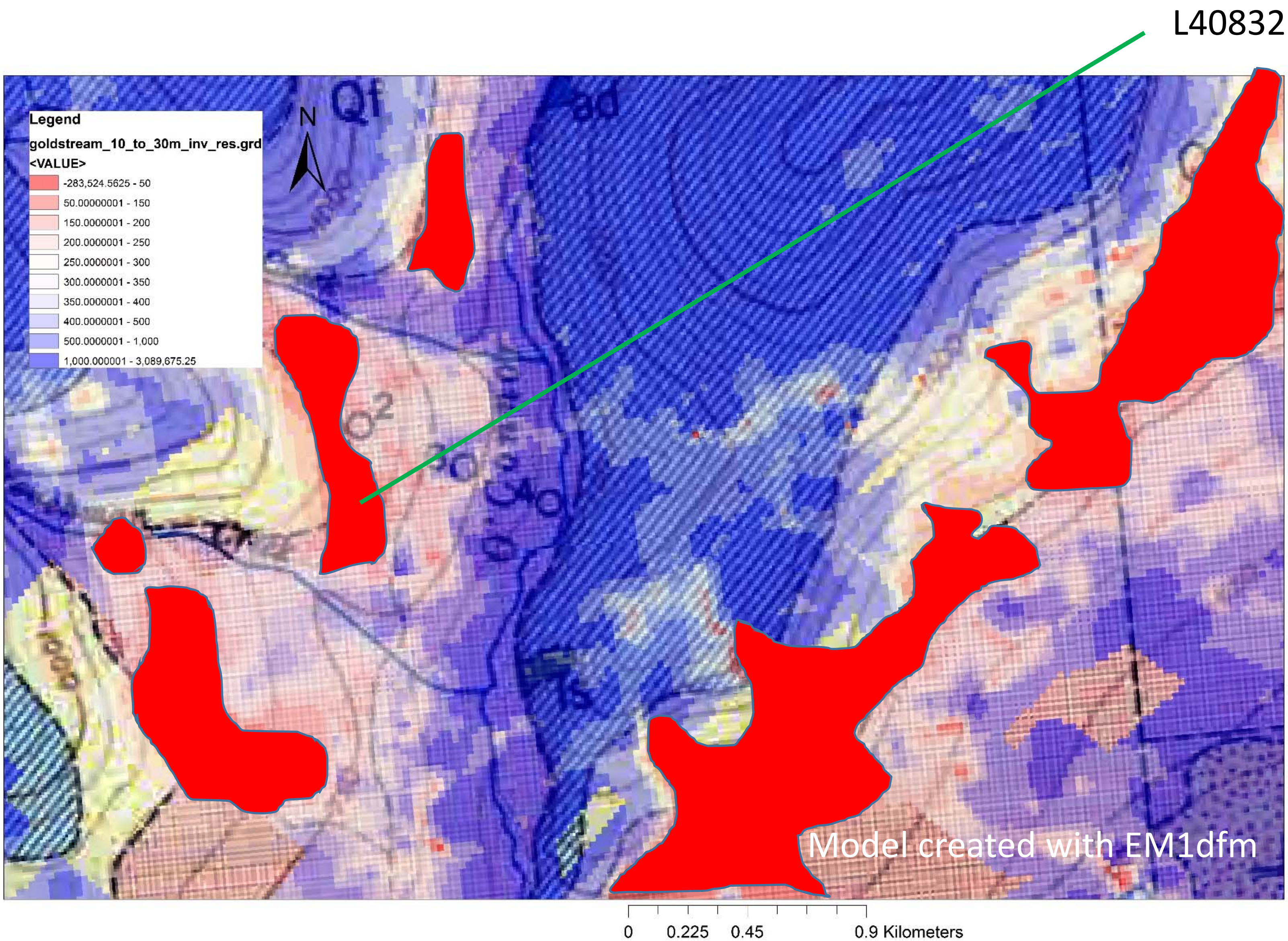
Auxiliary data



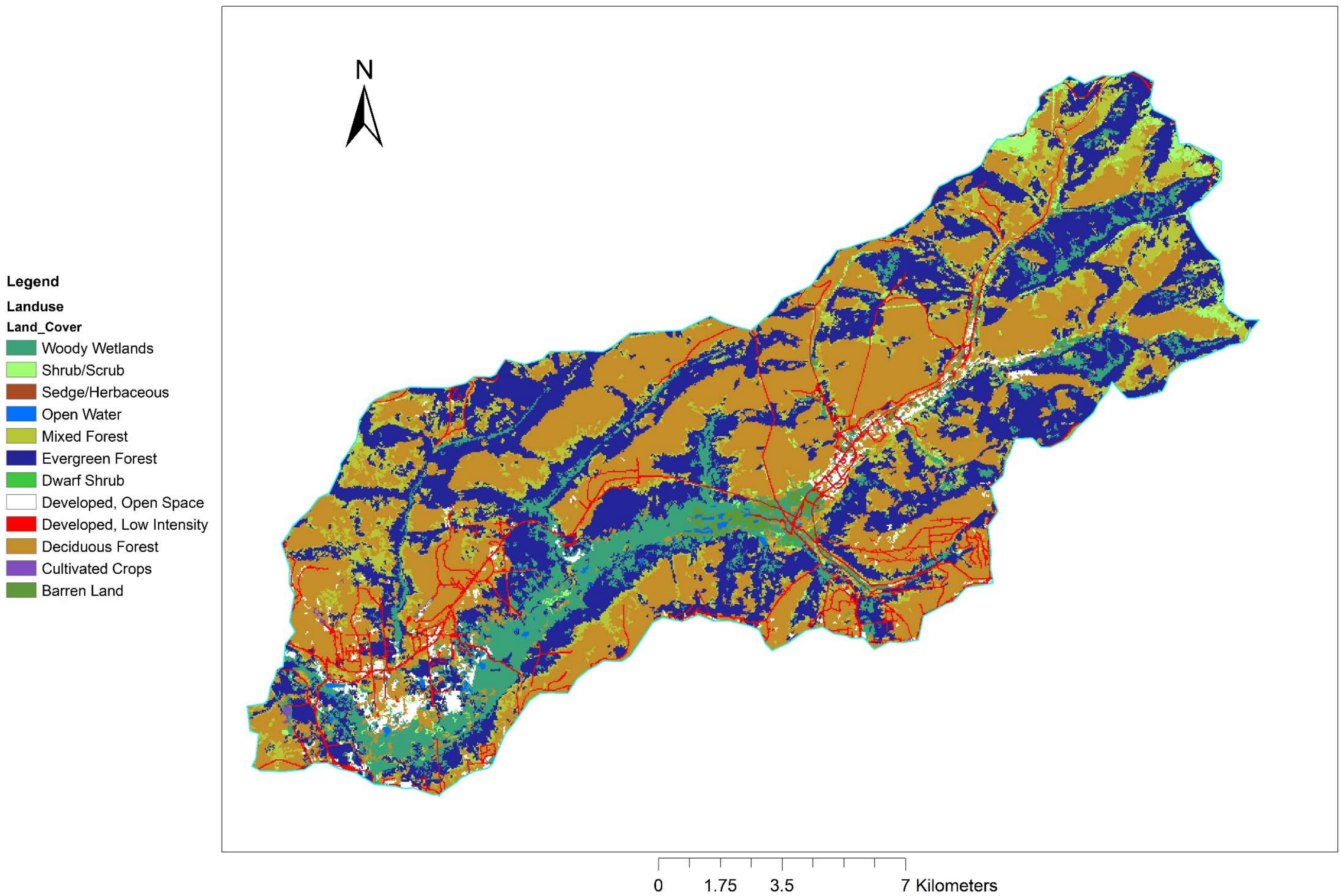
Péwé 1958 geologic map



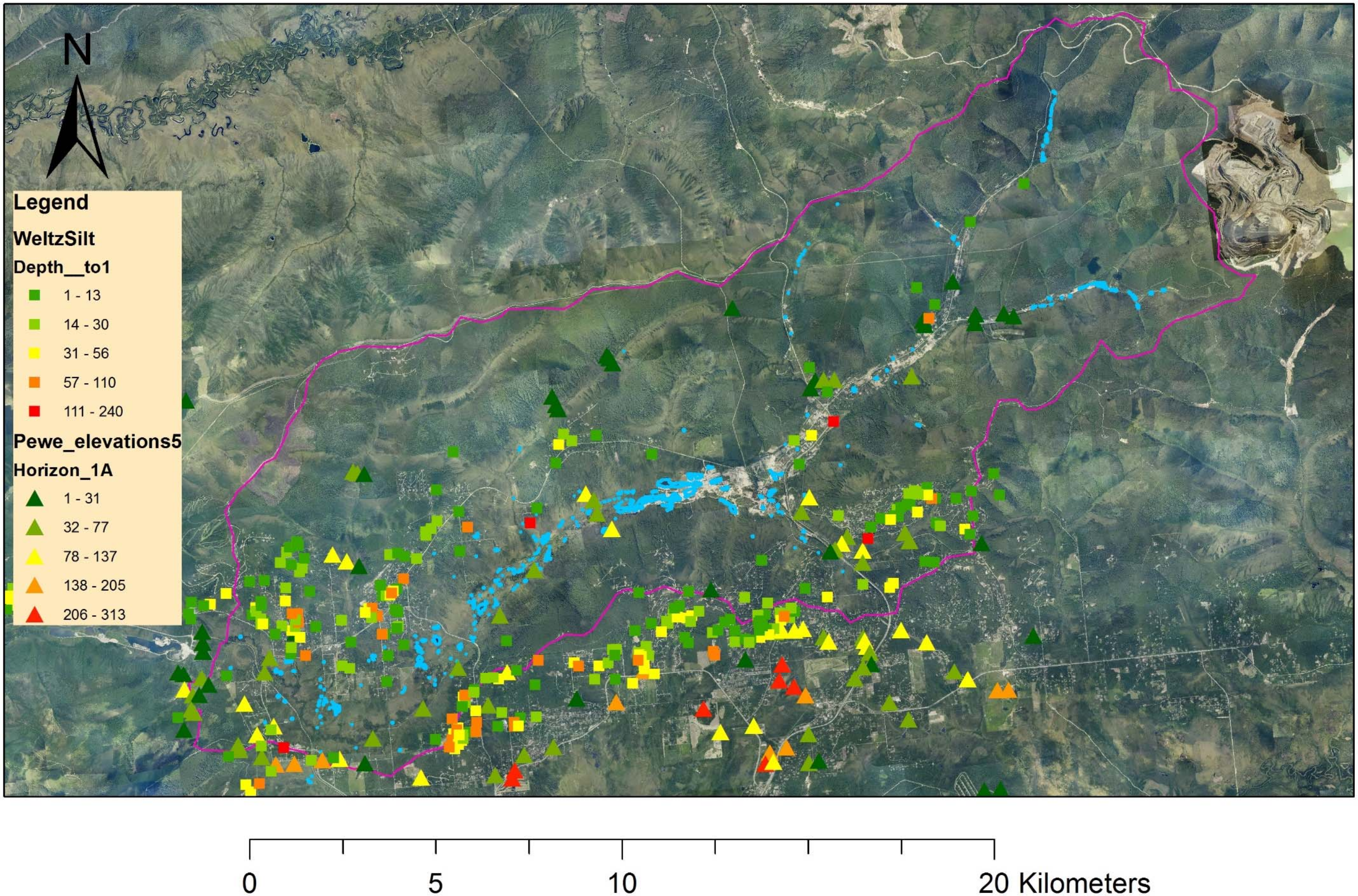
Péwé 1958 geologic map and resistivity



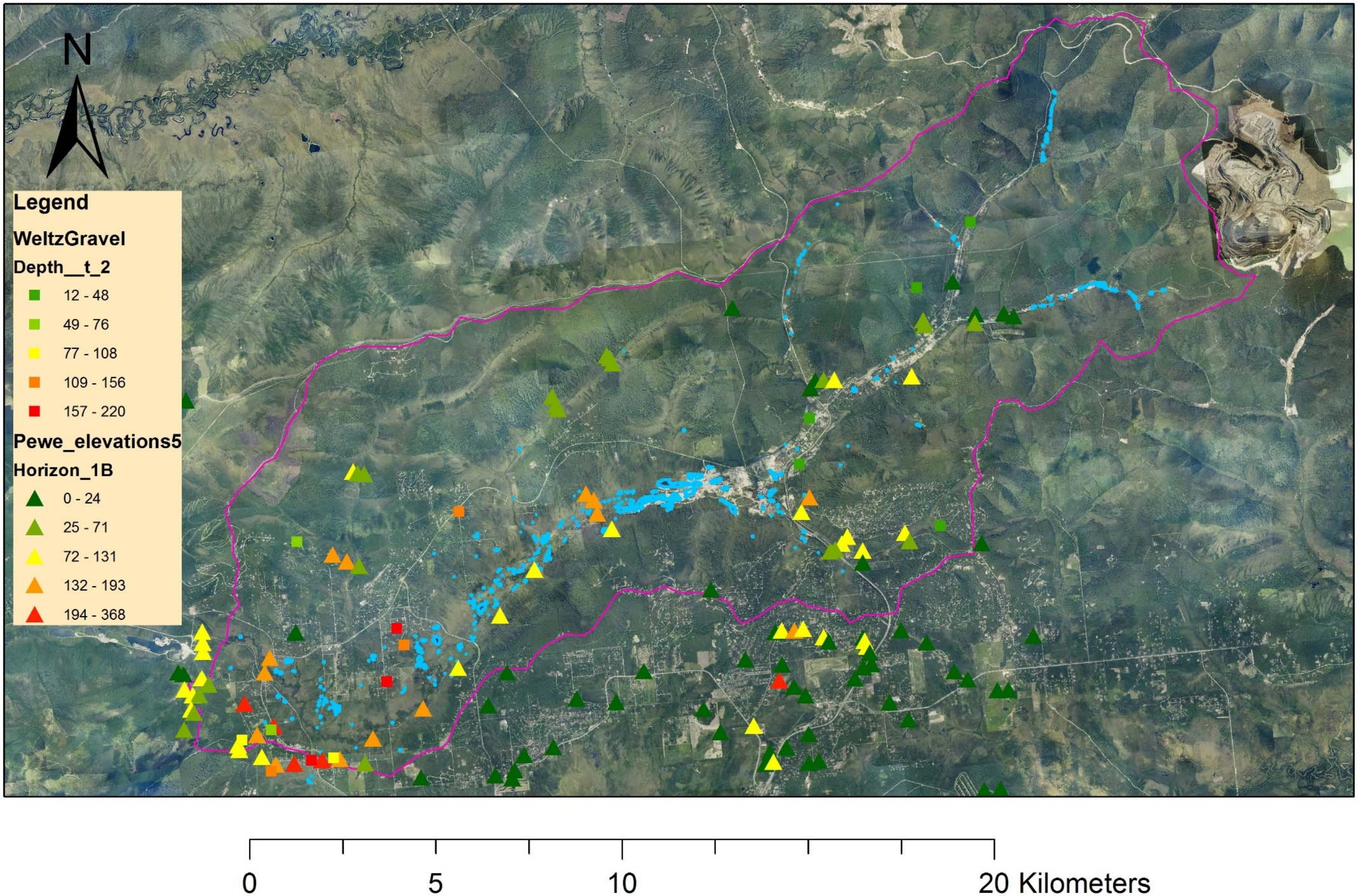
Vegetation cover



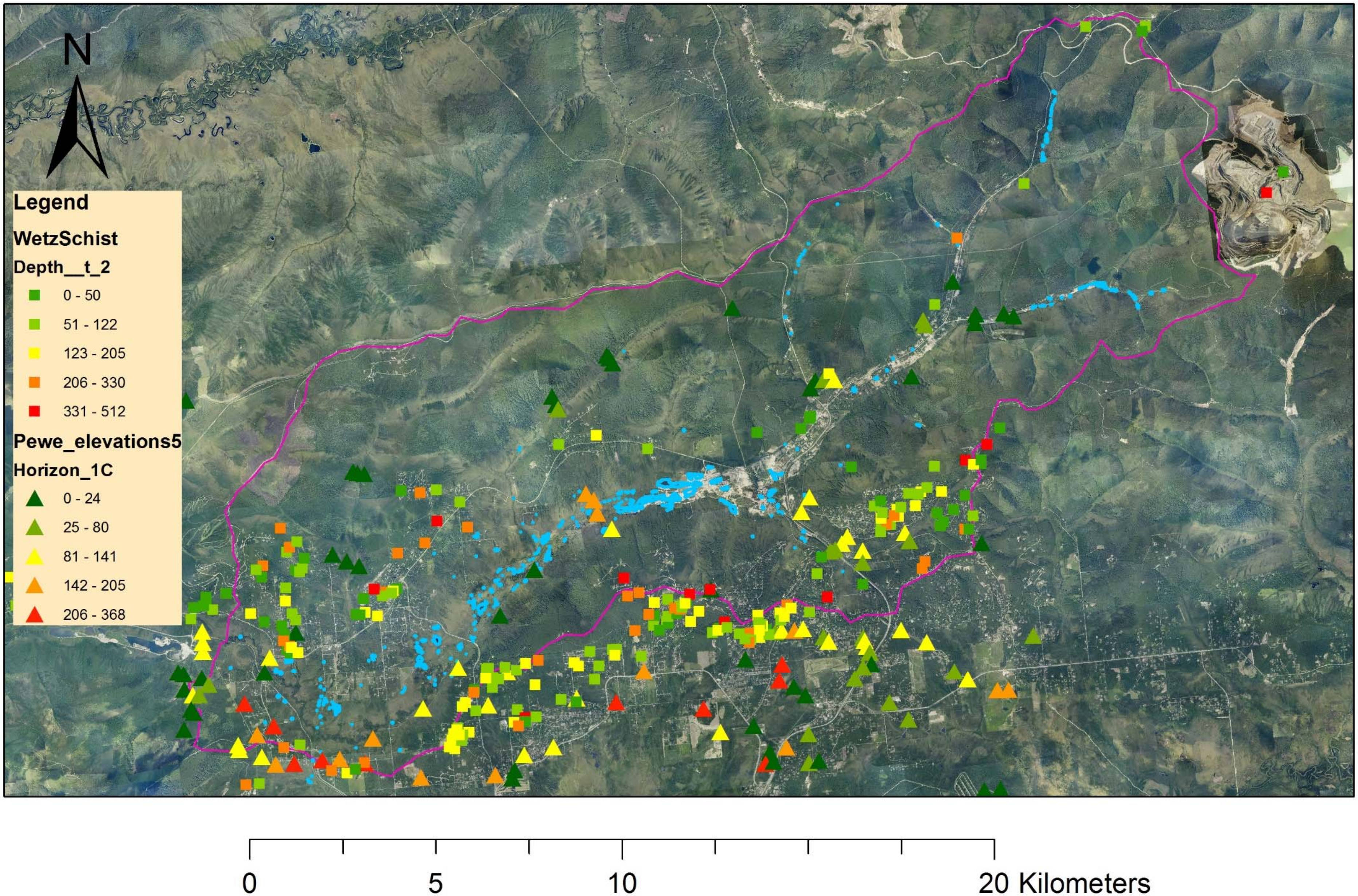
Wells with silt



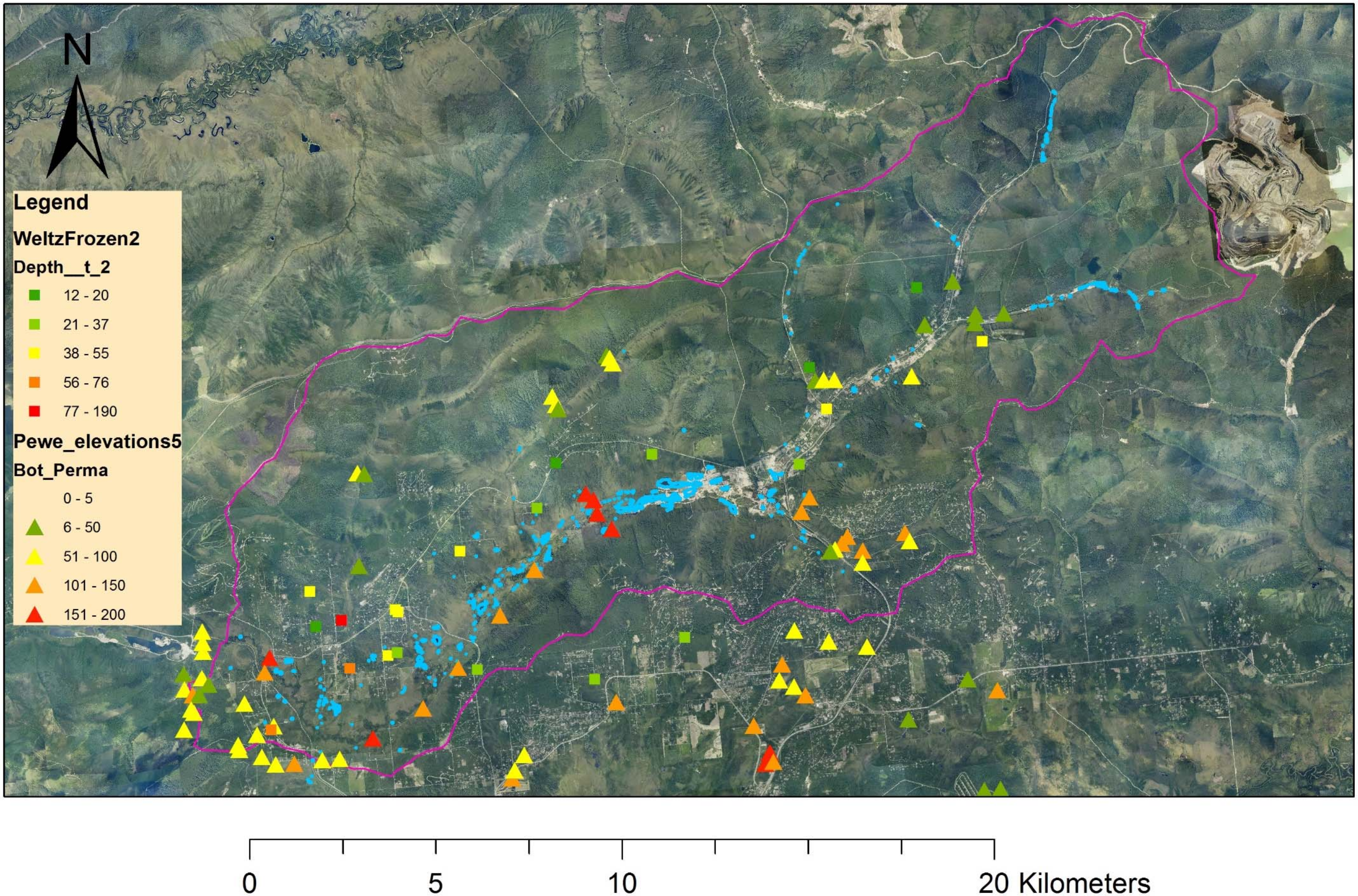
Wells with gravel



Wells with schist

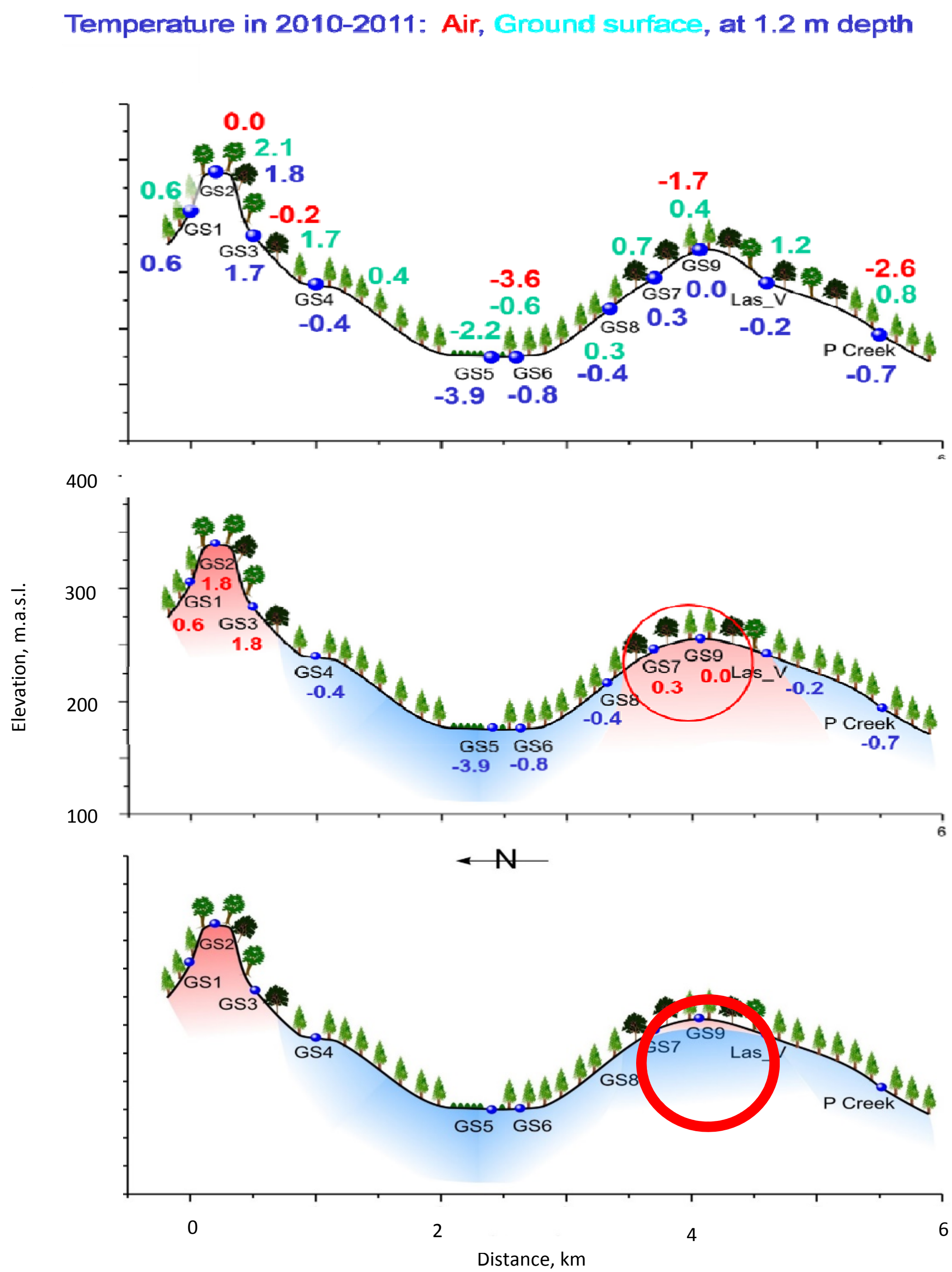


Wells with frozen ground



Measured air & soil temperatures across Goldstream Valley

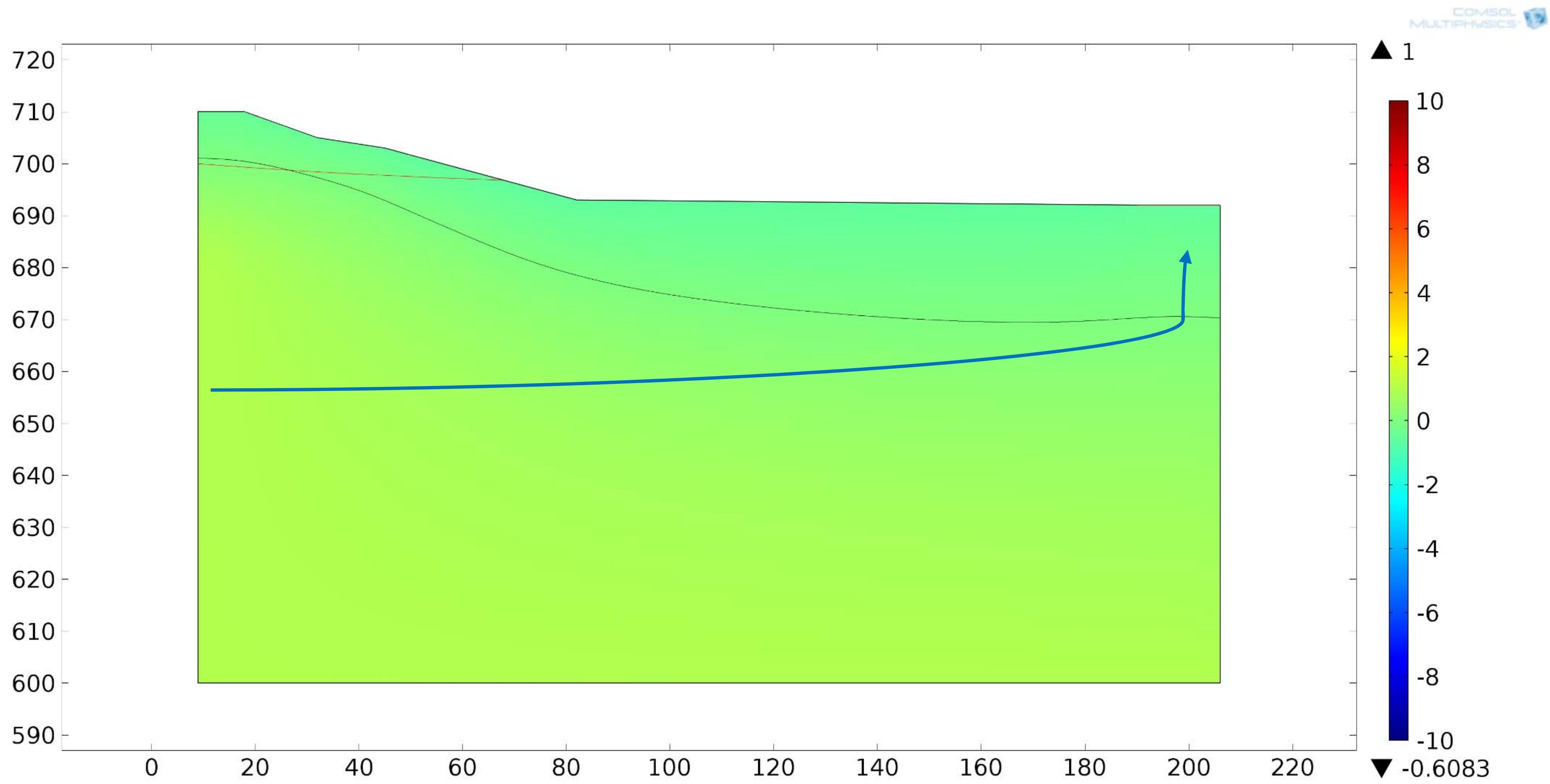
- The winter air temperature inversion makes the valley bottom mean annual air temperature 3.6°C lower than the ridge crest
- Ground surface and ground temperatures at 1.2 m generally follow the air temperatures
- There is definitely no permafrost on the northern ridge crest above the valley
- There is no near-surface permafrost in the upper part of Ballaine hill
- However, there may still be permafrost present at depth >3m



Vladimir Romanovsky, GI/UAF
veromanovsky@alaska.edu

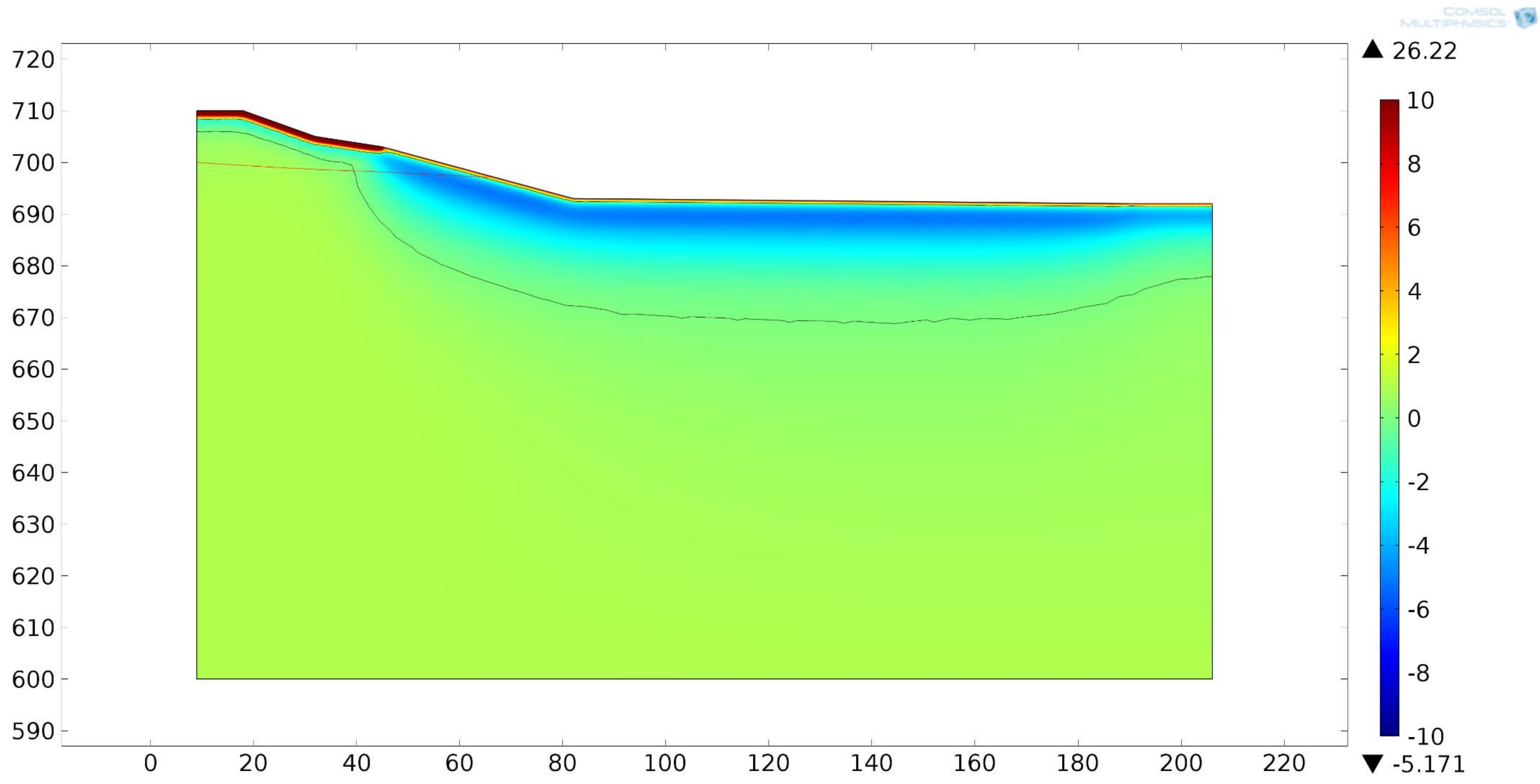
Modeled ground temperature

-1˚C mean annual air temperature and groundwater flow into the valley.



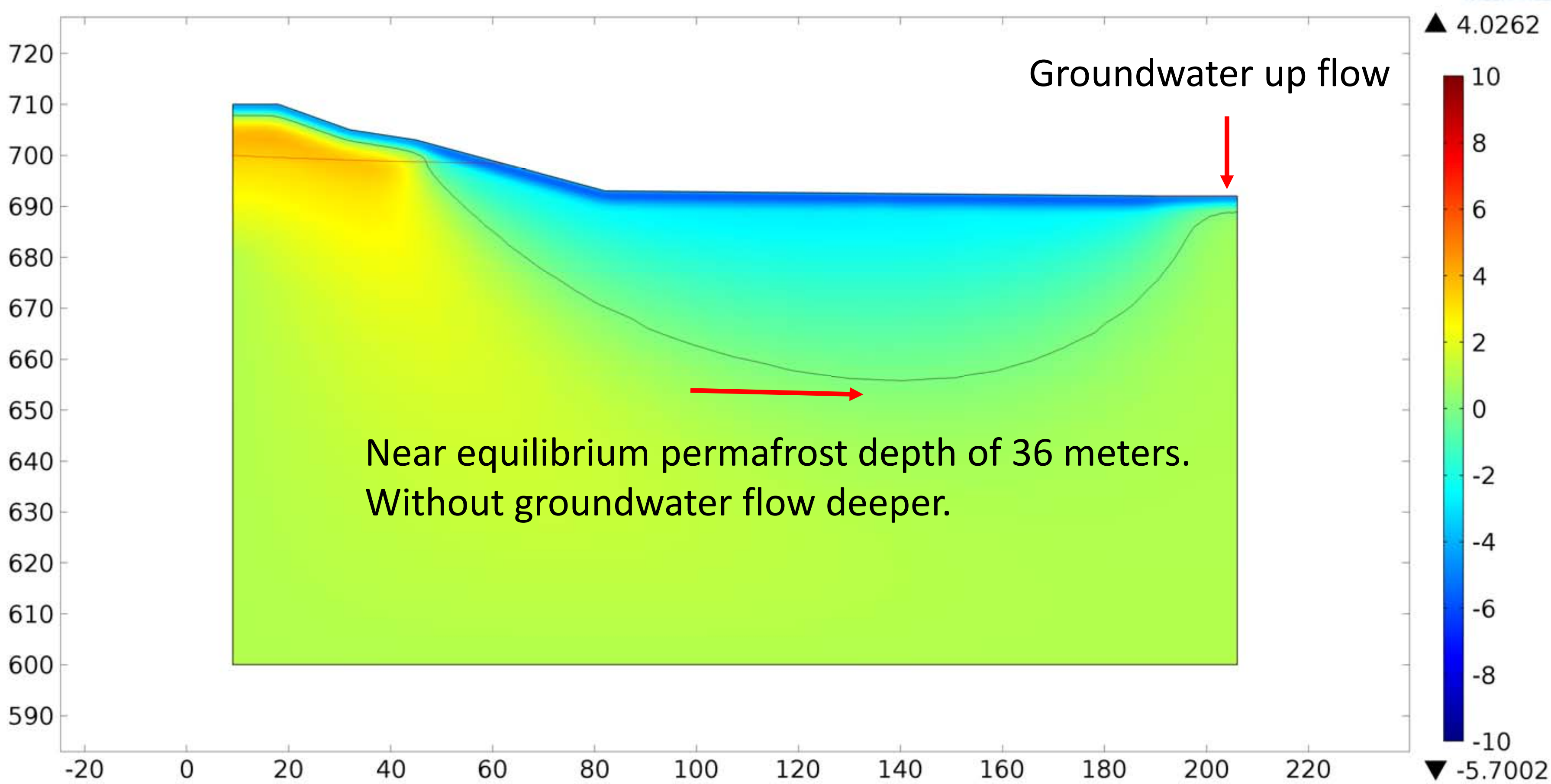
Modeled ground temperature

-1˚C mean annual air temperature around sinusoidal annual distribution.
Summer and winter n-factor correction for vegetation.



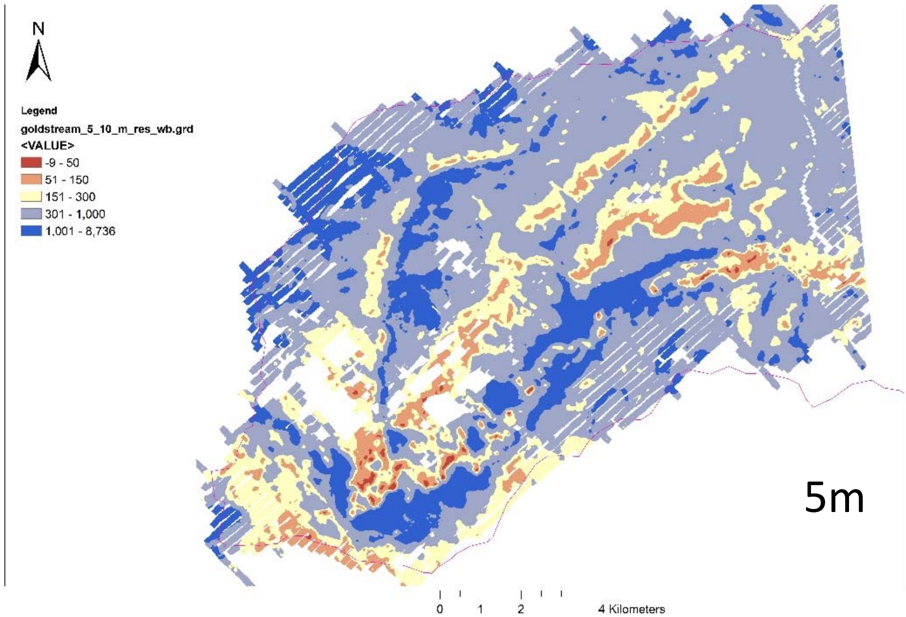
Modeled ground temperature

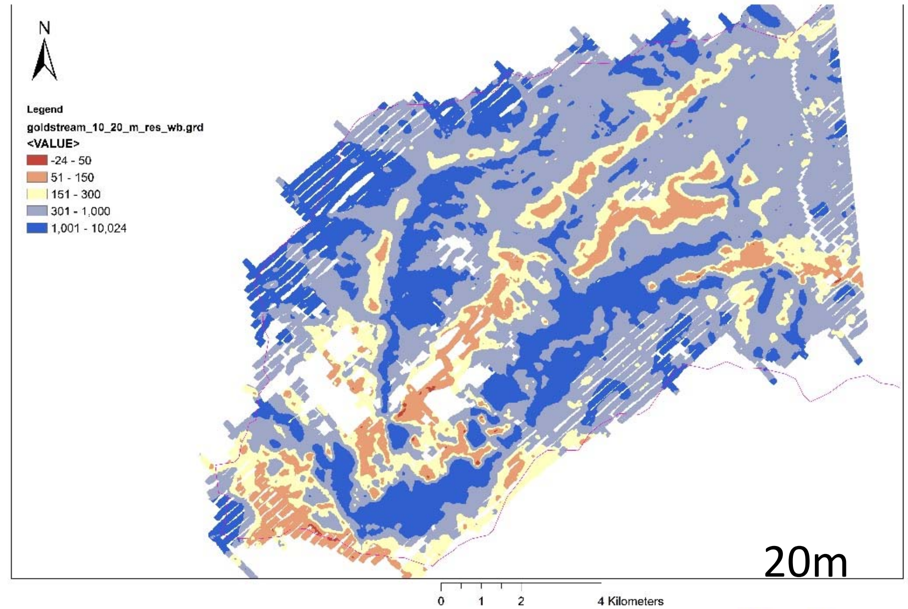
Same as before after 300 years.

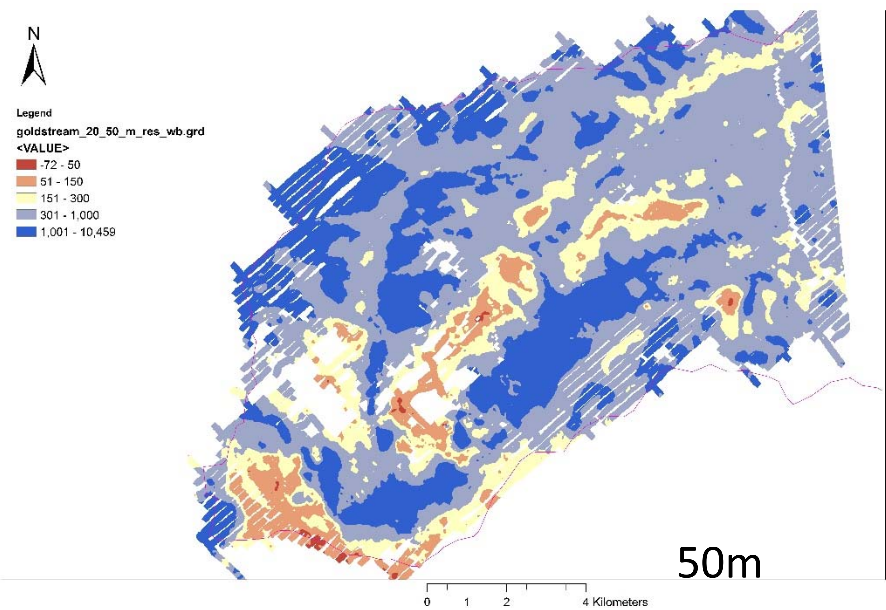


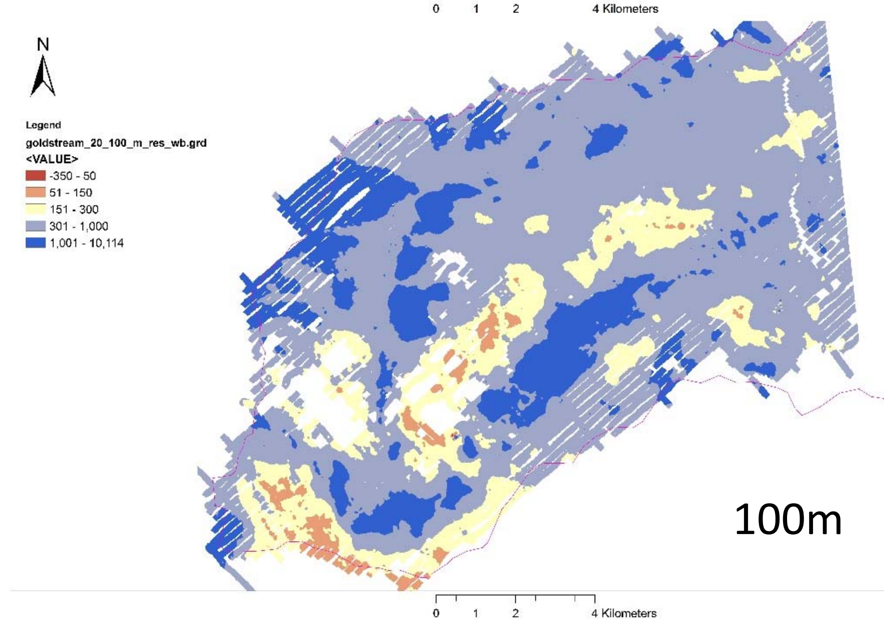
Bottom of permafrost?

2 ½ D inversion with Workbench

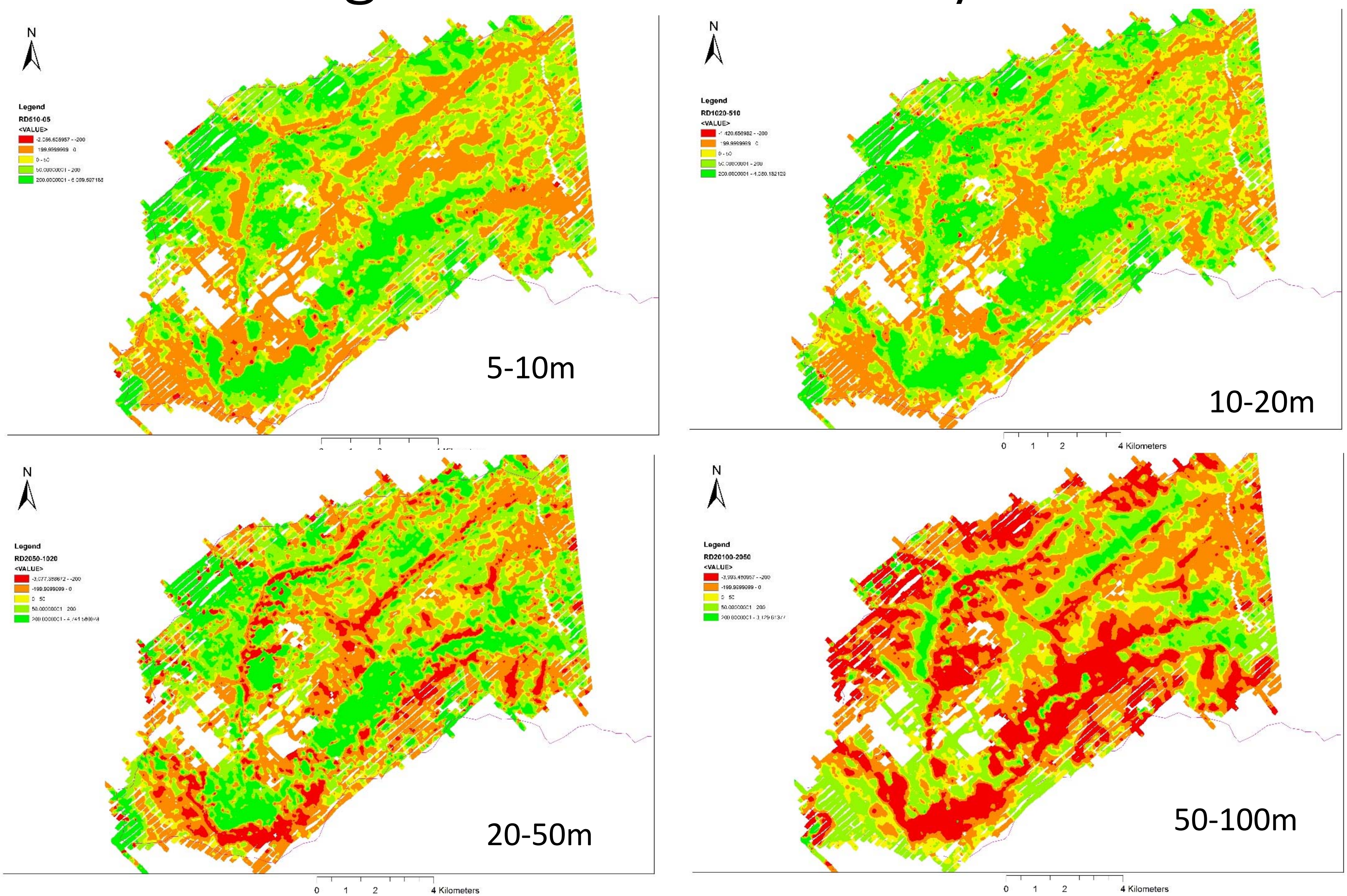




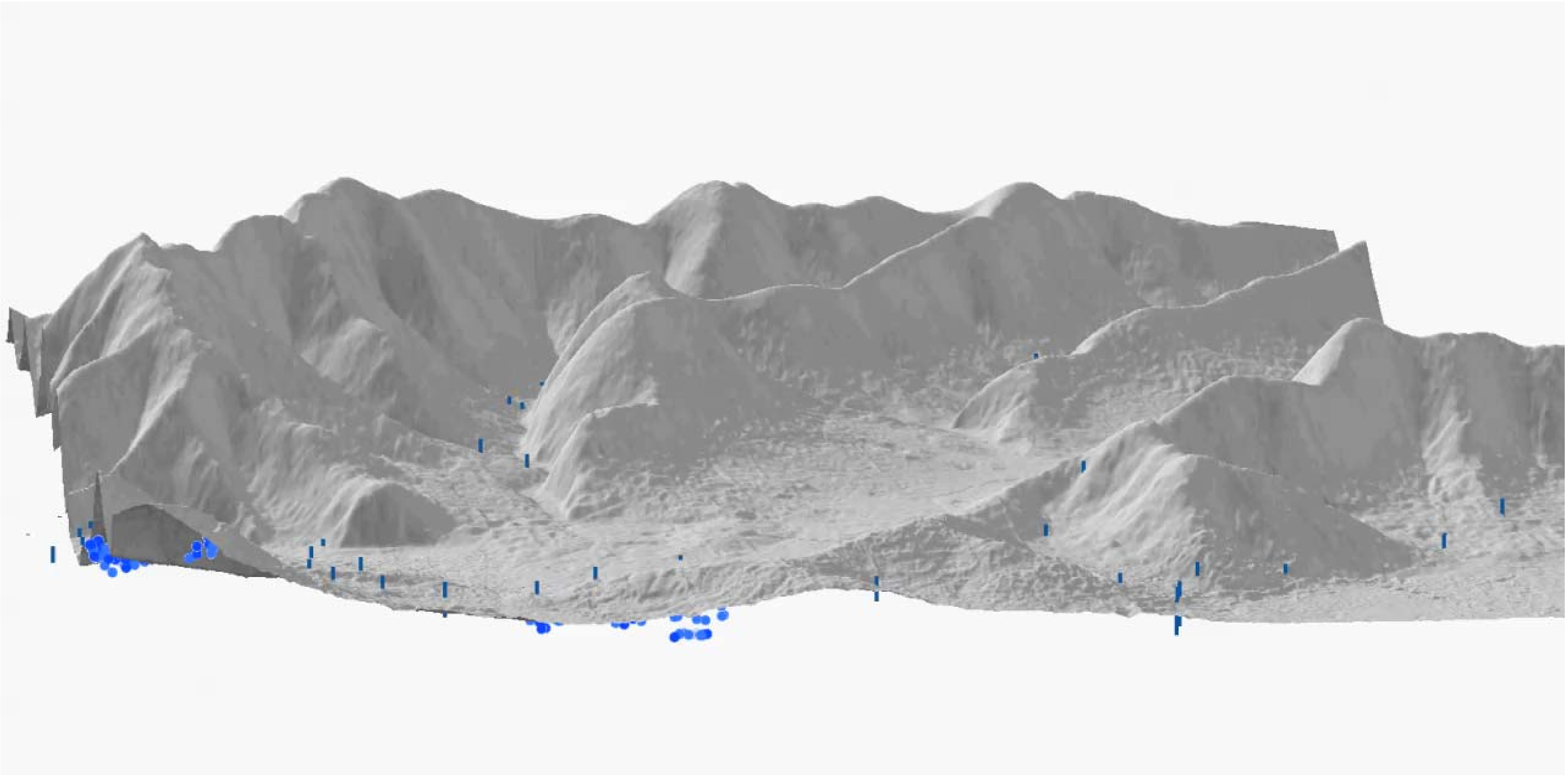




Vertical gradient of resistivity



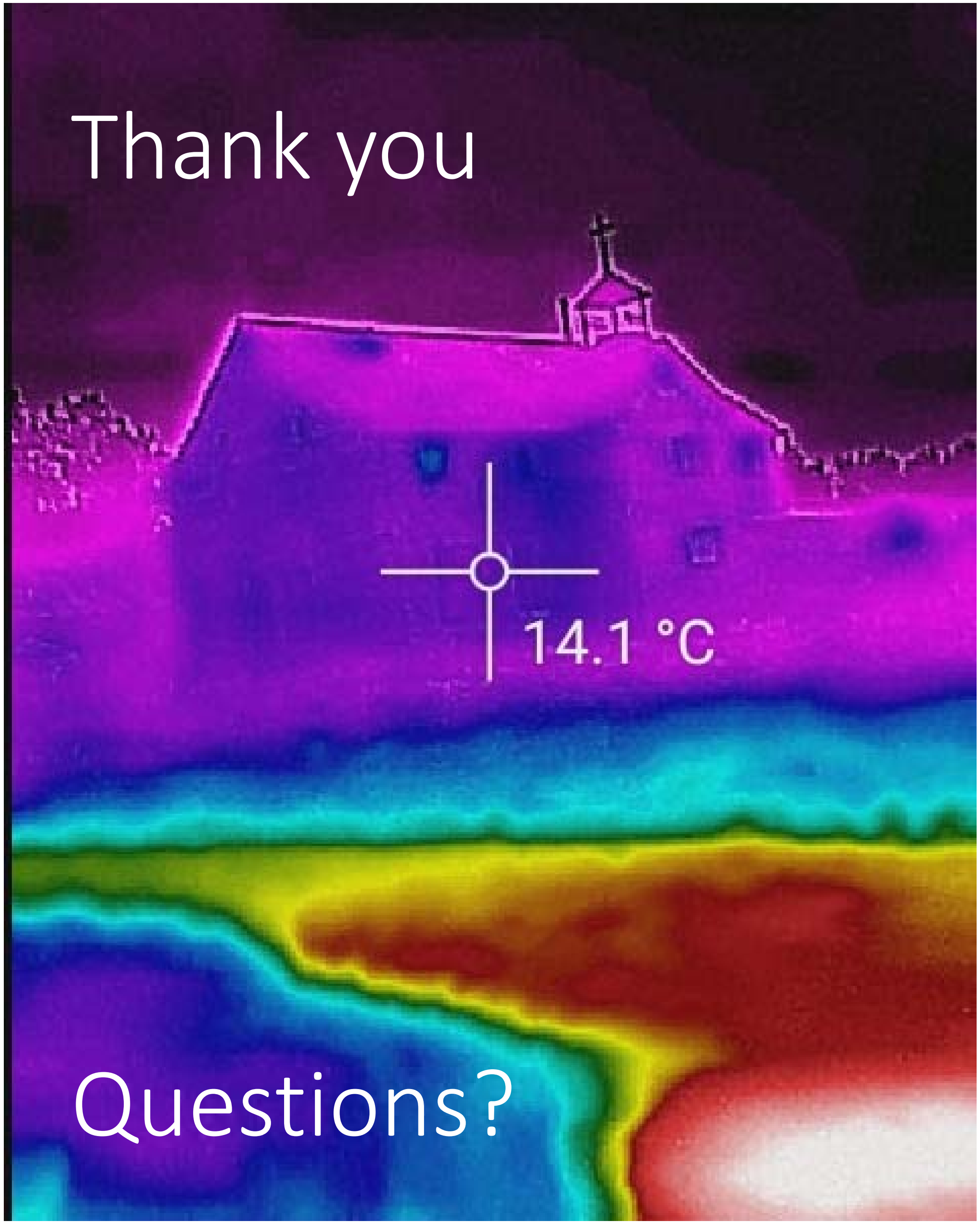
Silt layer (a first attempt)



Things to do

- Develop geological model in 3D GoCad environment
- Cross-reference the well data with resistivity to establish range of resistivities connected with frozen/unfrozen silt, gravel, and schist
- Thermal modeling
- Generate 3D permafrost model

Thank you



Questions?