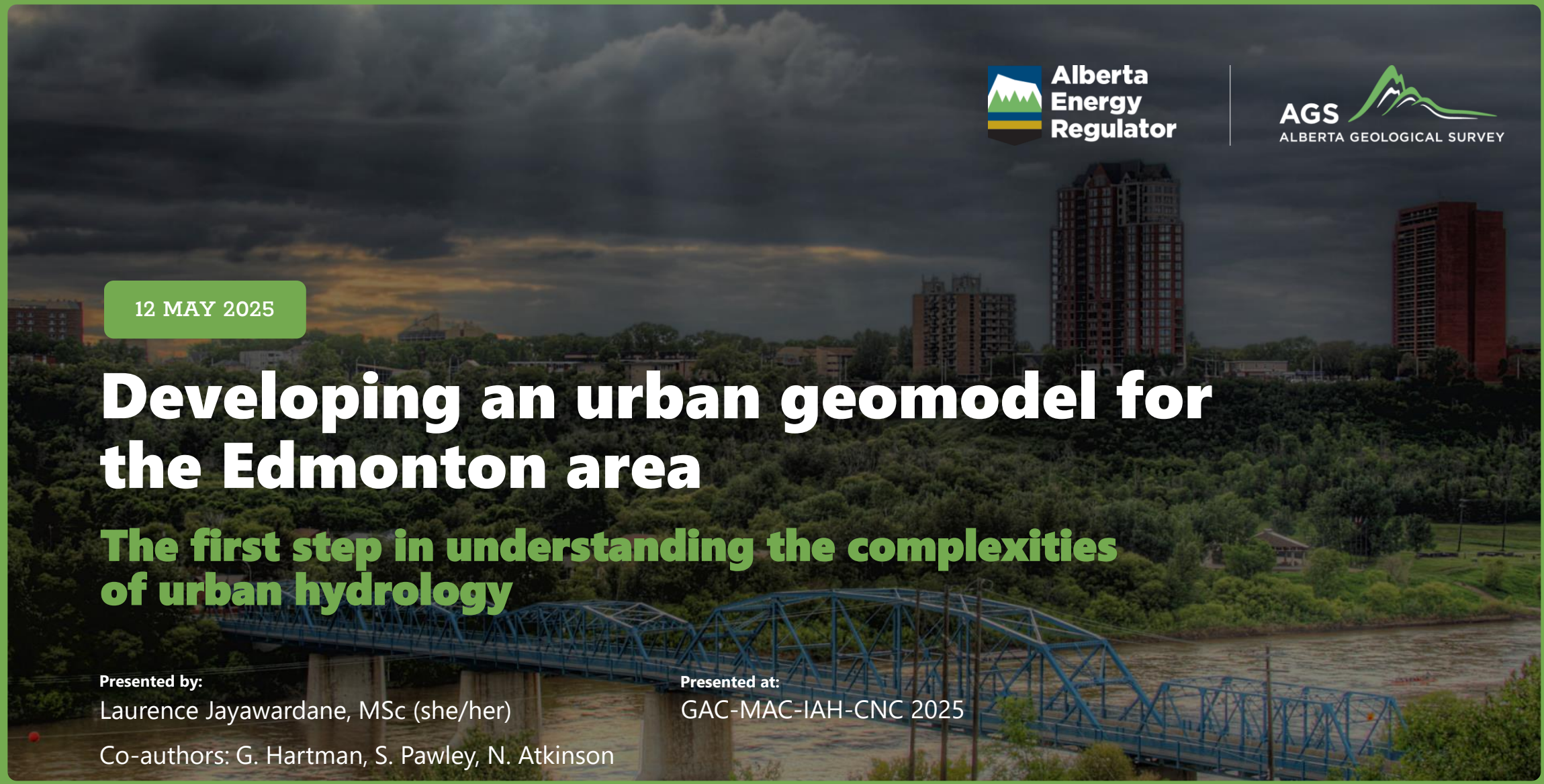


Alberta Energy Regulator

AGS ALBERTA GEOLOGICAL SURVEY

12 MAY 2025

Developing an urban geomodel for the Edmonton area

The first step in understanding the complexities of urban hydrology

Presented by:
Laurence Jayawardane, MSc (she/her)

Co-authors: G. Hartman, S. Pawley, N. Atkinson

Presented at:
GAC-MAC-IAH-CNC 2025

LAND ACKNOWLEDGEMENT

In the spirit of reconciliation, we respectfully acknowledges that the city this work focuses on, Edmonton, is on Treaty Six Territory, Métis Nation of Alberta Region 4, and is the home of one of the largest communities of Inuit south of the 60th parallel.

Edmonton is also named Amiskwacîwâskahikan, which means Beaver Hill House in nêhiyaw/Cree.

We would like to recognize that the land in this area has been marked by centuries by the footsteps of the ancestors of diverse Indigenous Peoples, including the nêhiyaw, Dene, Anishinaabe/Saulteaux, Nakota Sioux, Niitsitapi/Blackfoot, and Métis peoples.

Collaborators

Alberta Innovates – Water Innovation Program

Building water security and climate resilience into the City of Edmonton through innovative watershed management practices

- 3-year collaborative project led by the University of Alberta
- Funding support from the Alberta Innovates Water Innovation Program and project partners, including EPCOR, AGS and City of Edmonton

collaborators:

UNIVERSITY OF ALBERTA

Alberta Energy Regulator | AGS ALBERTA GEOLOGICAL SURVEY

THE CITY OF Edmonton

EPCOR

NSWA NORTH SASKATCHEWAN WATERSHED ALLIANCE

Project Objective

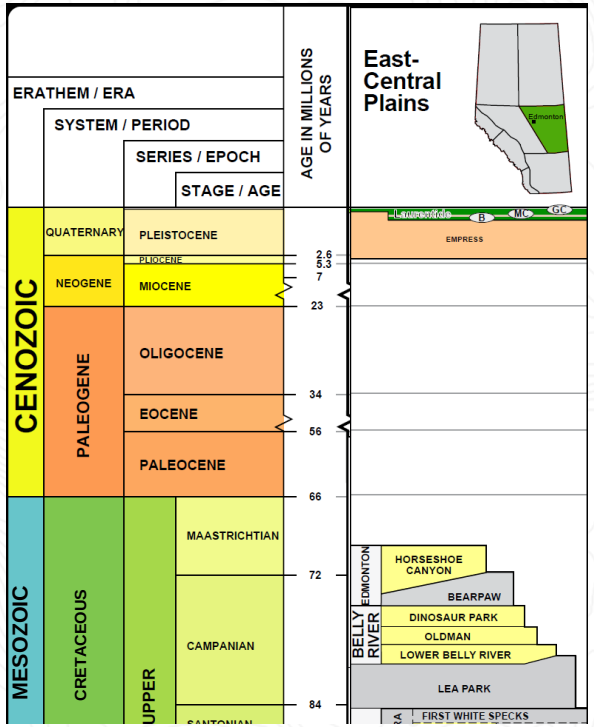
> The AGS will develop an urban geological model using a compilation of subsurface and geotechnical data held by the City of Edmonton, knowledge from major infrastructure projects by EPCOR and previous AGS work in the area

Overview

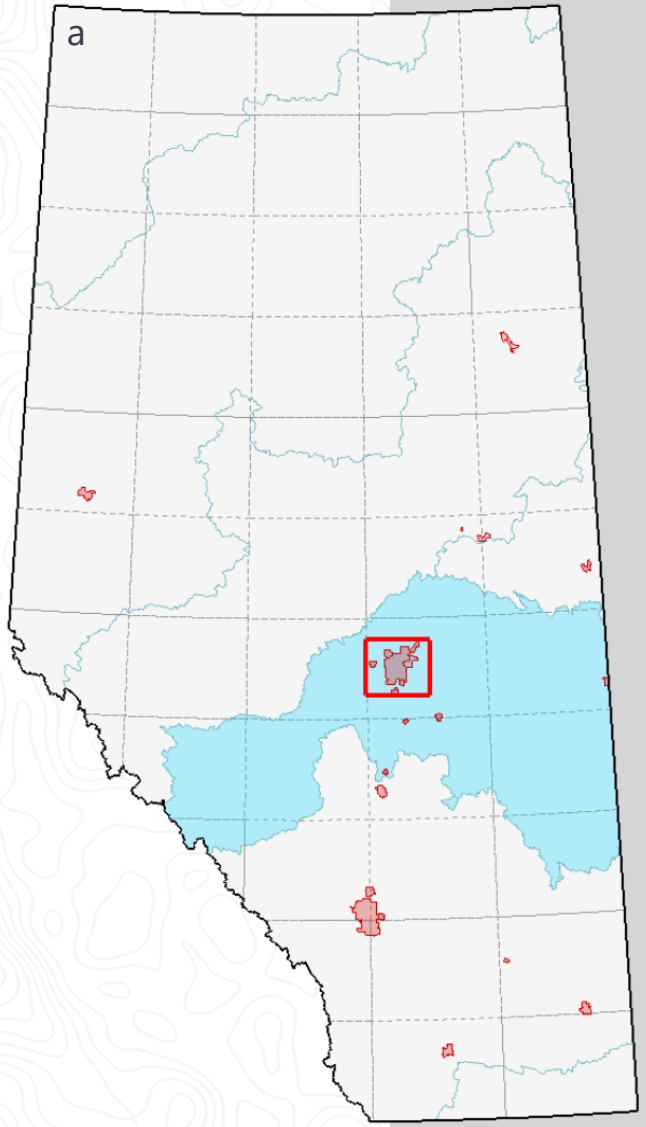
1. Project Scope & Outcomes
2. Update to surficial mapping
3. Update to bedrock topography
4. Update to Neogene-Quaternary interpretation
5. Update to geomodel bedrock zones
6. Predictive 3D sandiness model
7. Geomodel: Neogene-Quaternary & bedrock zones
8. Geomodel: Property model

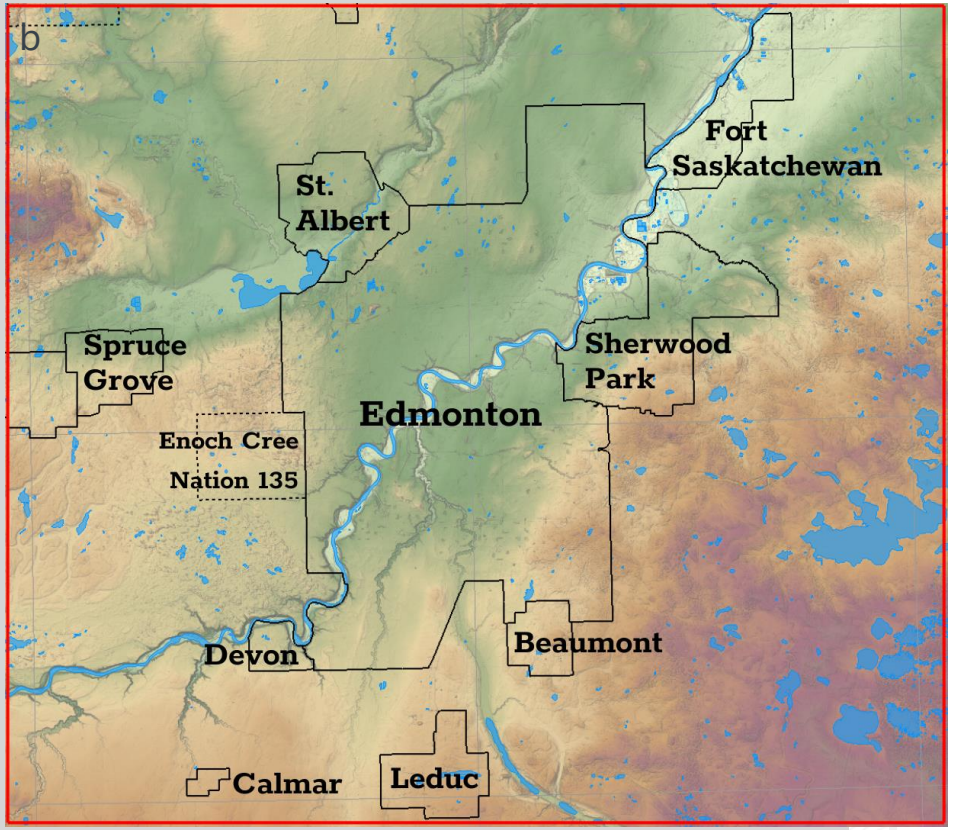
Summary

Project Location



AGS/AER Table of Formations





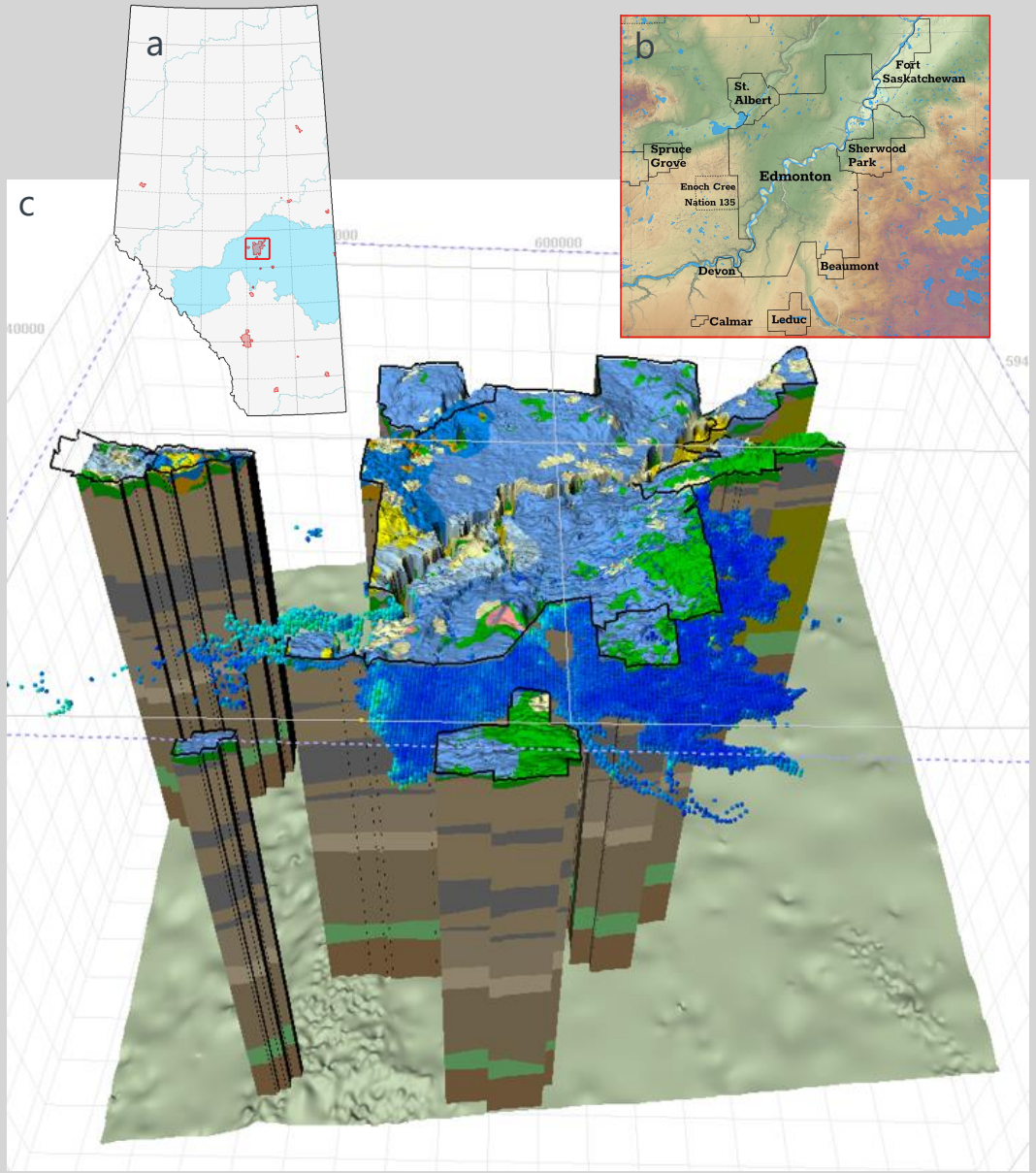
a) Red box: study area. Blue area: North Saskatchewan watershed.
b) Study area

Summary

Project Outcomes

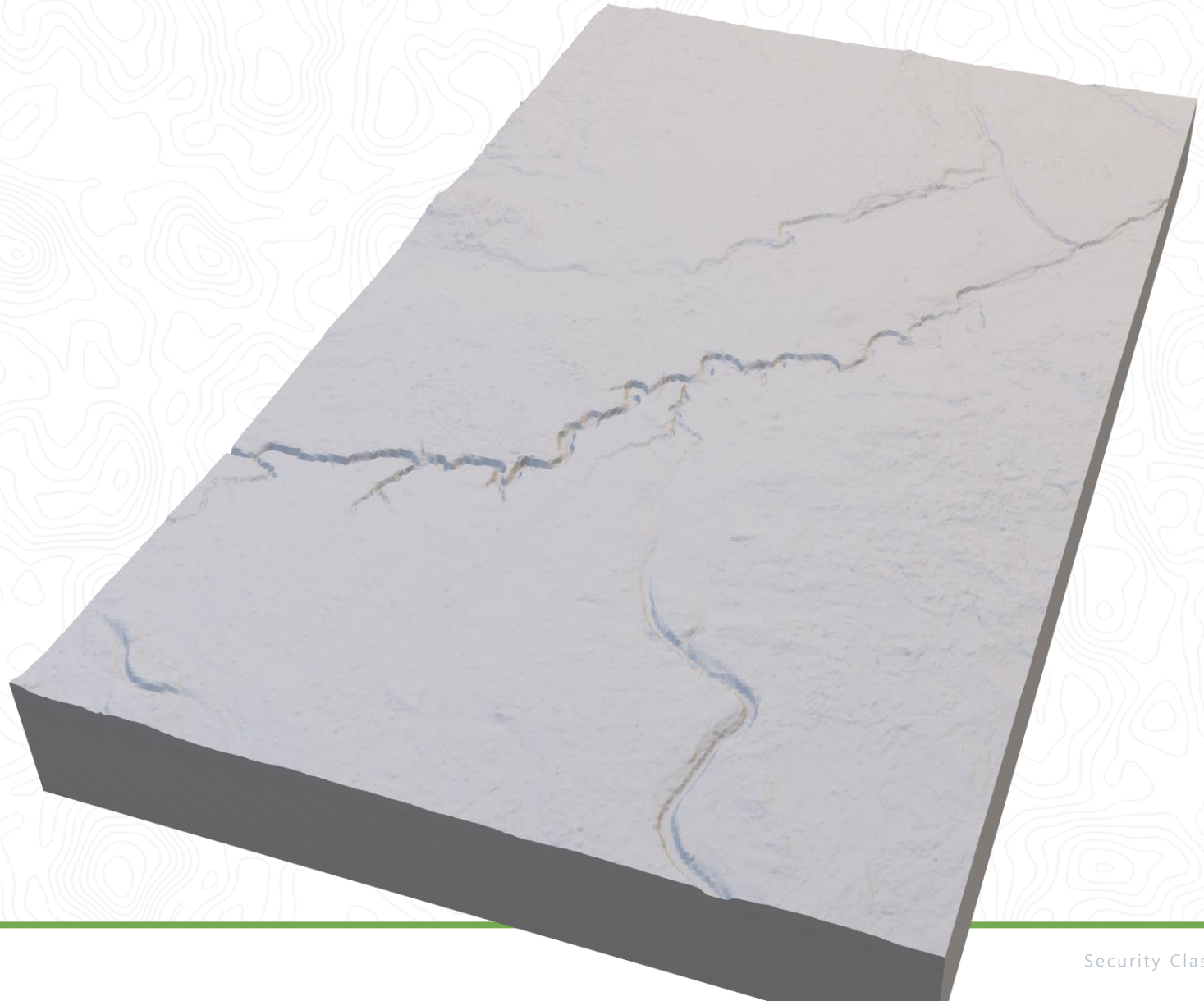
- New geological interpretation of LiDAR and 17,889 wells, with 32,685 well tops added
- Update to the bedrock topography grid using machine learning methodology
- 3D geomodel of the Upper Cretaceous (updated) and Neogene-Quaternary (N-Q; new)
- Lithology property model for N-Q zones
- Coarse-grained sediment probability predictive point cloud

➢ *Leading to a more comprehensive understanding of the subsurface beneath Edmonton's urban landscape*



a) Red box: study area. Blue area: North Saskatchewan watershed.
b) Study area
c) filtered view of the geomodel showing N-Q and bedrock zones under cities of the Edmonton region. The sandiness probability point cloud is filtered to show regions of higher probability of sandiness.

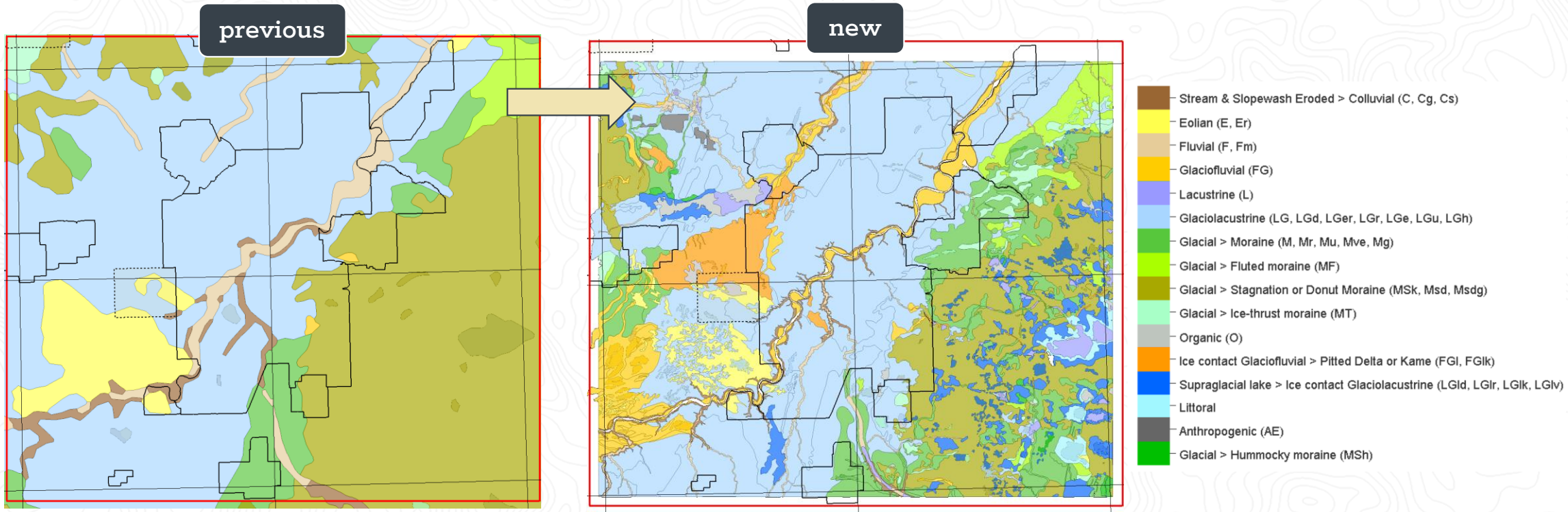
Inputs



Geological Mapping

Surficial Geology Update

- First update of Edmonton area surficial geology since 1983
- High resolution surficial mapping using LiDAR dataset



AGS/AER Map 601

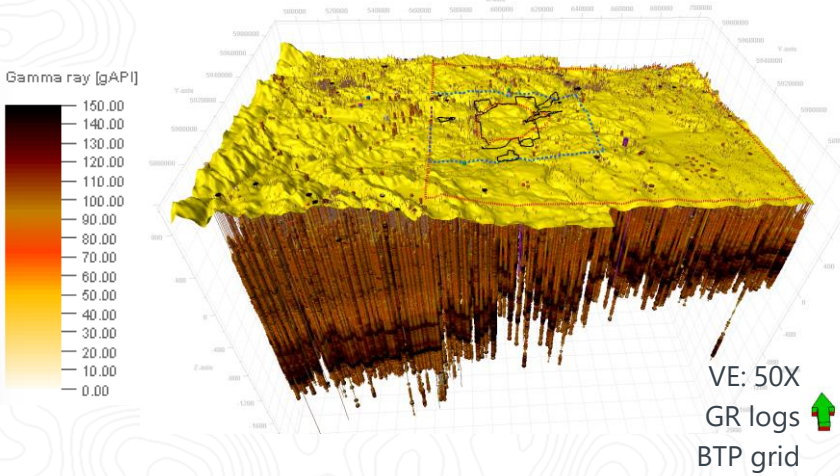
This study

Data

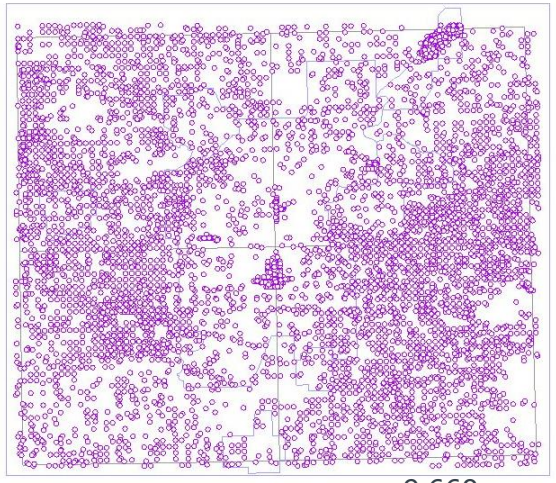
Well Data Compilation

- Dataset types: water wells, geotechnical boreholes and investigations, digitized datasets, and hydrocarbon wells
- High-quality logs from AGS/ARC and the City of Edmonton geotechnical database anchored stratigraphic interpretation

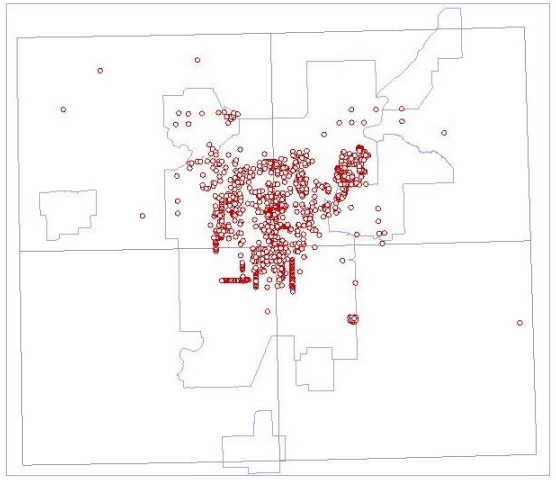
hydrocarbon wells dataset:



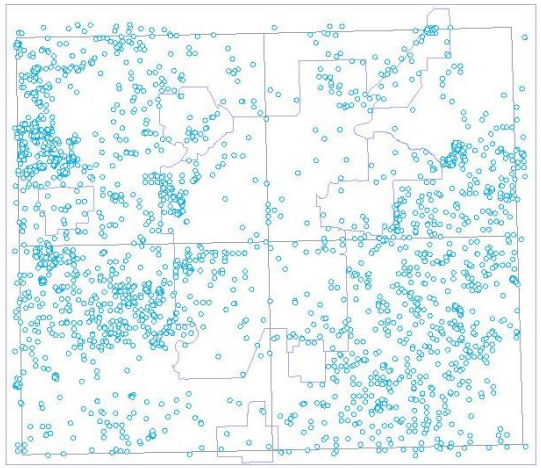
total: 17,889 lithologs



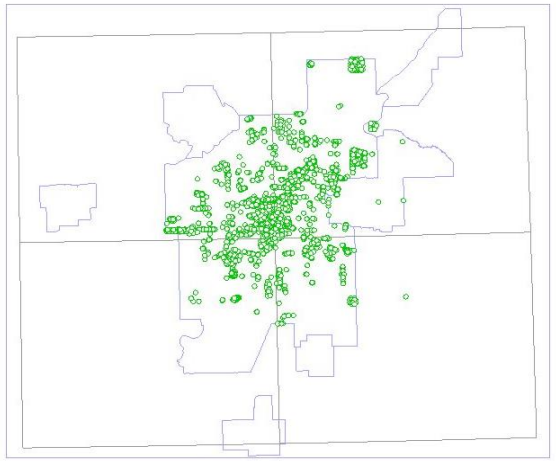
AGS 'AB Geology' database 9,668



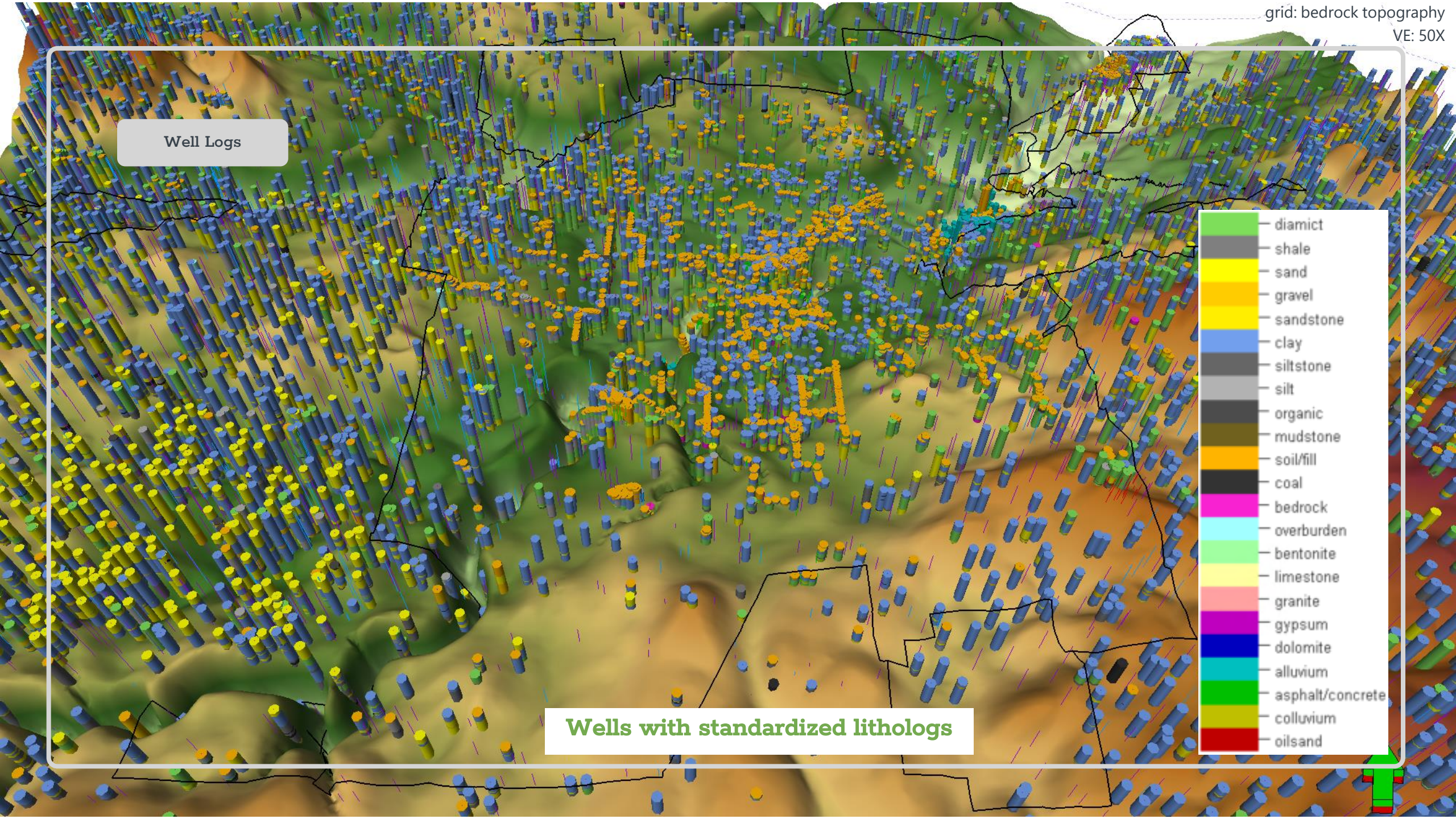
AGS/Alberta Research Council 1,187

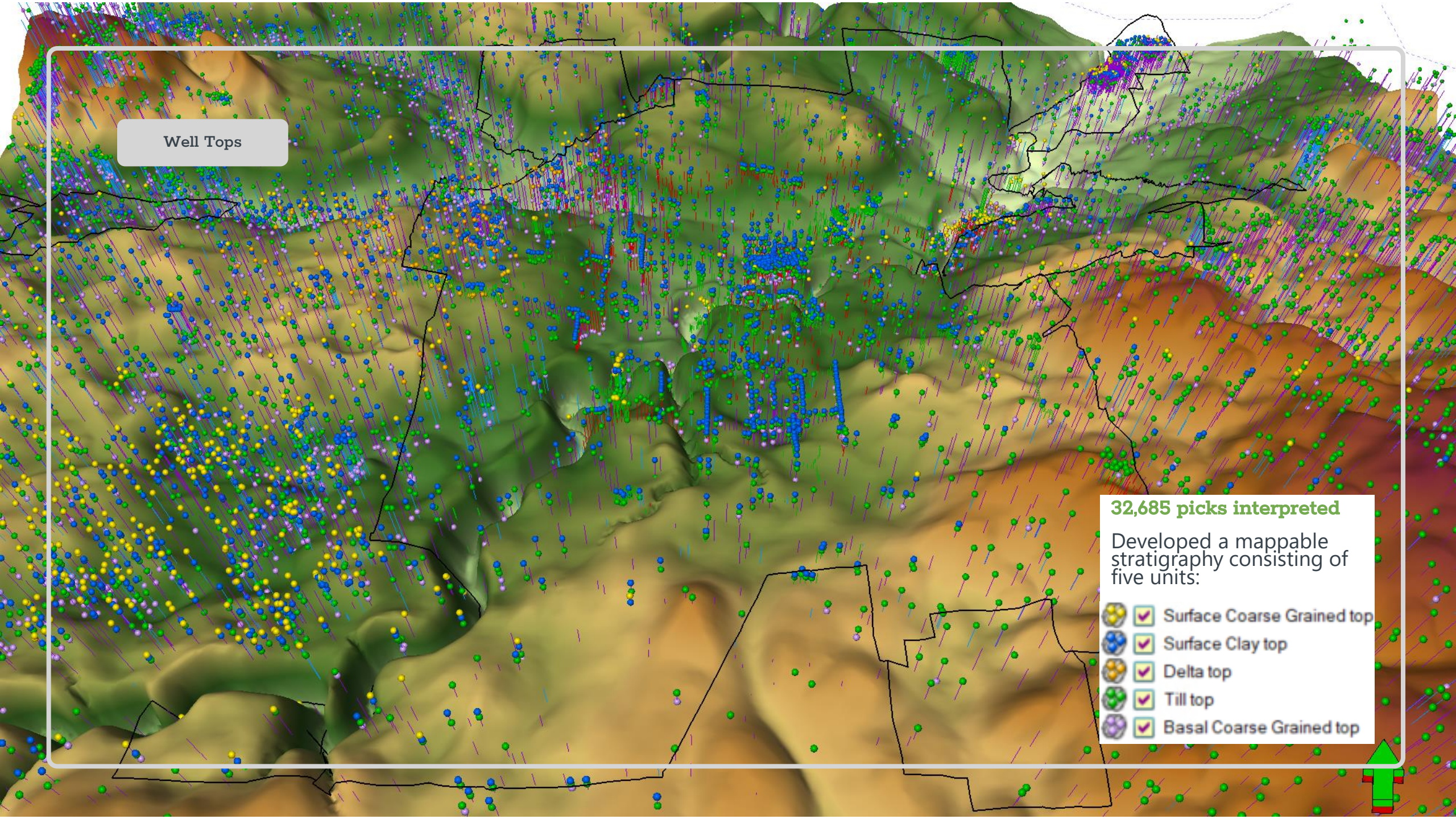


Alberta Water Well Information Database 2,591



City of Edmonton geotechnical boreholes 4,443

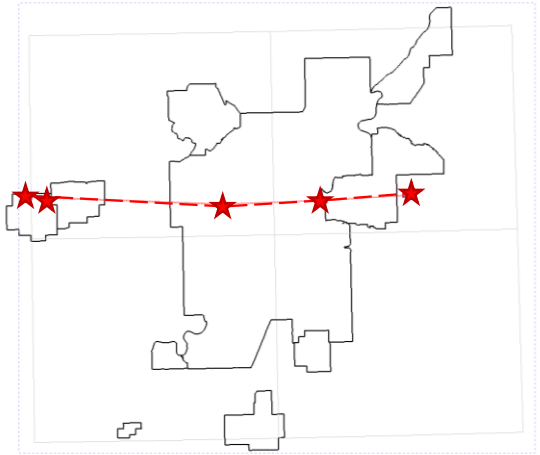

grid: bedrock topography
VE: 50X
Well Logs
diamict
shale
sand
gravel
sandstone
clay
siltstone
silt
organic
mudstone
soil/fill
coal
bedrock
overburden
bentonite
limestone
granite
gypsum
dolomite
alluvium
asphalt/concrete
colluvium
oilsand
Wells with standardized lithologs


Well Tops
32,685 picks interpreted
Developed a mappable stratigraphy consisting of five units:
Surface Coarse Grained top
Surface Clay top
Delta top
Till top
Basal Coarse Grained top

Cross-Section

Neogene-Quaternary Units

1. surface coarse grained (eolian dunes, modern river deposits)
2. surface clay (Glacial Lake Edmonton deposits)
3. deltaic deposits (pitted delta)
4. till (Glacial debris)
5. basal coarse grained (Empress Group, pre-/inter-glacial river gravels)



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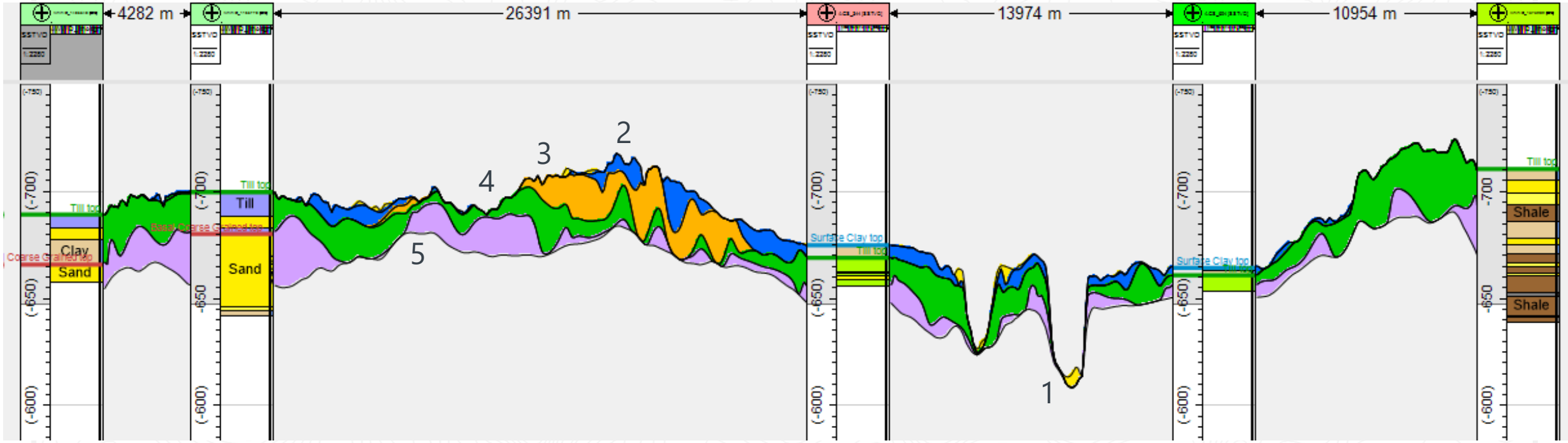
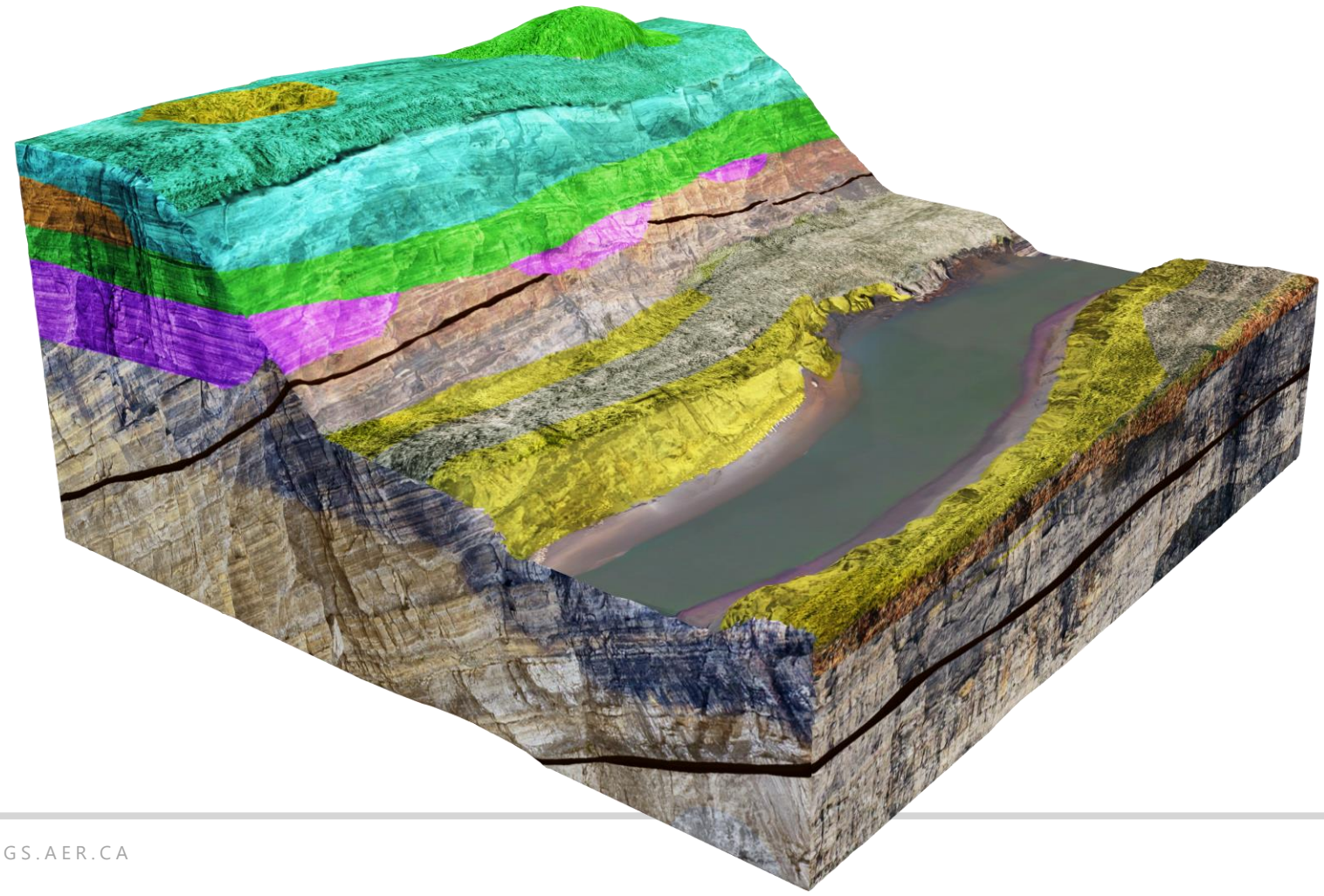
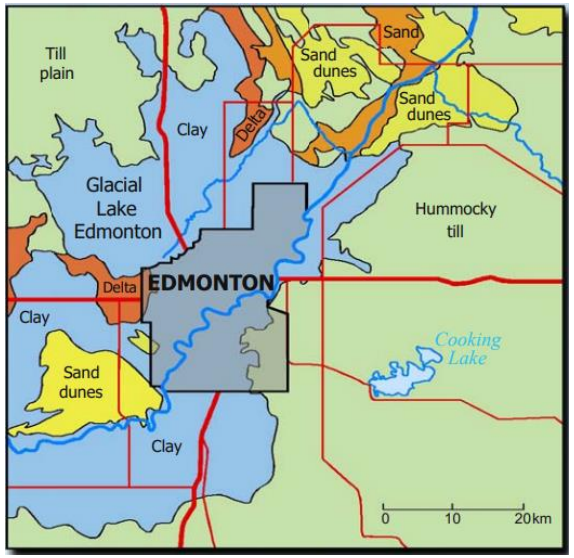


Geological Setting

Neogene-Quaternary History





AGS/AER INF 126

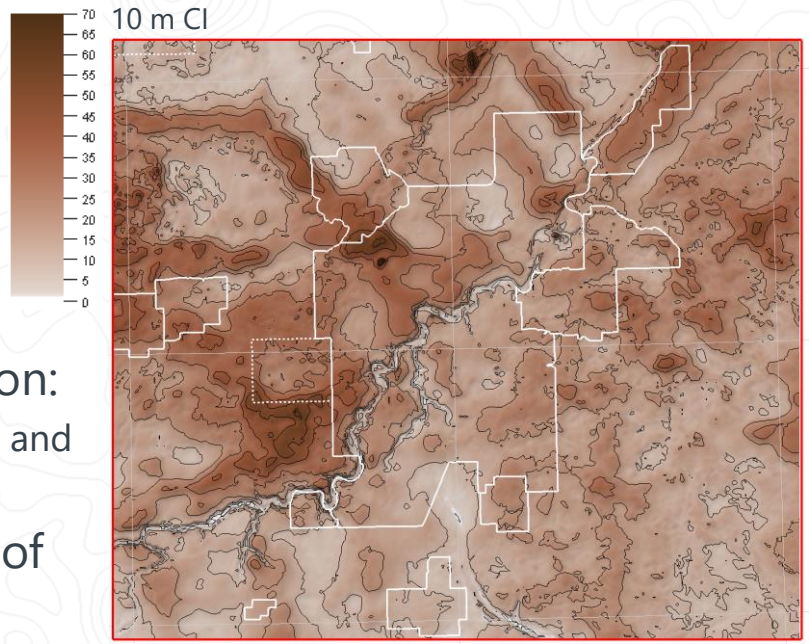
Five sediment packages:

1. River gravel & eolian dunes
2. Glacial Lake Edmonton clay, silt & sand
3. Deltaic deposits
4. Glacial debris (till)
5. Coarse sediment (gravel) deposits

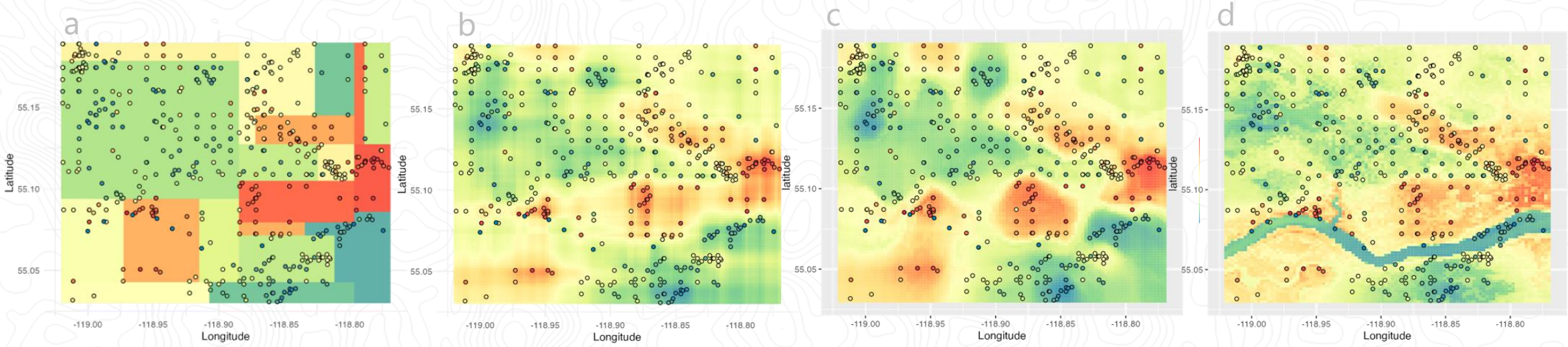
2D Predictive Modelling

Bedrock Topography Update

- Provincial scale bedrock topography and sediment thickness 2D machine learning model utilized all available bedrock top information:
  - ~170,000 boreholes, outcrops, terrain information, remote sensing spectral data, and spatial/autocorrelation features
- Model developed from (a) single decision tree, through (b) a forest of decision trees, to (c) addition of spatial features, and (d) addition of auxiliary features



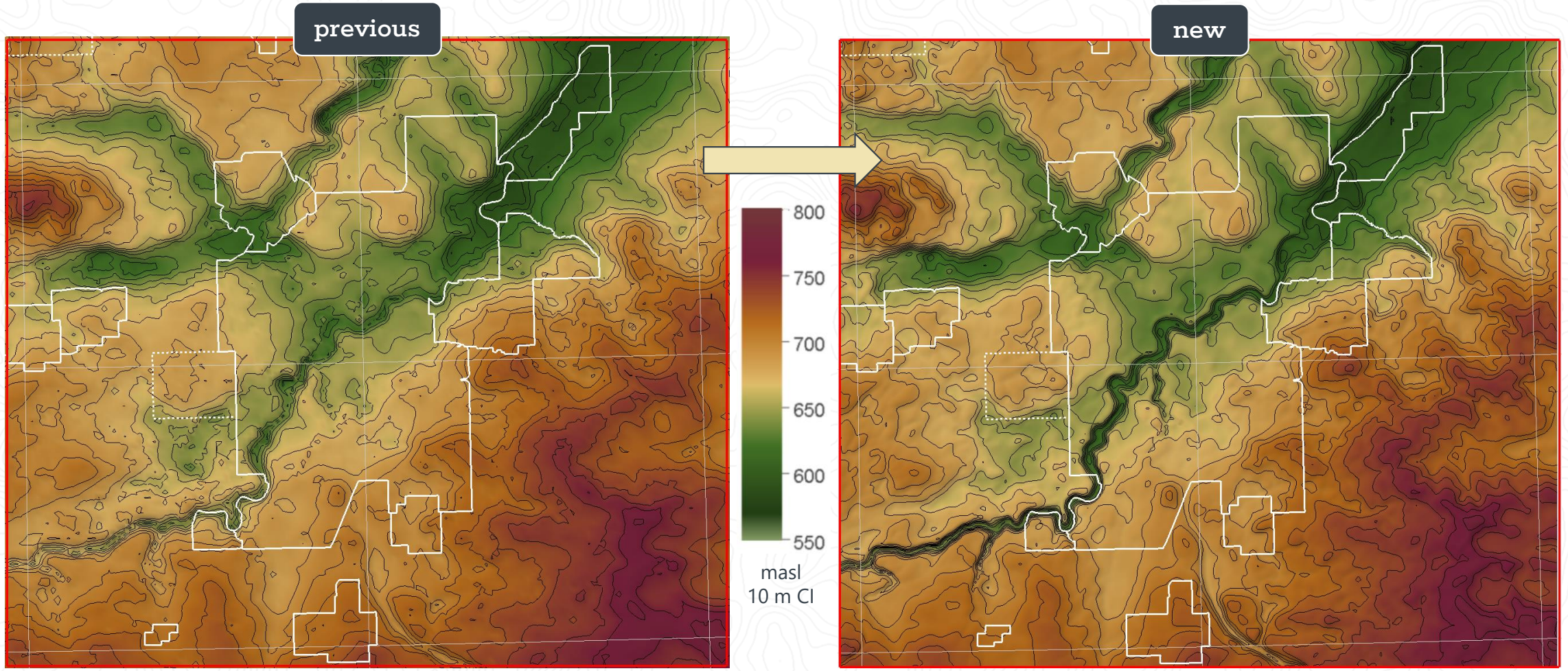
sediment thickness



Methodology developed in Pawley et al. 2023

2D Predictive Modelling

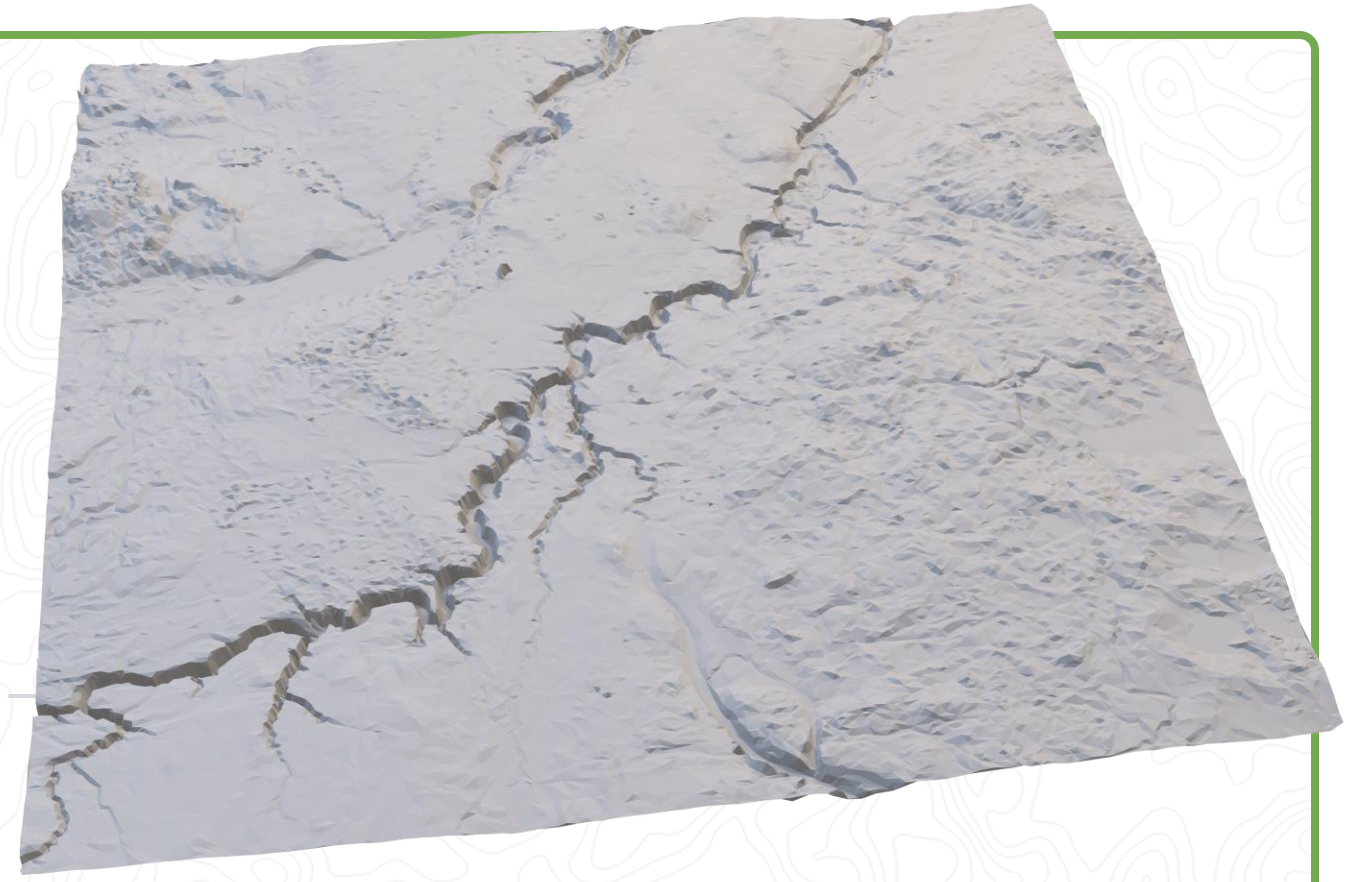
Bedrock Topography Update



AGS/AER Geological Framework of Alberta, version 3 (GFAv3)

This study

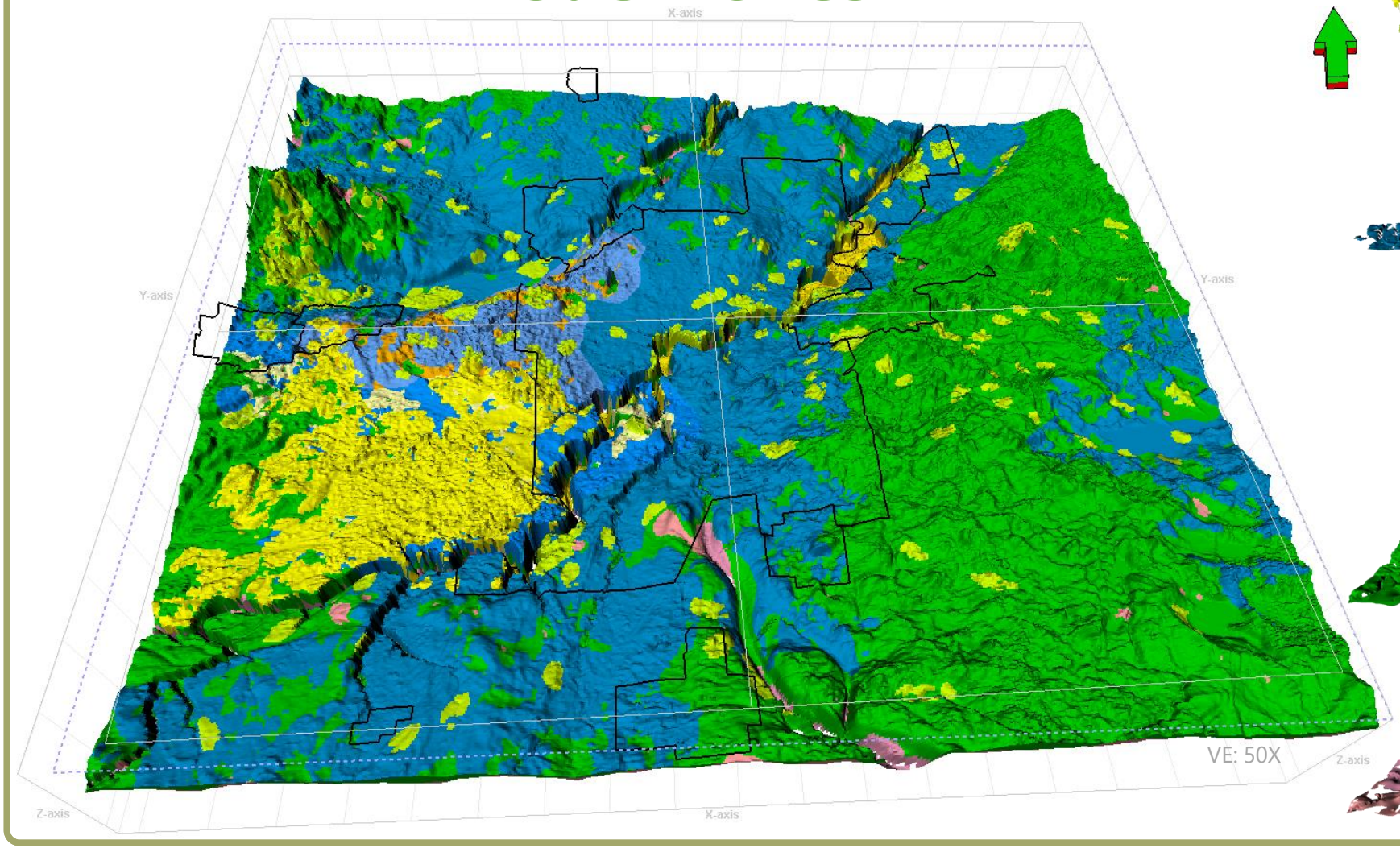
Methodology developed in Pawley et al., 2023



Neogene-Quaternary Geomodelling

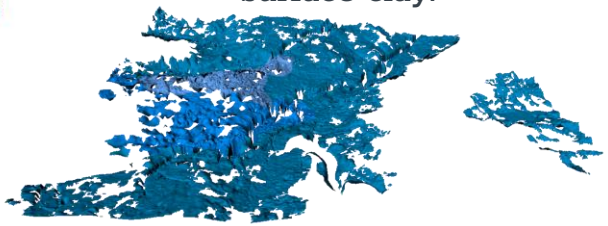
Neogene-Quaternary model zones

3D model

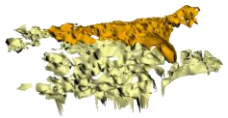


surface coarse grained:

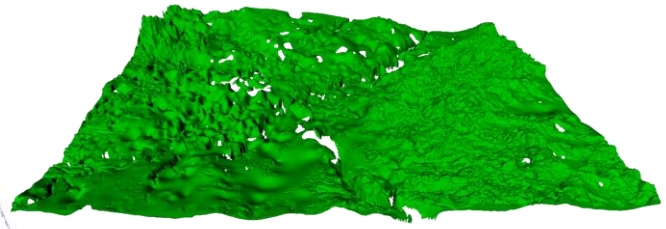
surface clay:



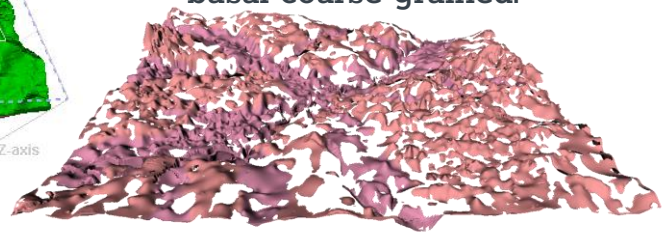
deltaic deposits:



till:



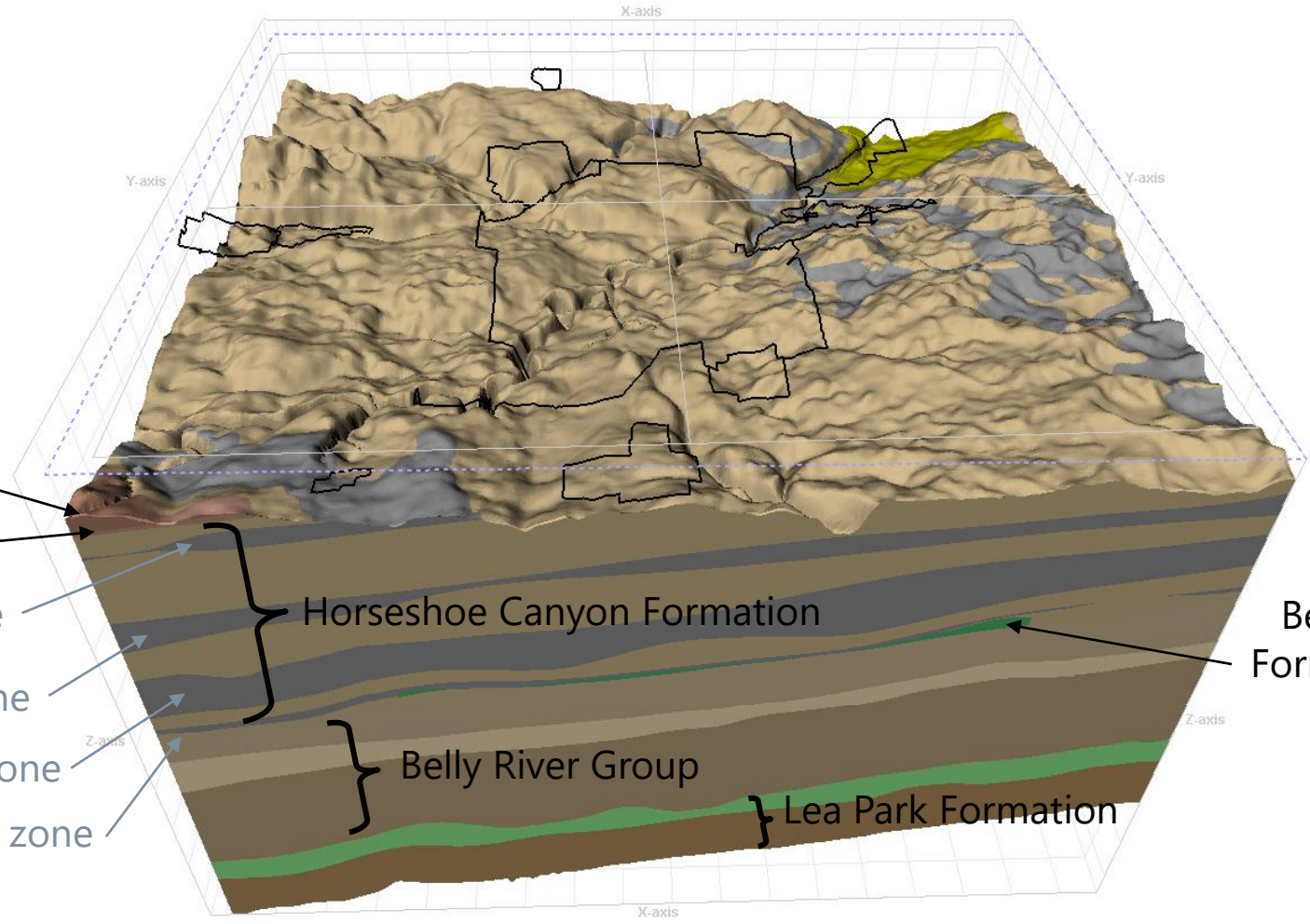
basal coarse grained:



Bedrock Zones

Updated bedrock model zones

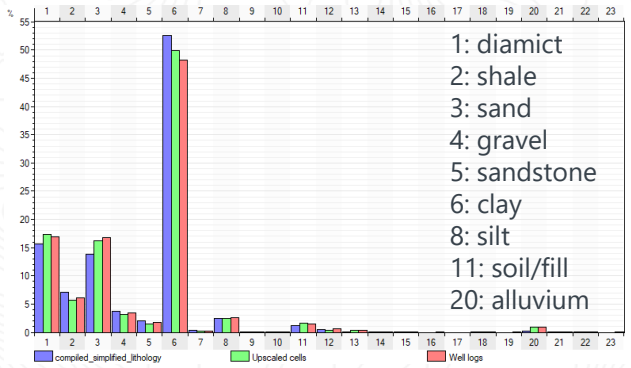
- AGS's GFA v3 geomodel zones updated with new bedrock topography and integration of coal zones of Horseshoe Canyon Formation

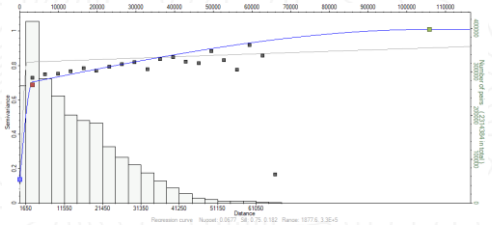


Property Model

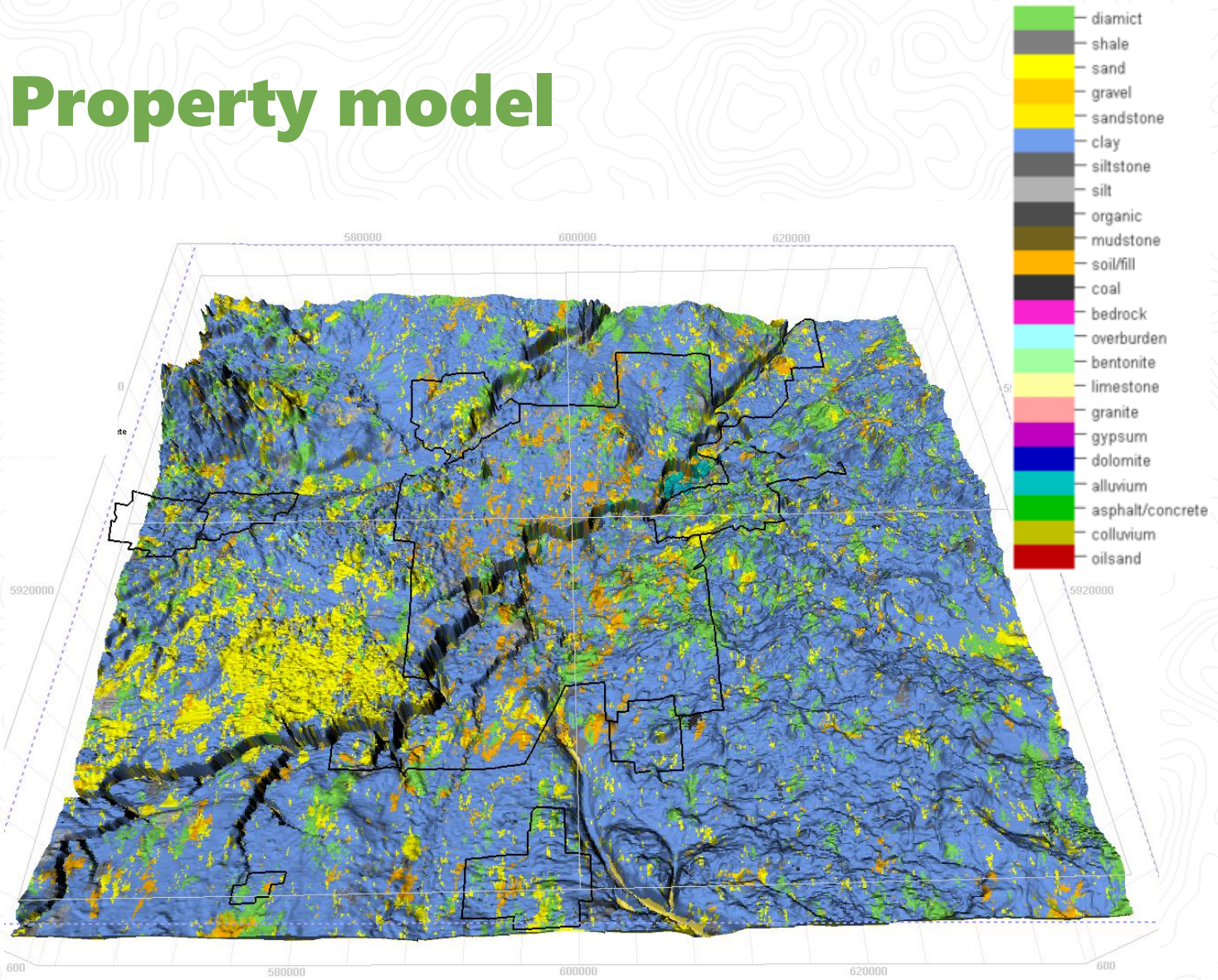
Lithology Property model

- Within N-Q zones
- Sequential indicator simulation
- Major direction NE (28-87 degrees)





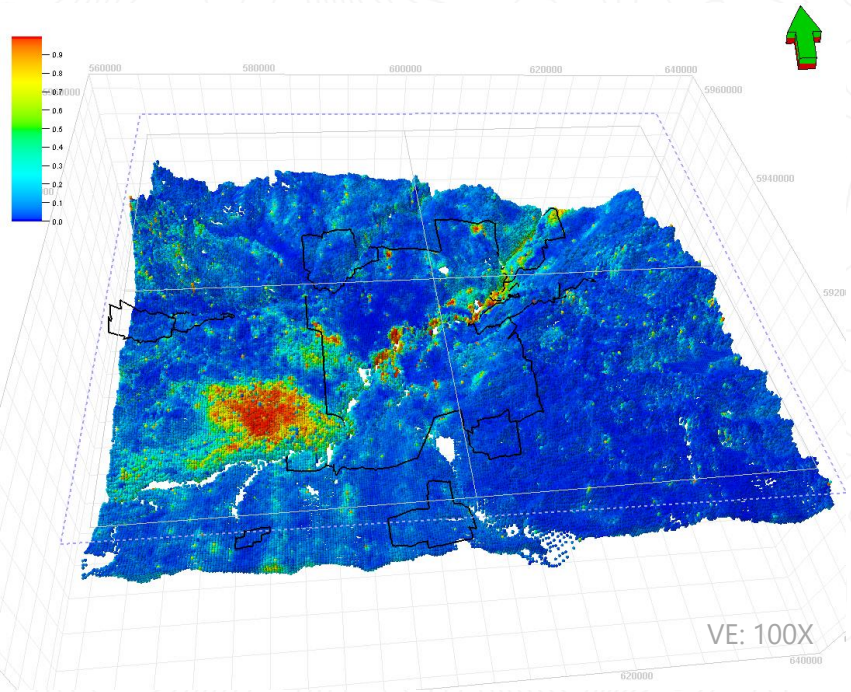
Major direction variogram for clay

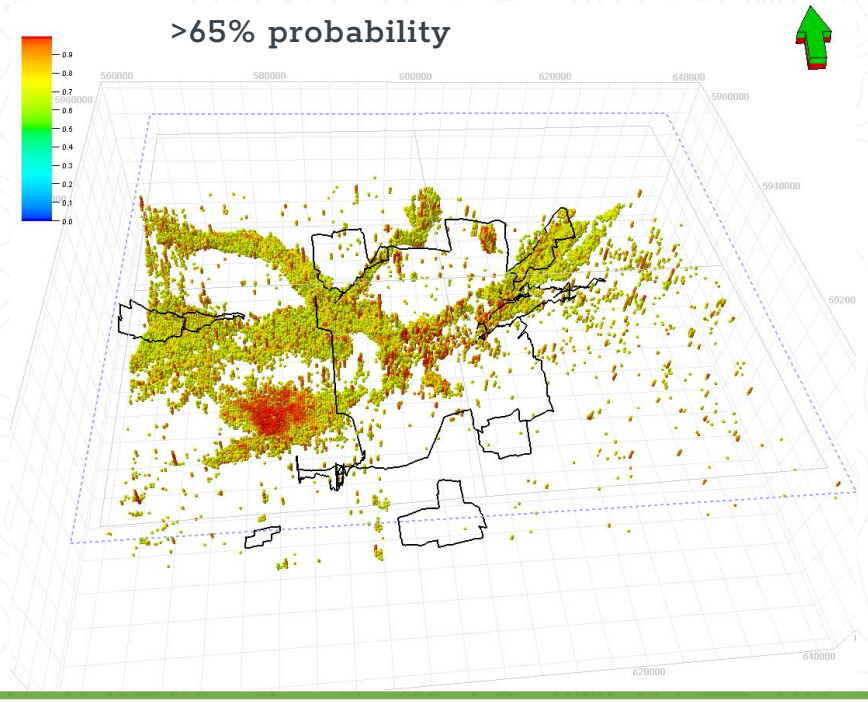


3D predictive modelling

Probability of coarse-grained deposits

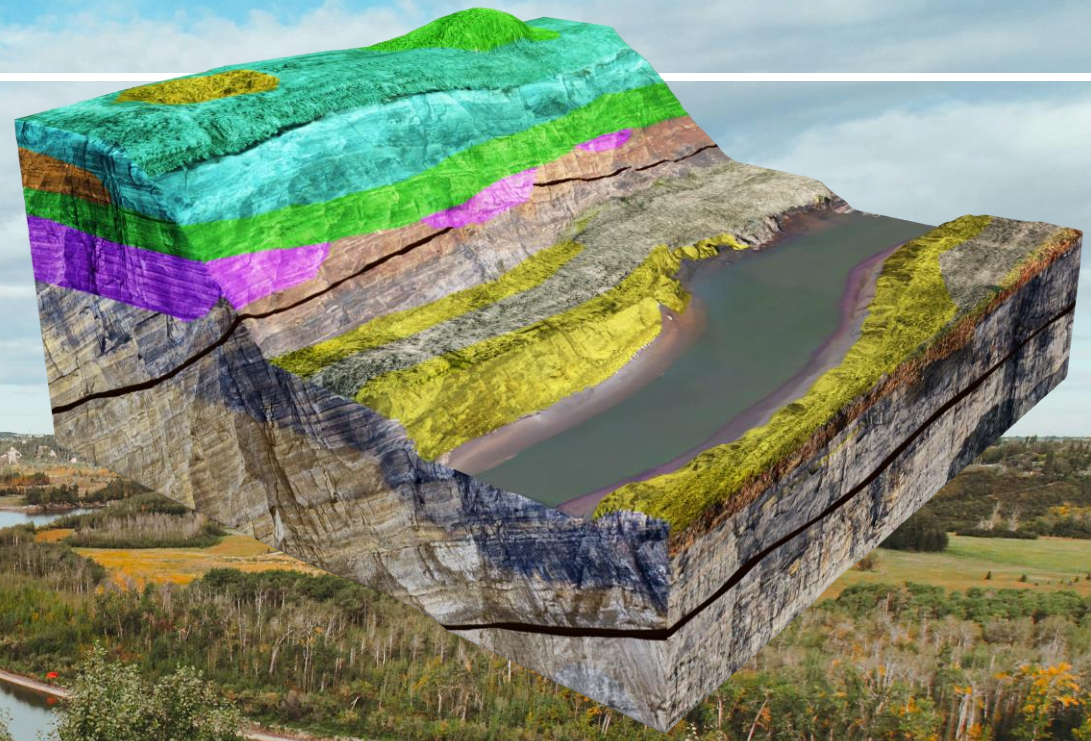
- 3D machine learning model of the probability of coarse-grained materials in 3D (X,Y,Z) space
- Utilizes all lithologs available (>350,000) to create a model from ~ 1Ma lithological descriptions





methodology developed in AGS/AER DIG 2023-0014

Figure sources: Alberta Geological Survey (Table of Formations, INF 126, MAP 601), Edmonton Geological Society (Edmonton Beneath our Feet)
Photo sources: Unsplash



Thank you!

Questions?

Presenter Notes

slide 6	- stratigraphy: model goes from ground through sediment above bedrock to the base of the Lea Park Formation (Upper Cretaceous)
slide 7	- 3D view showing a filtered version of the geomodel, so that it is showing the zones of the model only under the cities - newly developed zone framework for the N-Q at the top, - bedrock zones are from the Horseshoe Canyon Formation down to the Lea Park Formation - point cloud is a filtered view of the predictive model showing areas with higher probability for coarse-grained materials
slide 9	- refinement of eolian deposits in yellow, and moraine in green - delineation at surface of an ice-contact feature (in orange), to the west of Edmonton: Carvel pitted delta, an area of groundwater recharge currently being investigated in the second phase of this project
slide 11	- go from 328 unique lithology descriptors to 23 standardized lithologies
slide 12	- N-Q stratigraphy was interpreted in all these wells - identified five key sediment packages
slide 14	- block diagram of five sediment packages and Cretaceous bedrock visible at surface in the river valley (Horseshoe Canyon Formation, with coal zones)
slide 15	- top right: resulting sediment thickness map: in darker brown, thicker packages, some of which coincide with the buried valleys - new wellbore interpretation of the bedrock top was incorporated into the provincial scale predictive model to provide a locally refined grid

Presenter Notes

slide 16	- better refined around the North Saskatchewan valley (important for latter phase of project: surface water-groundwater interactions can be better modelled)
slide 18	- resolution of model: 100 m x100 m
slide 19	- bedrock zones were modelled after the GFA v3 geomodel and incorporate coal zones of the Horseshoe Canyon Formation (potential aquifer zones) - model goes down to the base of the Lea Park Formation, a regional, thick marine shale which acts as a continuous aquitard in the area
slide 20	- standardized lithologies upscaled into 3D grid - developed a lithology property model using sequential indicator simulation (kriging-based approach) - each model zone was used to guide the property - each of the lithologies were analyzed independently, ensuring their variograms were representative - vertical layering of model: 2 m
slide 22	- next steps: AI-WIP project continues through the University of Alberta (via Drs. Brian Smerdon and Dan Alessi), MSc students are using this model as an anchor point to the work they are doing, which spans from investigating water chemistry in the Carvel pitted delta west of Edmonton, to a surface water-groundwater simulation within the city - this project was a critical first step in our journey to better understand shallow groundwater flow in Edmonton