Geologic Assessment Methodology for Underground Targets (GAMUT)

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NATIONAL LABORATORY
EST. 1943

Outline

- The GAMUT concept, process, and general framework
- Model development – Divine Strake example
- Red vs Blue Models
- Summary

The GAMUT Framework

Develop 3-d geologic model for high fidelity shock propagation modeling

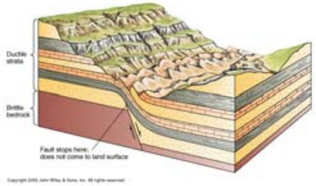
Motivation: **Current DOD/DOE geologic models are “half spaces”**

Recognition that “geology matters” –
structure has a primary influence on shock wave propagation

Criteria	***Purpose***
Scripted, documented, archived	Reproducible results
Common output file format (ACIS)	Compatibility w/other software (CUBIT, ABAQUS, IMEA)
Inexpensive, portable tools	ARC-Info, RHINO3d, EarthVision

Schematic of the GAMUT Process

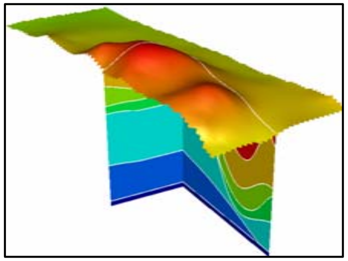
Structure

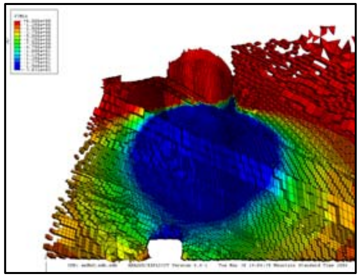


Information from the IGAT (Interagency Geotechnical Assessment Team)

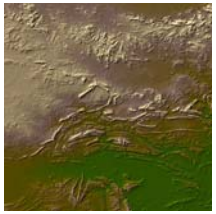
Material Properties

Basic Information → **Model Development** → **3-d Geologic Model** → **3-d High-Fidelity Model**

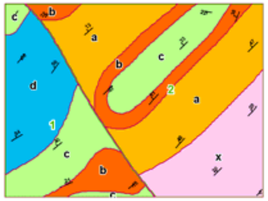




DEMs



Surface Geology



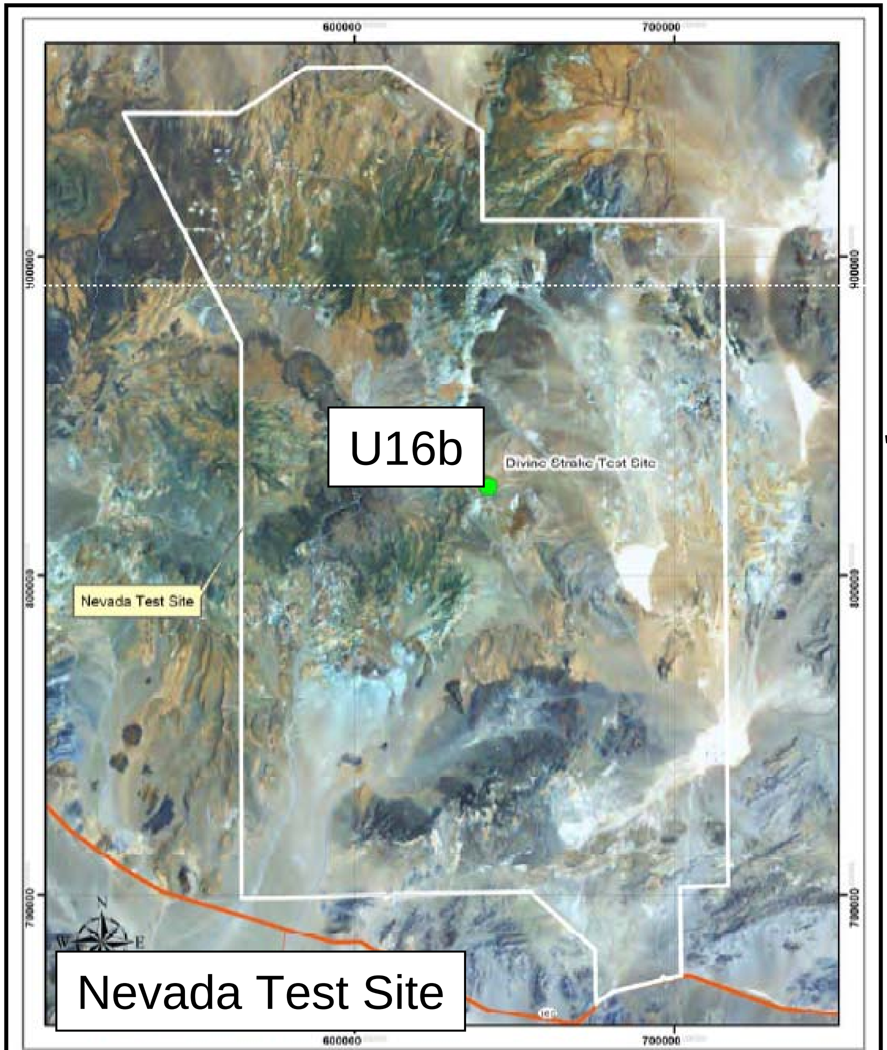
Spatial Relationships
Rhino3d
Operator Expertise

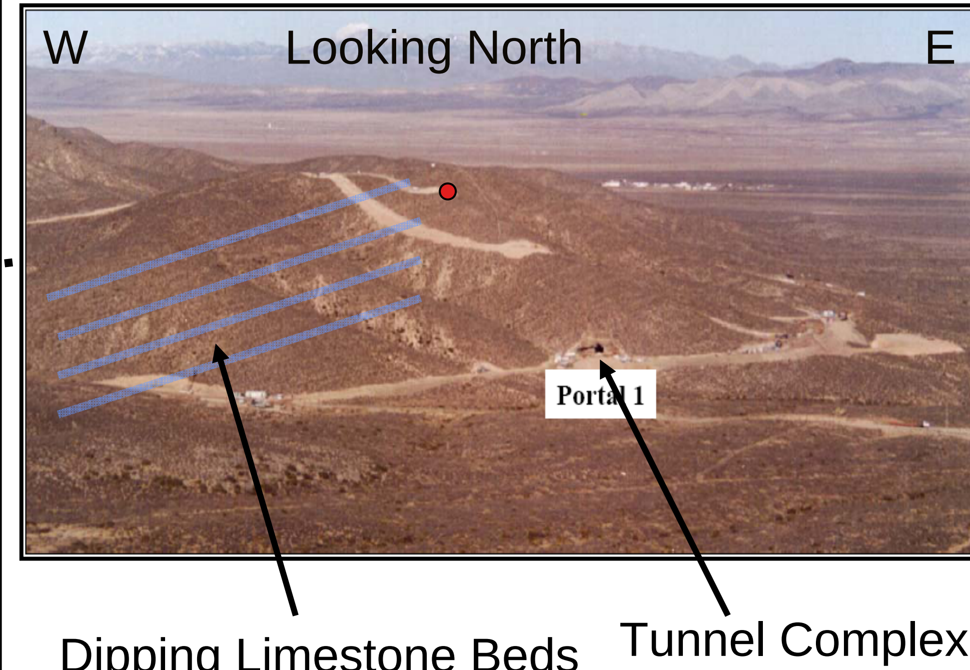
Accounts for complex subsurface geology – facilitates modeling

Optimum use of available data

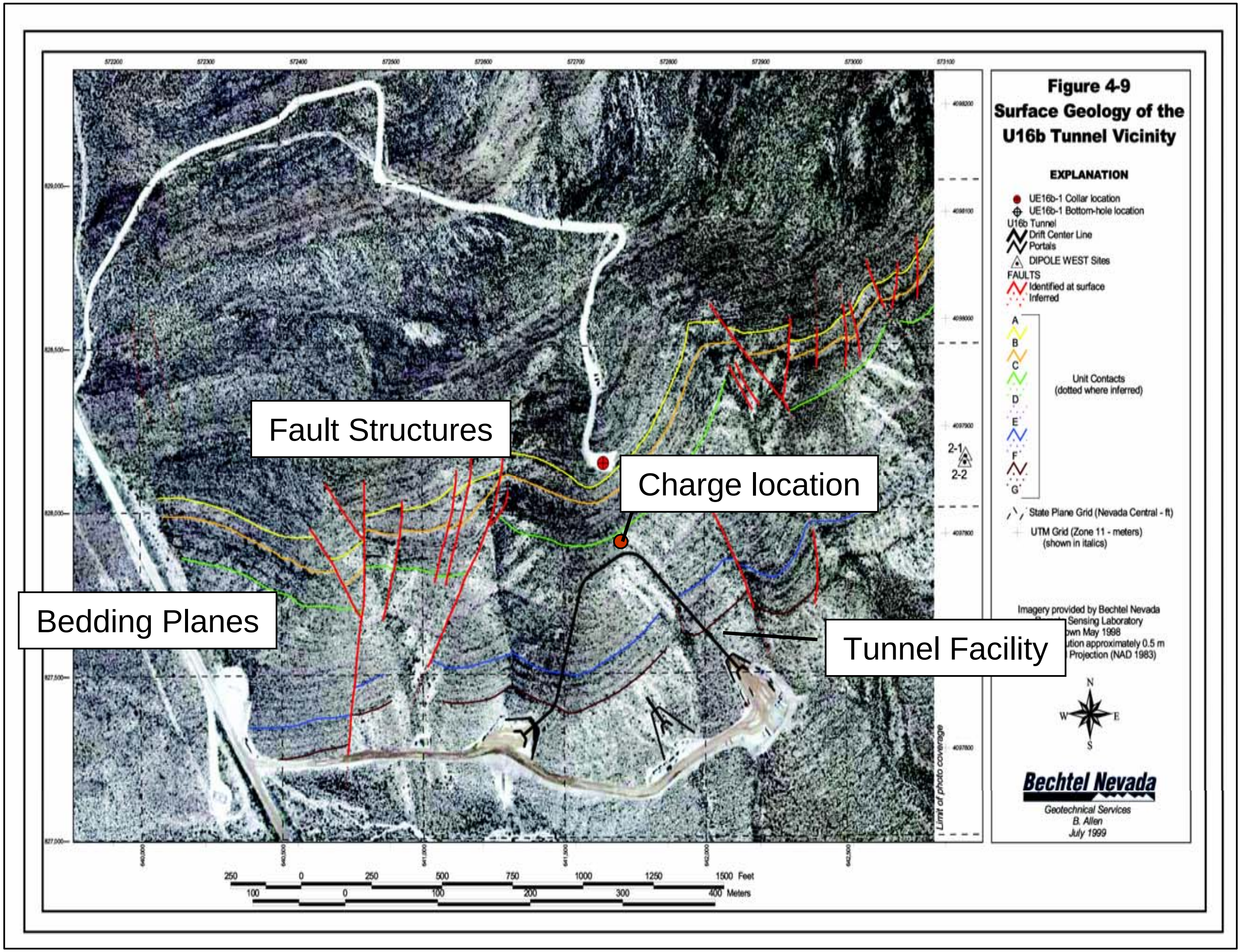
Provide high resolution models for numerical calculations

GAMUT Example: Divine Strake at NTS





U16b Facility -- Aerial Photo

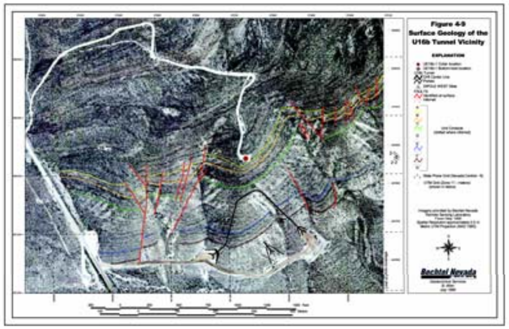


Converting U16b Red Team Information to 3d Model

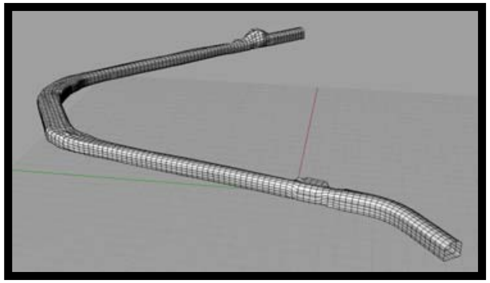
Available Information

GAMUT Model

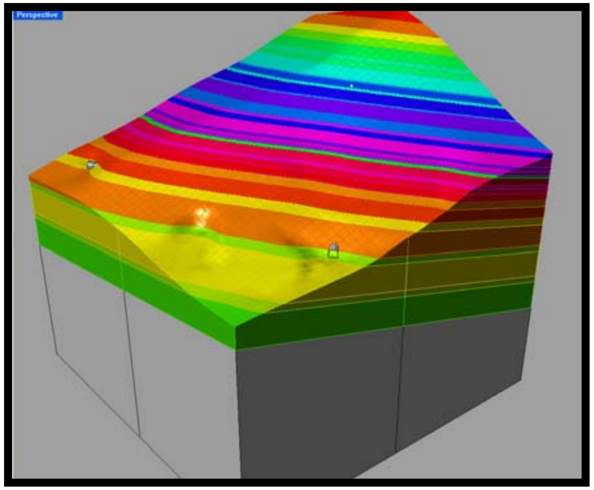
Imagery



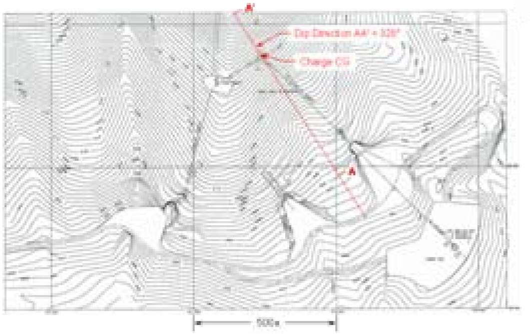
Tunnel Geometry



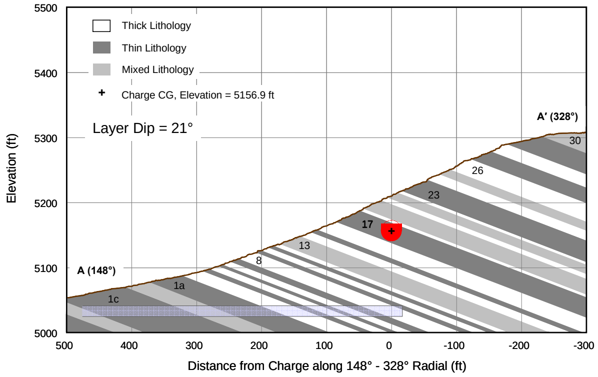
3d Model



Topography



Geology/Stratigraphy



Two Levels of Information: Red vs Blue

<u>Red Model:</u>

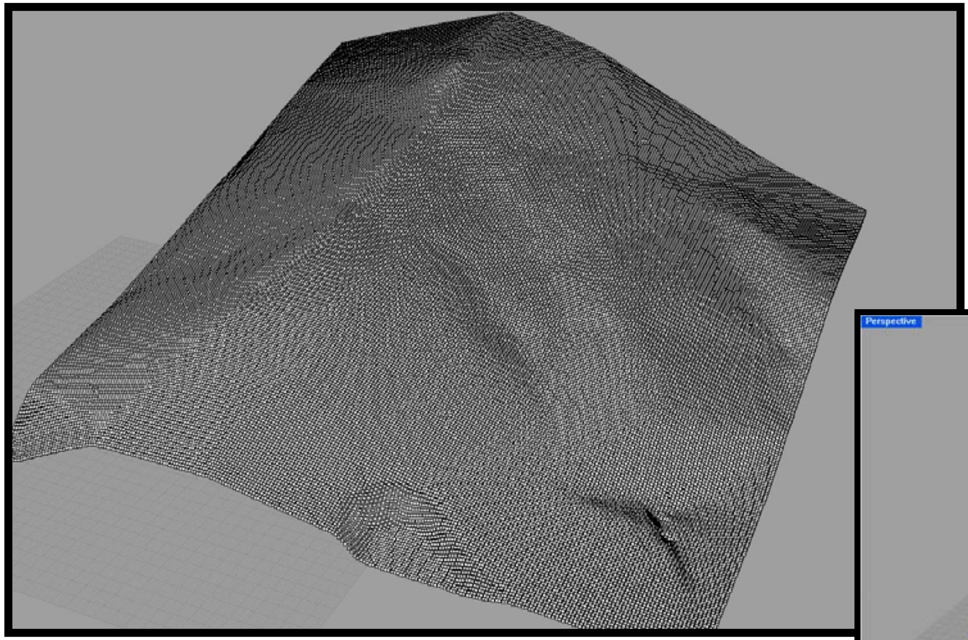
Flat Geologic Layers
Simplified Geology
No Faults/Fractures

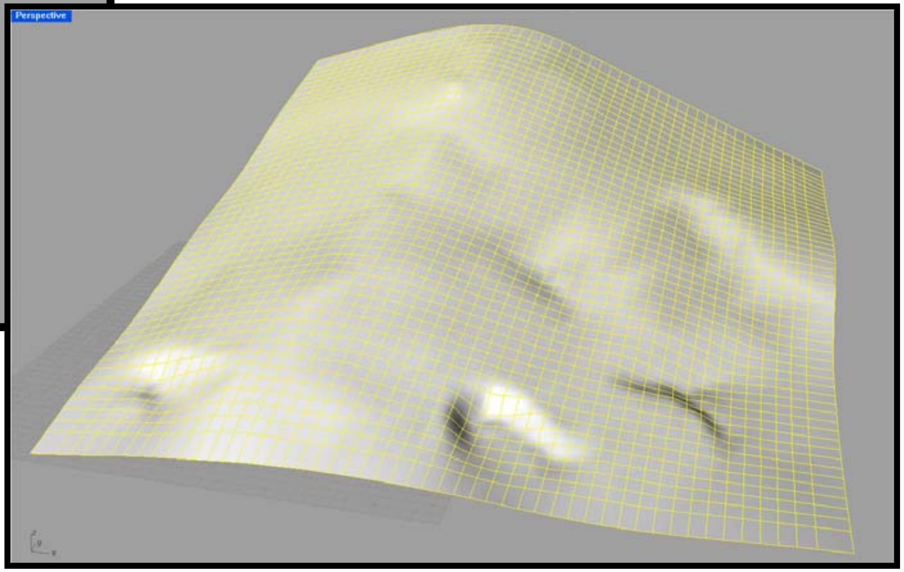
<u>Blue Model:</u>

Complex Geologic Layers
Include Faults
Include Fractures

GAMUT DS Red

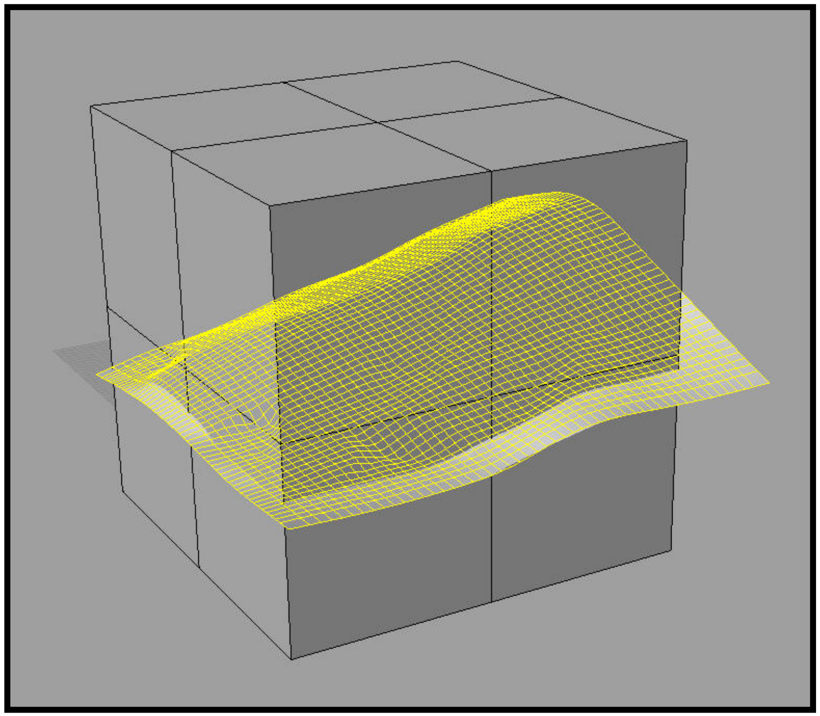
1. Convert DEM (1m resolution - ~60,000 points) to a NURBS surface

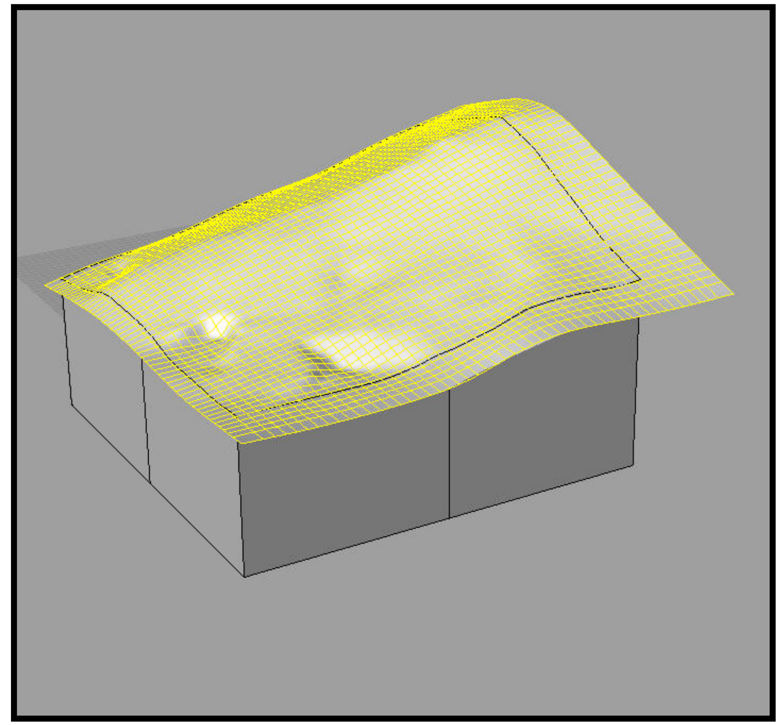




GAMUT DS Red

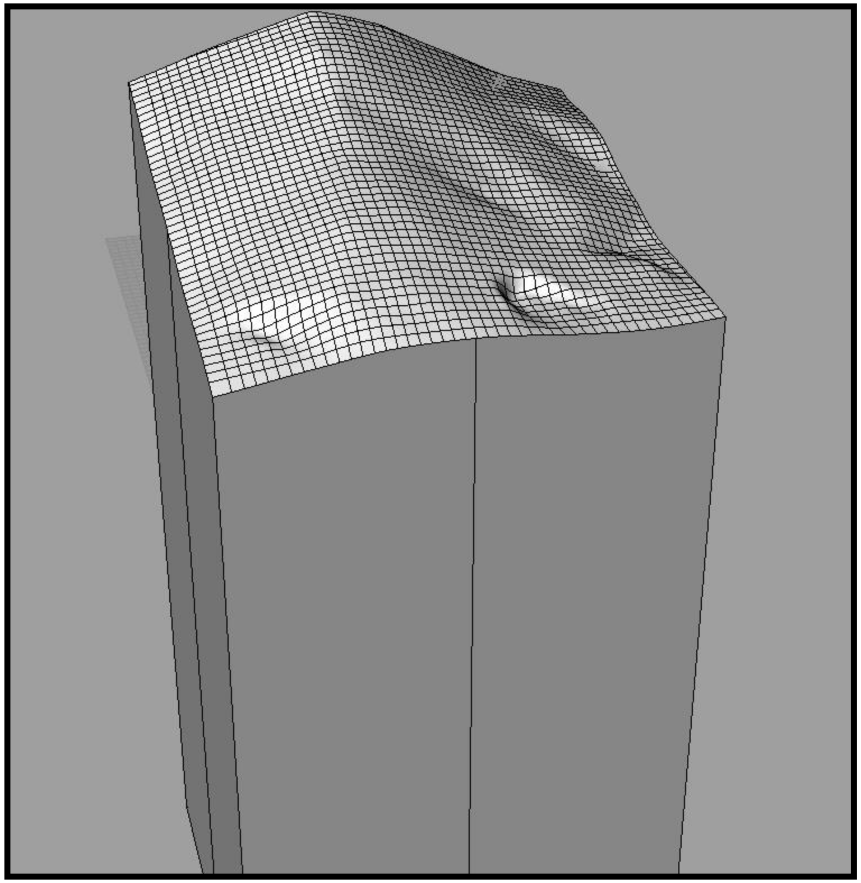
2. Clip volume with NURBS surface





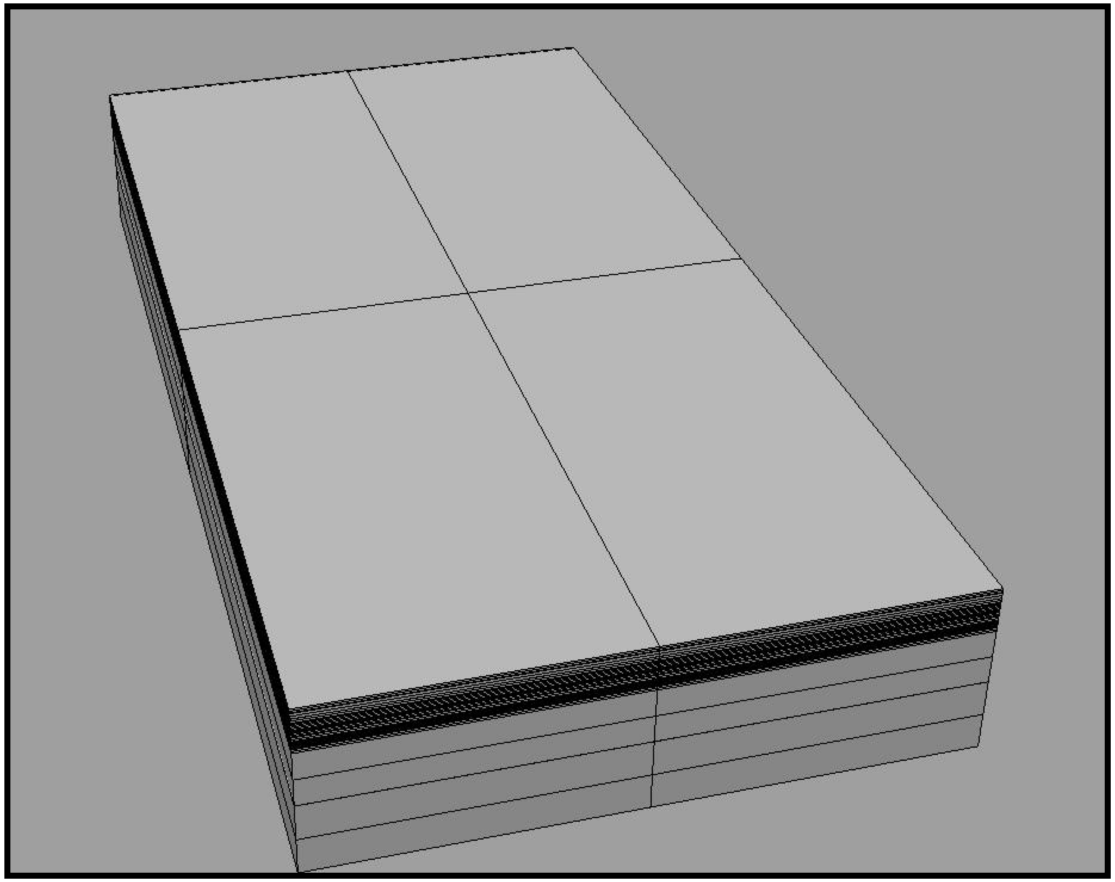
GAMUT DS Red

3. Extend volume to depth



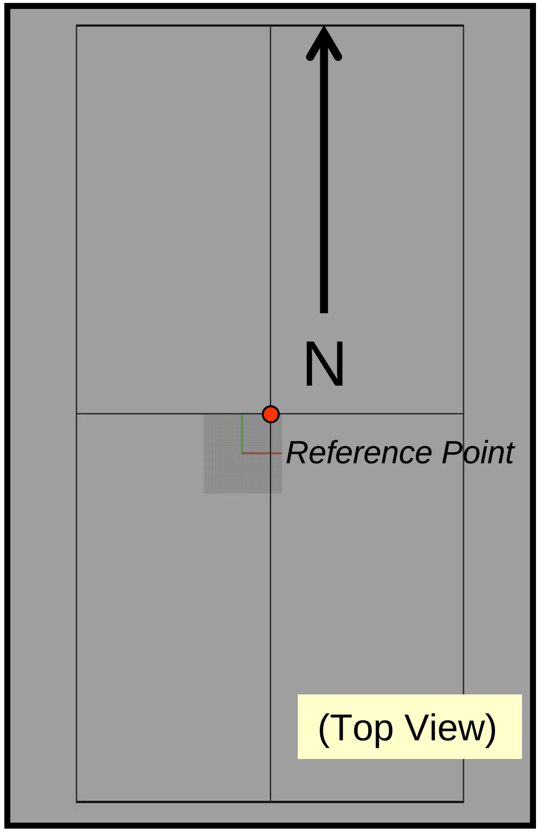
GAMUT DS Red

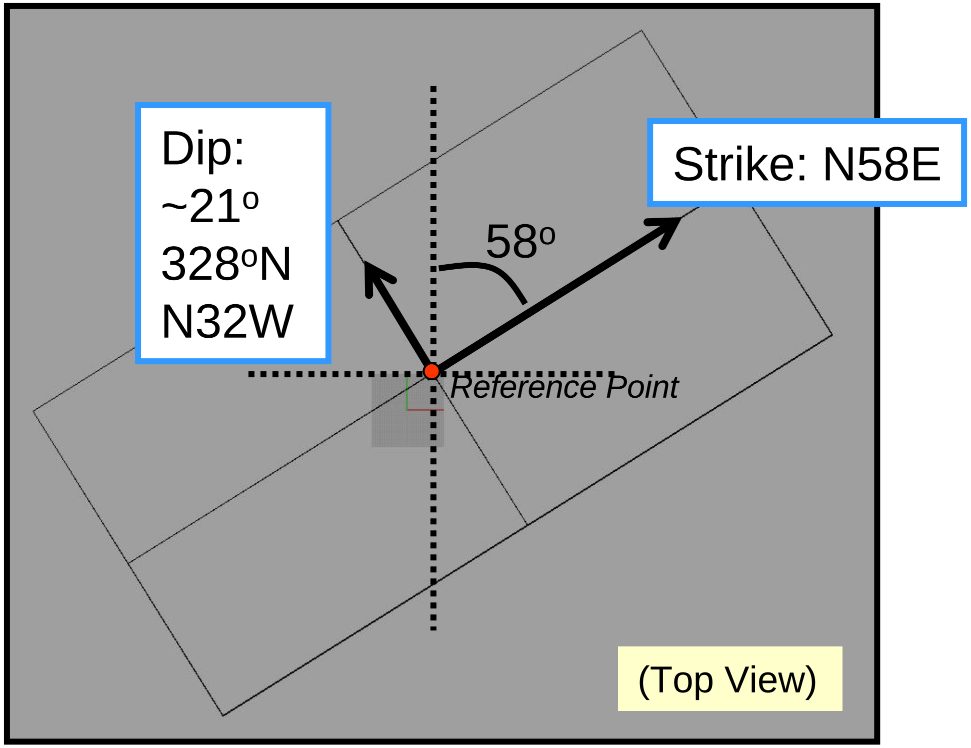
4. Create stratigraphic layers



GAMUT DS Red

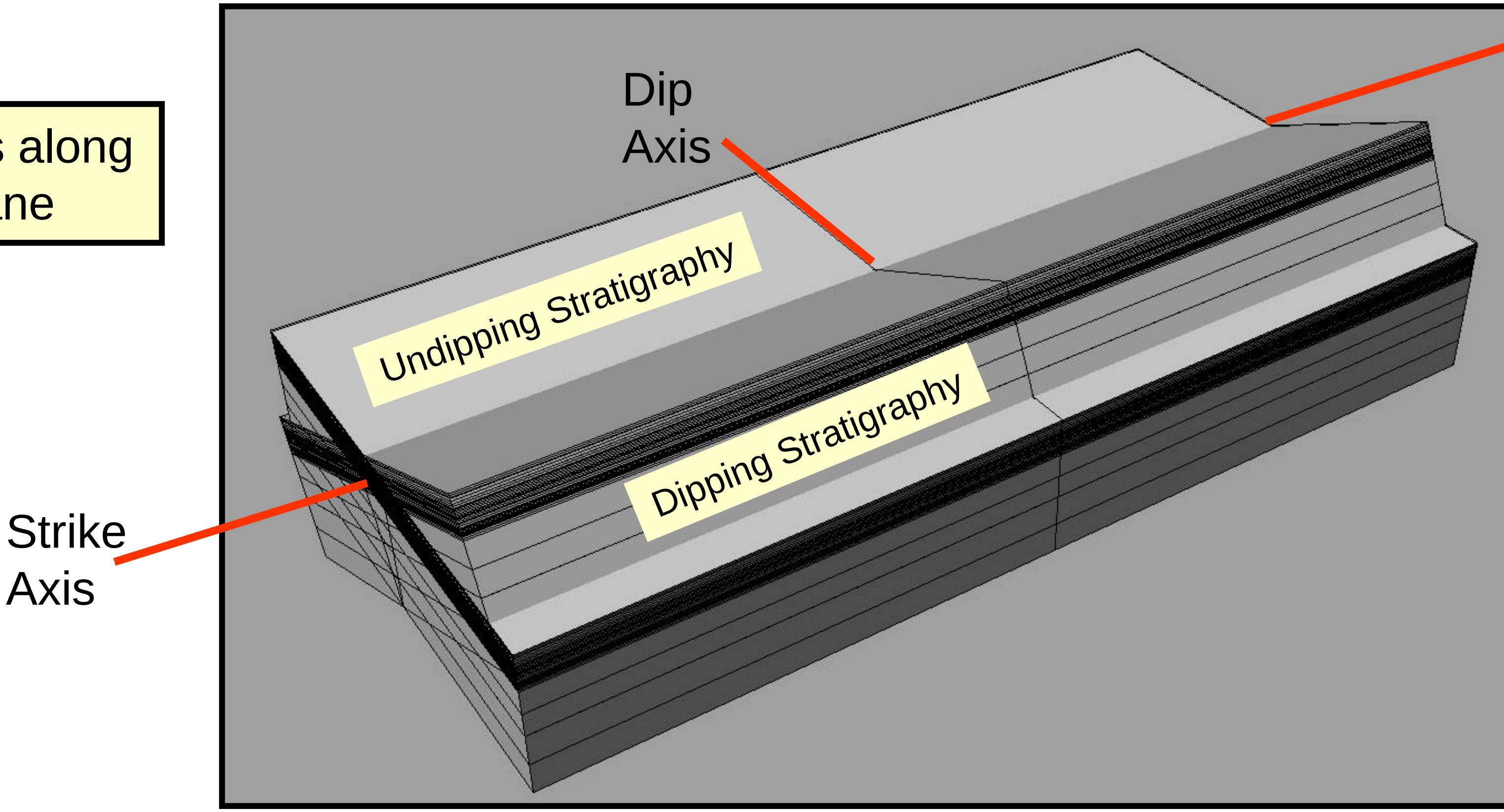
5. Rotate the stratigraphy to align with bedding strike





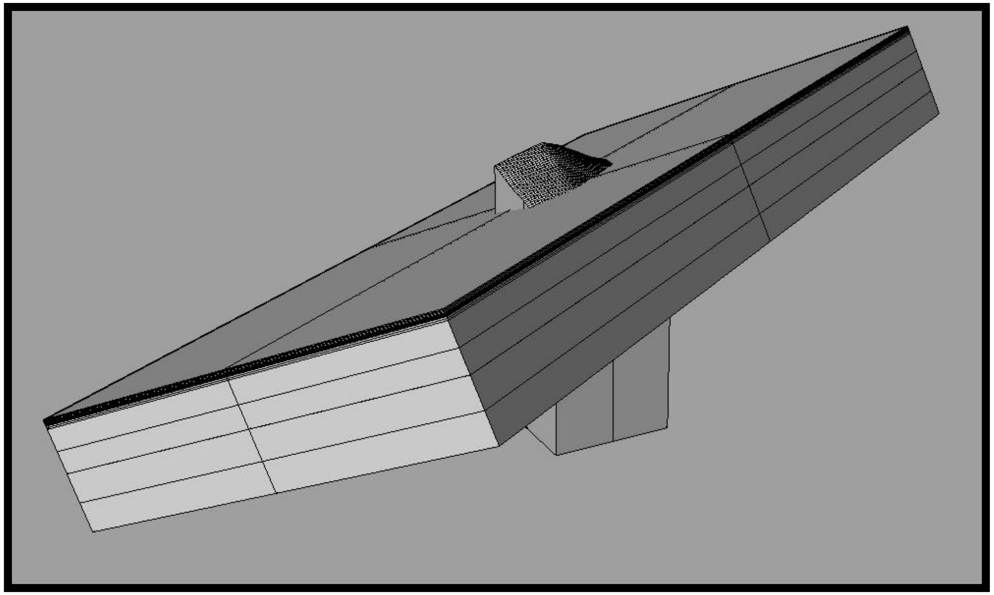
GAMUT DS Red

6. Tilt beds along dipping plane



GAMUT DS Red

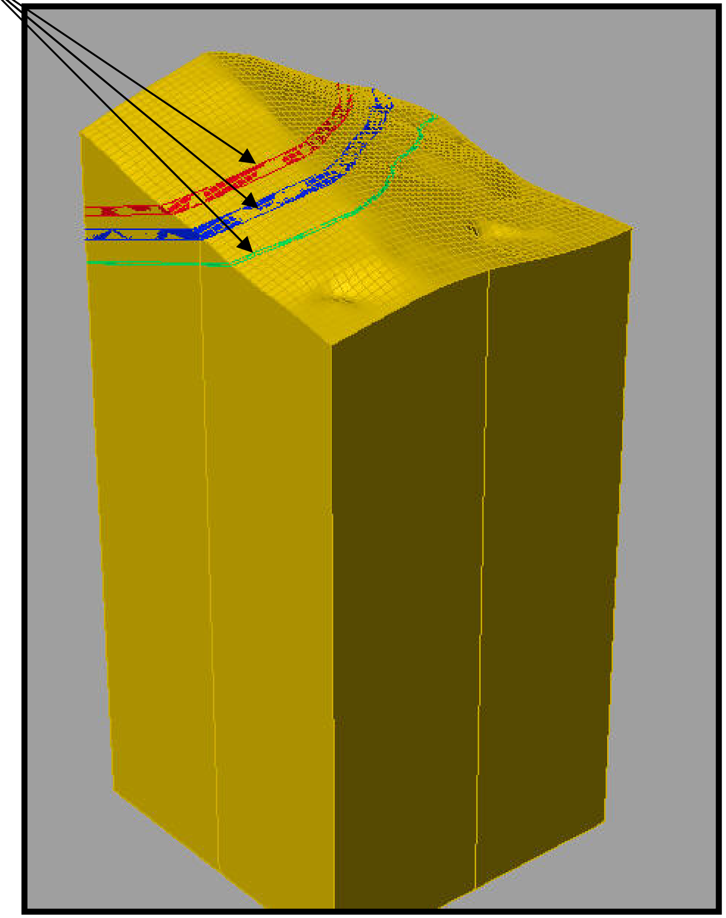
Topography and basis subsurface block shown with stratigraphy



GAMUT DS Red

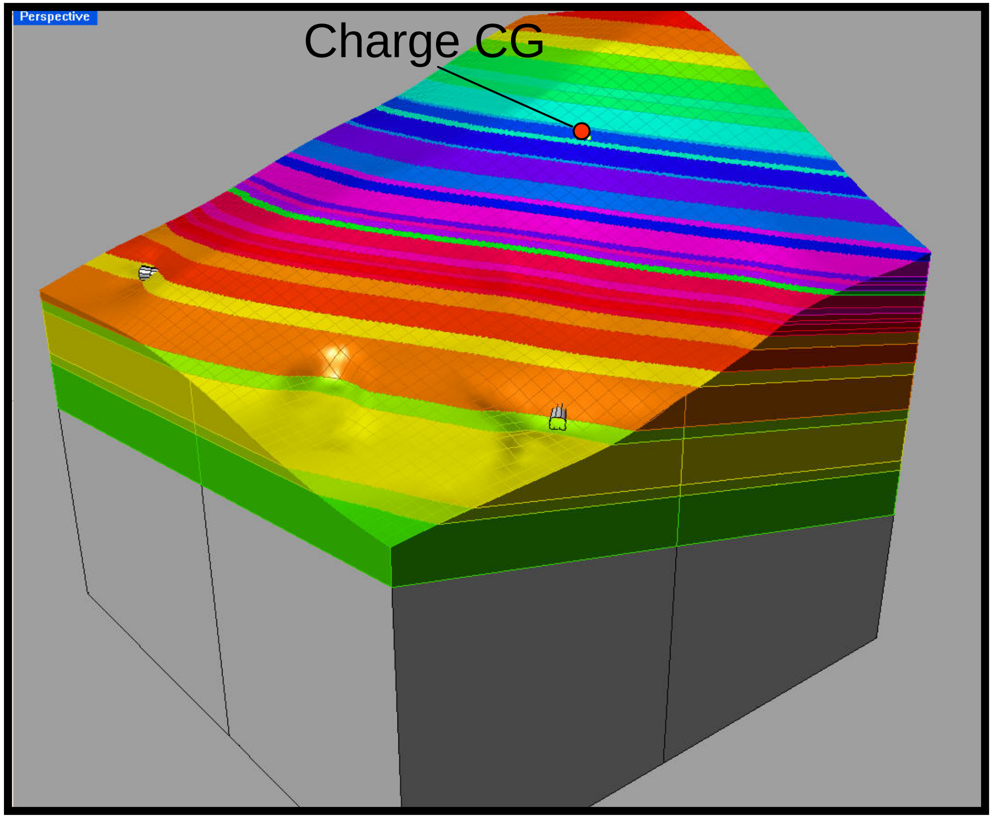
7. Clip/Trim dipping layer with surface topography.

3 example layers



GAMUT DS Red

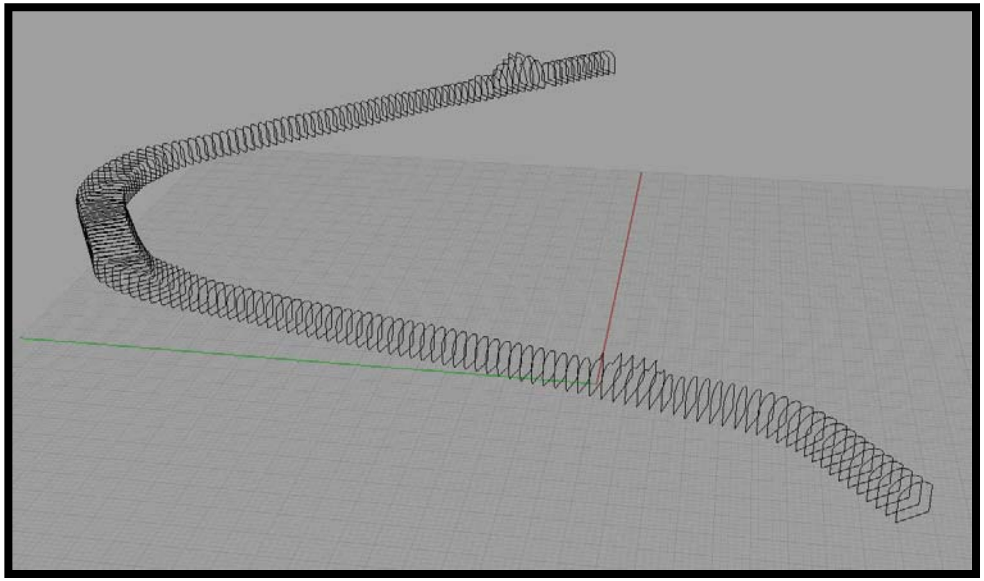
Final Stratigraphy



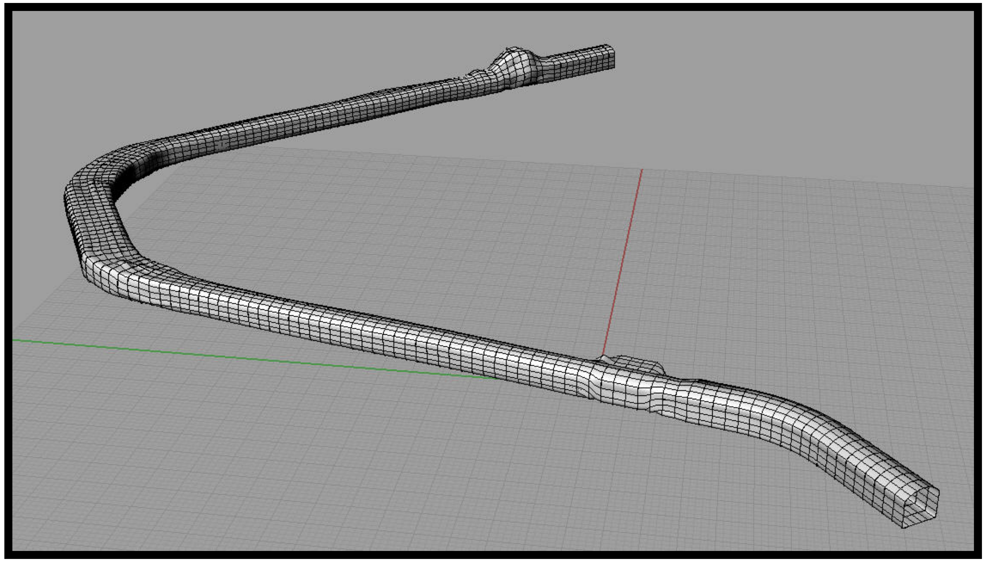
GAMUT DS Red

8. Add Tunnel

Rhino3d
Tunnel Hoops
Generated with
GEN.F



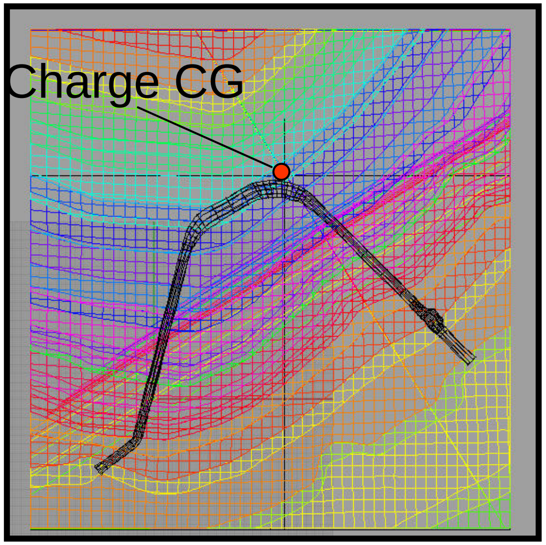
Rhino3d
Tunnel Surface –
produced by lofting
through hoops

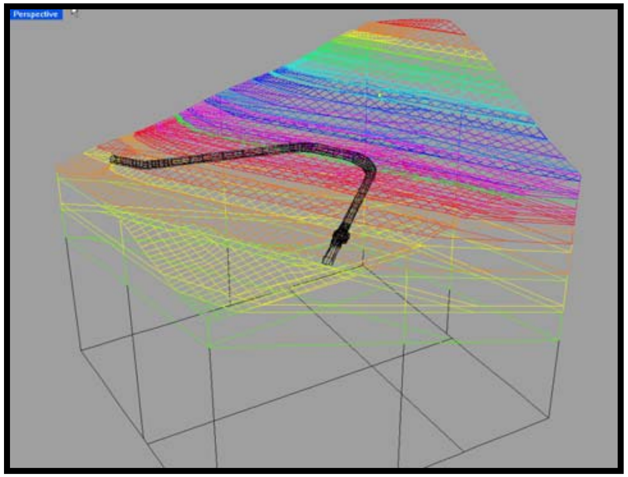


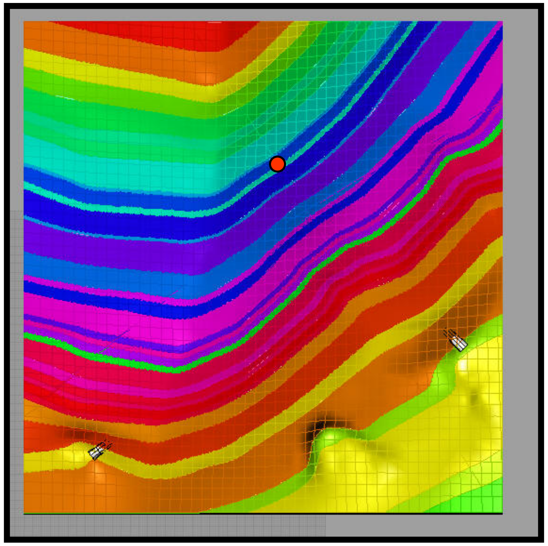
GAMUT DS Red

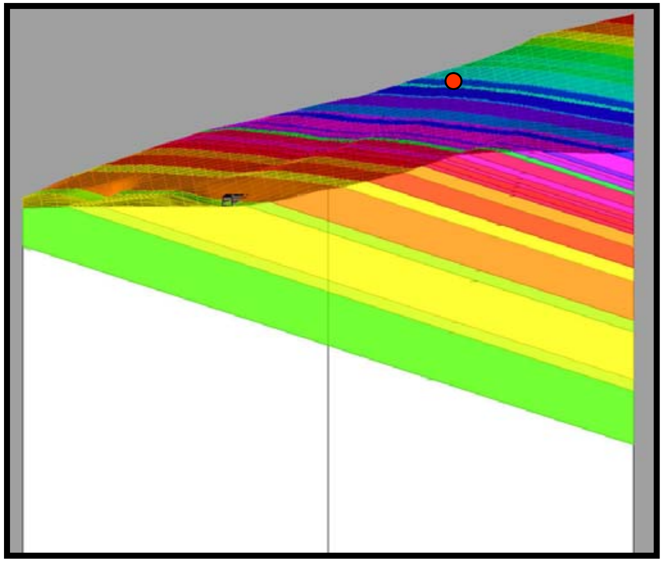
4. Final Model

Add tunnel to stratigraphy

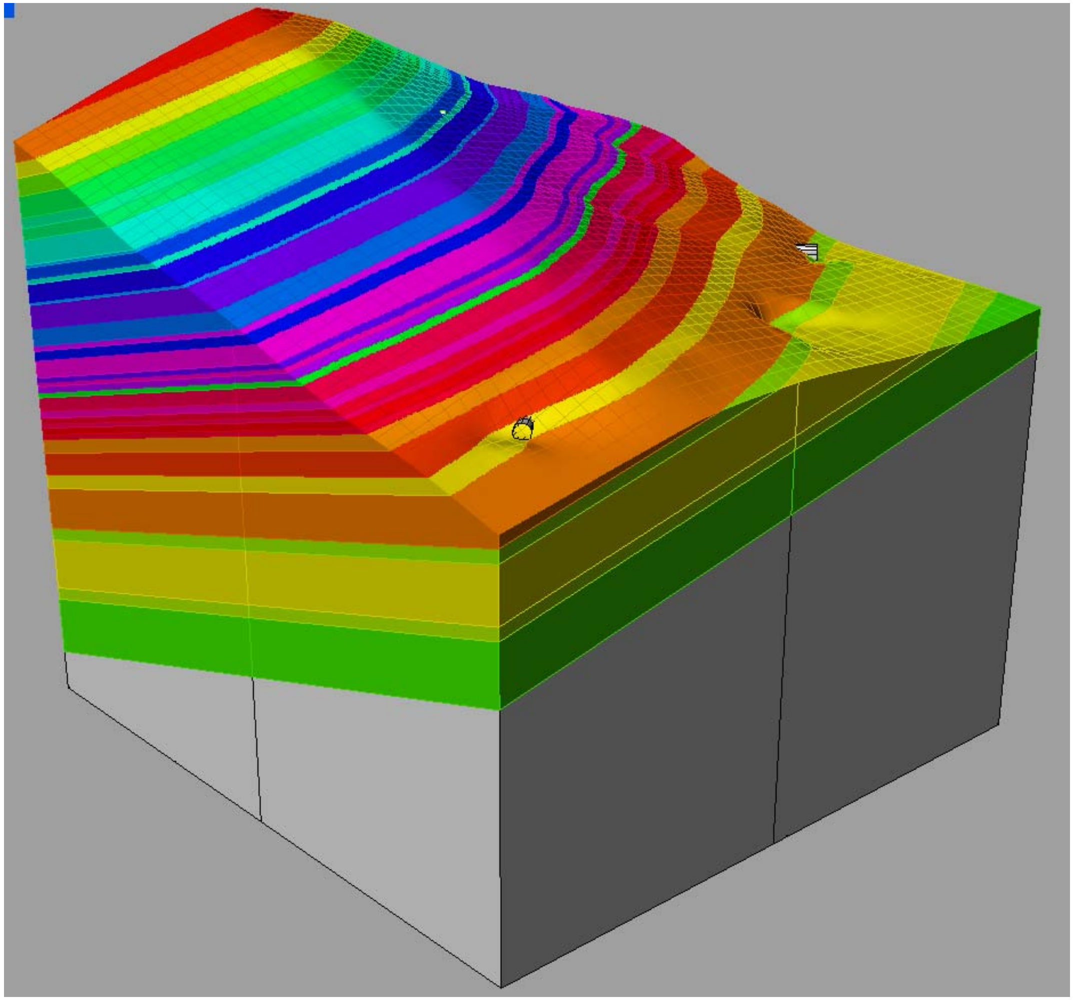








GAMUT DS Red– Final Model



"Red Model" :

1. Simple dipping geology

2. No faults or fractures

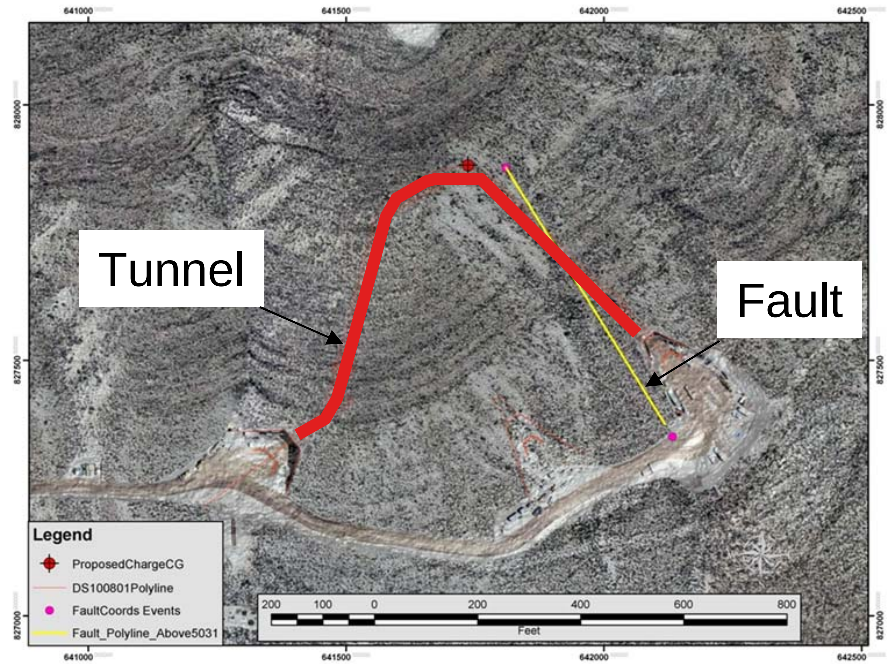
DS Blue Model

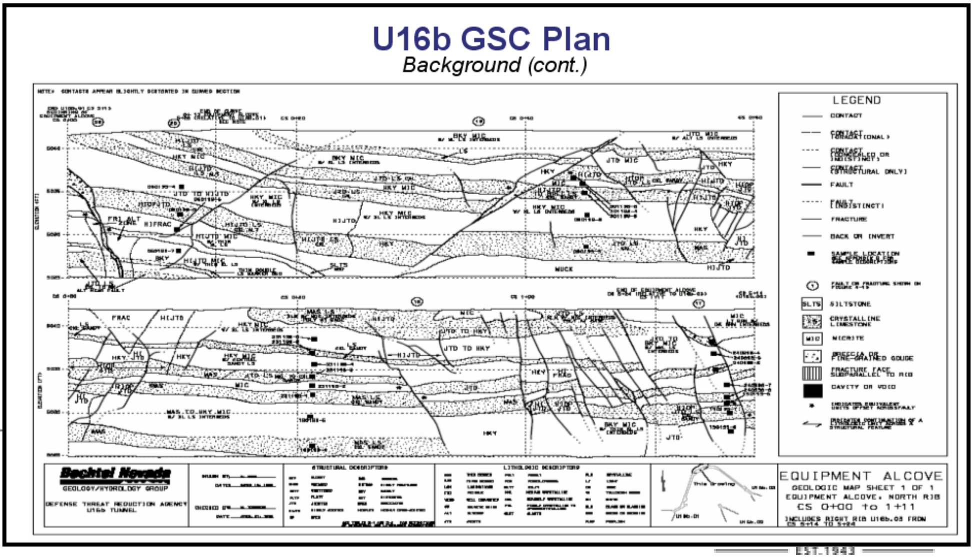
“Blue Model” Challenges:

1. Complex Geologic Layers

2. Include Faults
   (one major fault in DS Blue)

3. Include Fractures
   (incorporated into material models for DS Blue)





Definition of the Stratigraphy (Blue Model):

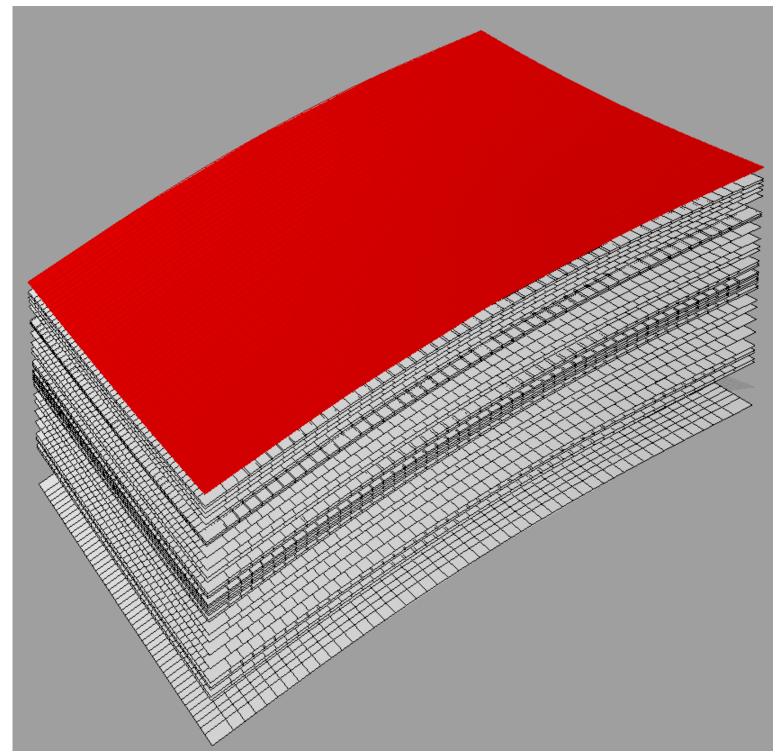
$$Z_i = a(X-X_o) + b(X-X_o)^2 + c(Y-Y_o) + d(Y-Y_o)^2 + e_i$$

where: Zi = the vertical coordinate of the ith bed top at horizontal position: X, Y
a, b, c, d = coefficients defining the bed shape, which are the same for all beds
ei = constant defining the vertical position of the ith bed
X0, Y0 = constant coordinate offsets

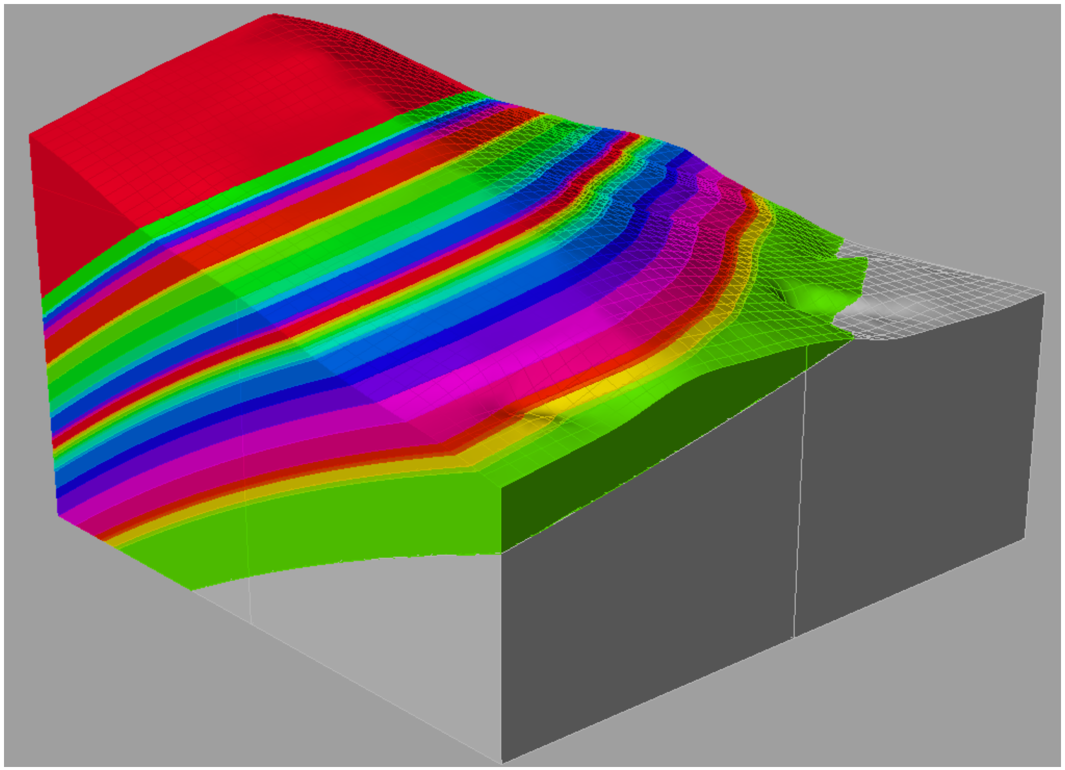
coefficients:

X_o = 91.44 m
Y_o = 121.92 m
a = 0.2607
b = 0.000288 m^{-1}
c = -0.5166
d = -0.000537 m^{-1}
e_i values are tabulated in the Blue Team Report.

32 layers



GAMUT DS Blue Final Model



"Blue Model" :

1. Complex stratigraphy

2. One major fault included

3. Fracture density included in material model (not explicit geometry)

GAMUT Summary – Future Directions

- GAMUT provides a way to link site geology/facility information with Hi-Fi calculators

- The GAMUT process has been tested end-to-end for a real situation – used by 4 modeling teams for DS Blue

- LANL is developing a true FEM-DEM modeling capability to facilitate realistic fault/fracture modeling.

- DS “Green” model is a work in progress.