YUCCA MOUNTAIN PROJECT

Studies

Preliminary Three-Dimensional Finite-Element Ground-Water Flow Model of the Site Saturated Zone, Yucca Mountain, Nevada

Presented to:
Nuclear Waste Technical Review Board

Presented by:
John B. Czarnecki and Claudia C. Faunt
United States Geological Survey
and
Carl W. Gable and George A. Zyvoloski
Los Alamos National Laboratory

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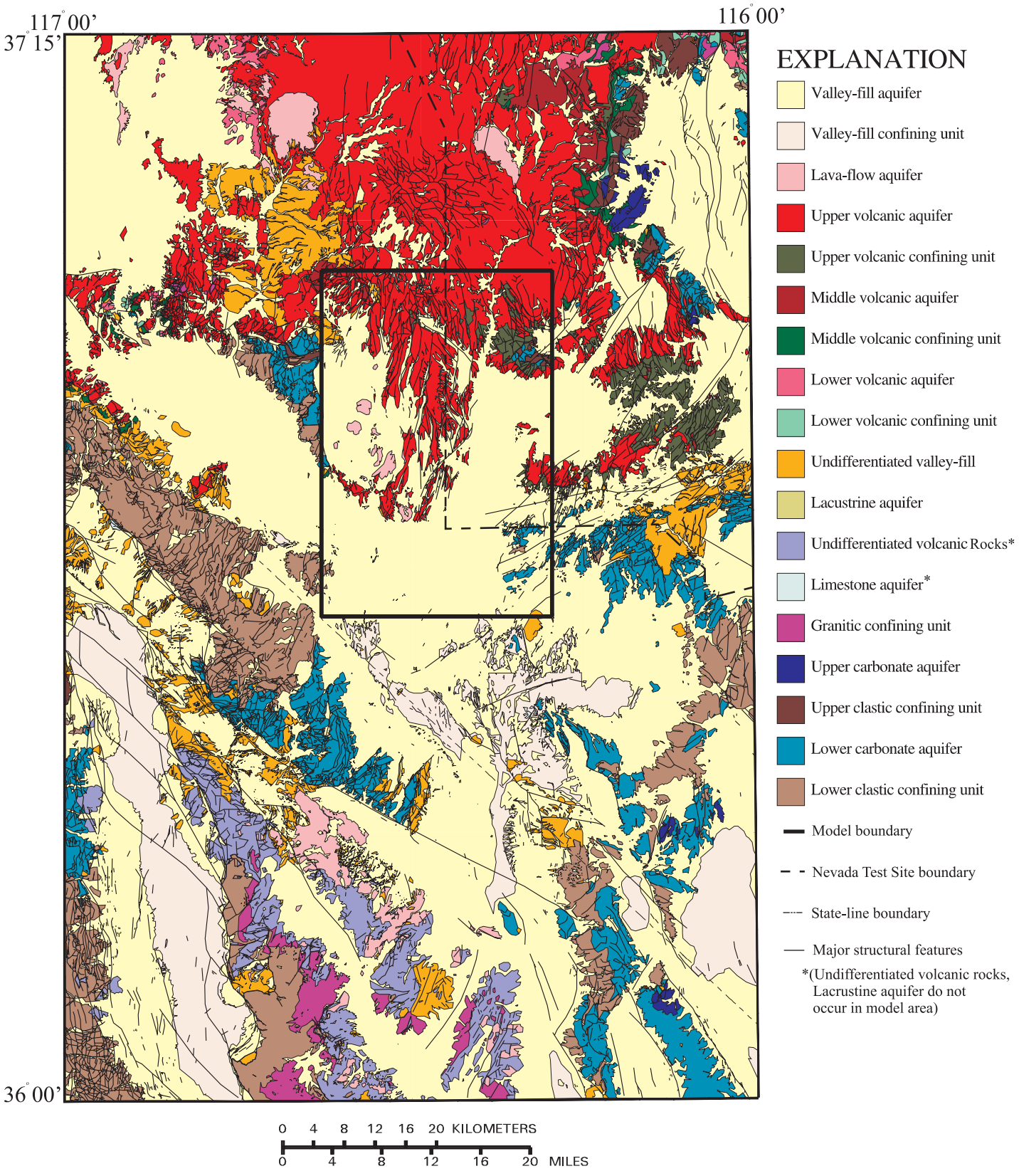
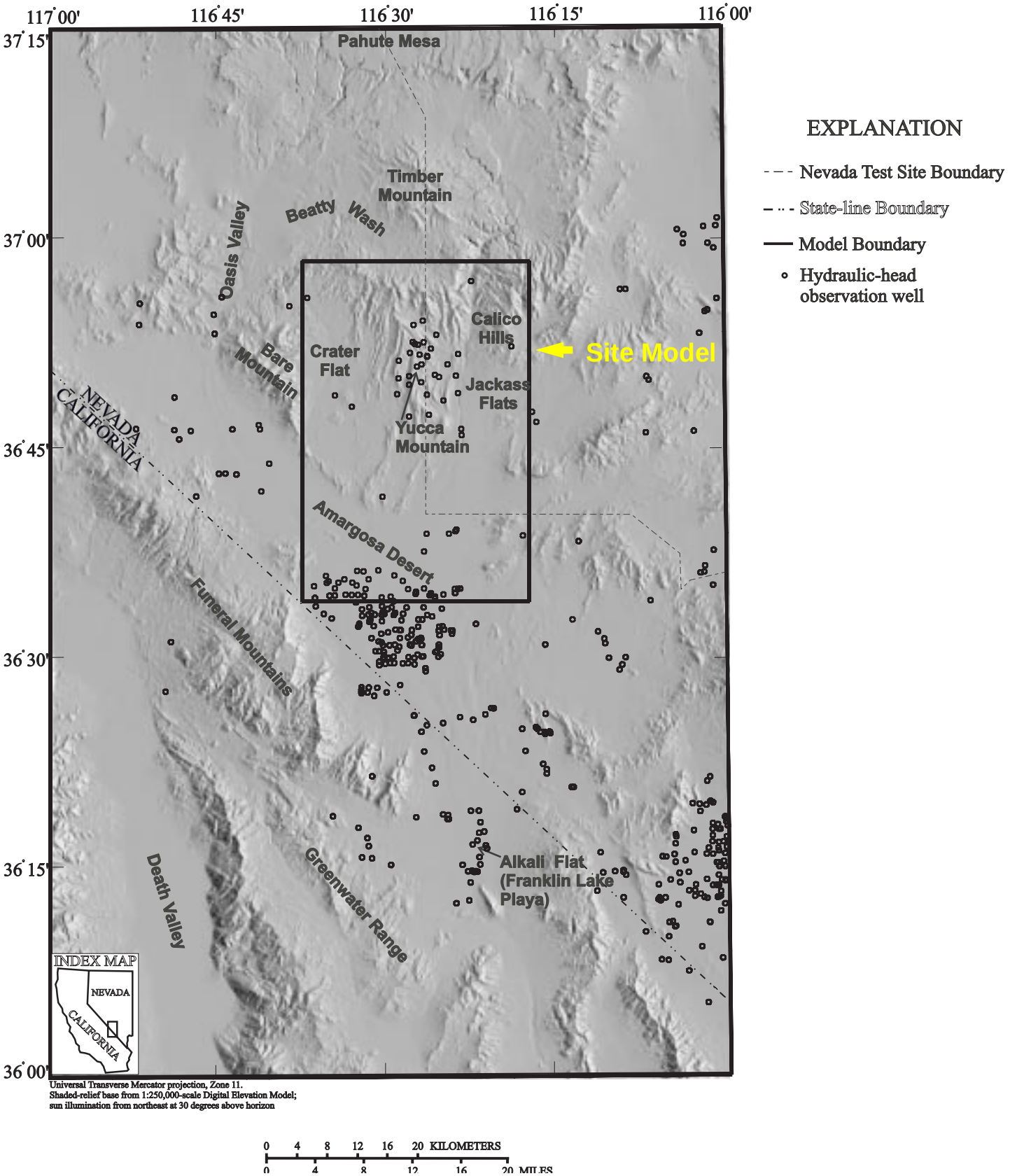
Model Domain

- Coincident with grid cells in the regional ground-water flow model such that the base of the site model was equivalent to the base of the regional model
- Sufficiently large to minimize the effects of flow and pressure boundary conditions on estimating permeability values at Yucca Mountain
- Sufficiently large to be able to assess ground-water flow at distances 30 km downgradient from the design repository area
- Small enough to minimize the number of computational nodes used in the model
- Thick enough to include part of the regional Paleozoic carbonate aquifer
- Large enough to include well control in the Amargosa Desert at the southern end of the model

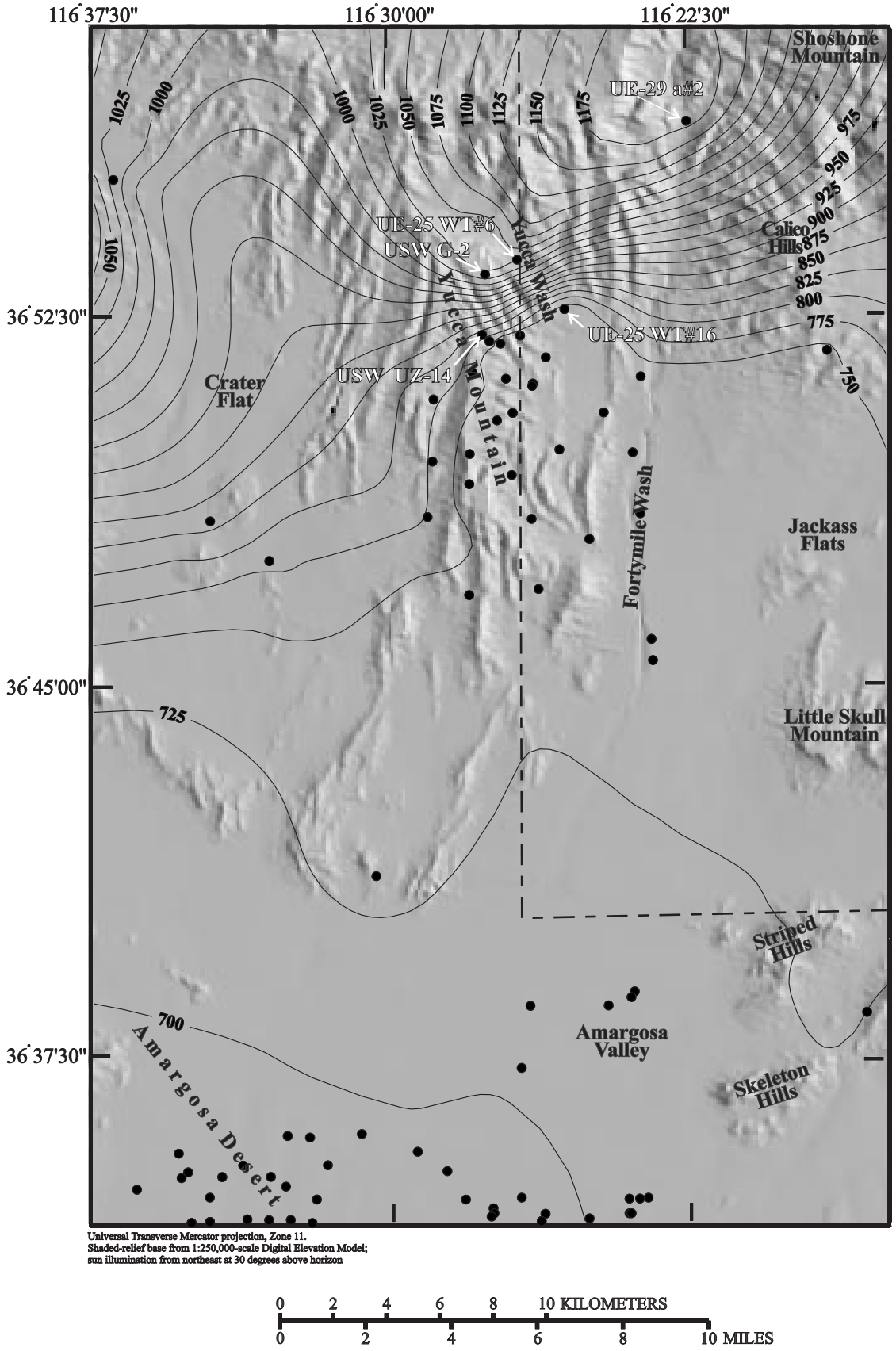
Hydrogeologic Units in the Vicinity of Site Model



Well Control in the Vicinity of Site Model



Potentiometric Surface Within Site Model Area



EXPLANATION

- Nevada Test Site Boundary
- —1000— Potentiometric contour - Shows altitude of potentiometric surface. Contour interval 25 meters. Datum is sea level.
- ● Observation Well

Universal Transverse Mercator projection, Zone 11.
Shaded-relief base from 1:250,000-scale Digital Elevation Model;
sun illumination from northeast at 30 degrees above horizon

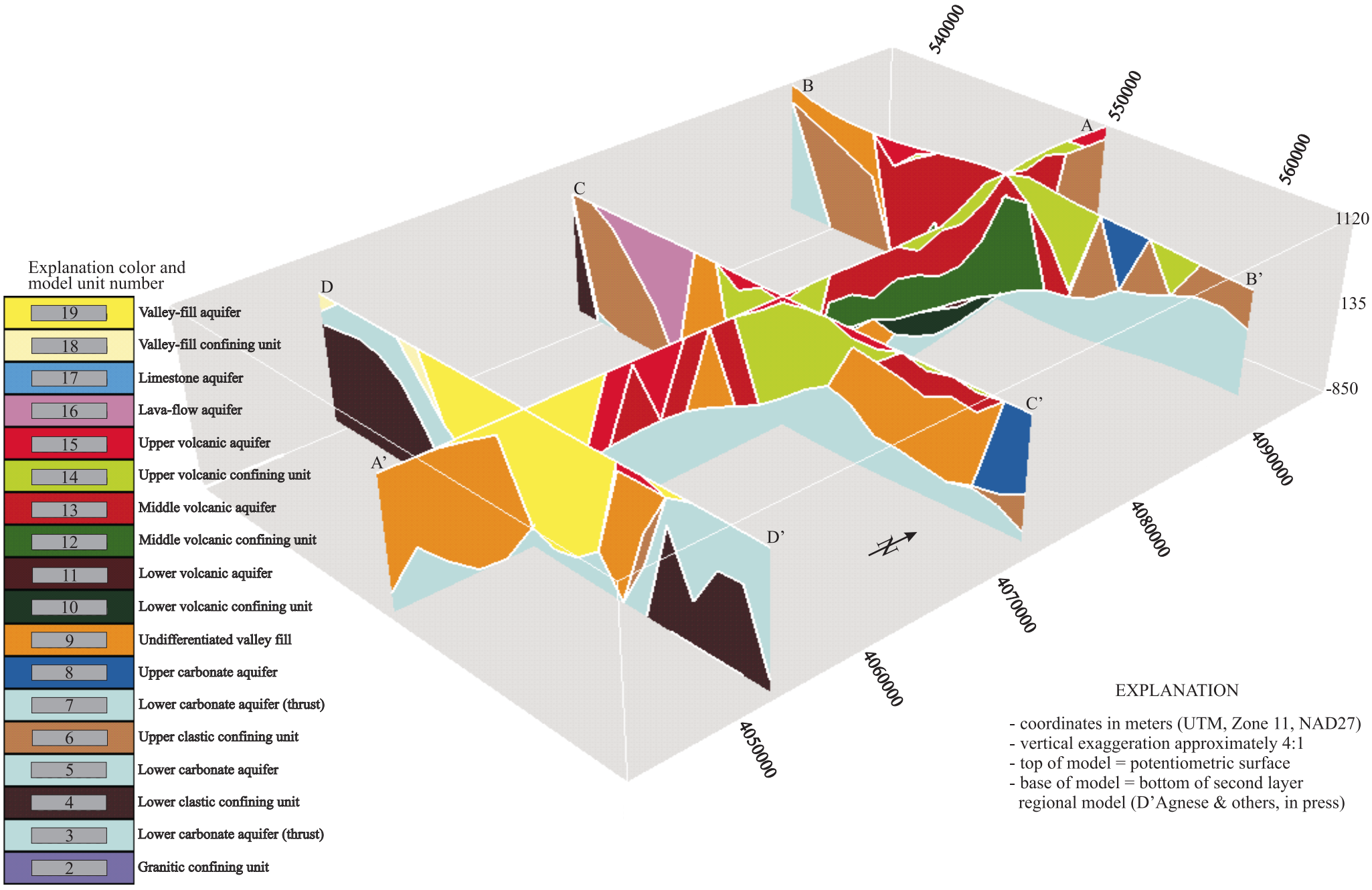
0 2 4 6 8 10 KILOMETERS
0 2 4 6 8 10 MILES

Large Hydraulic Gradient

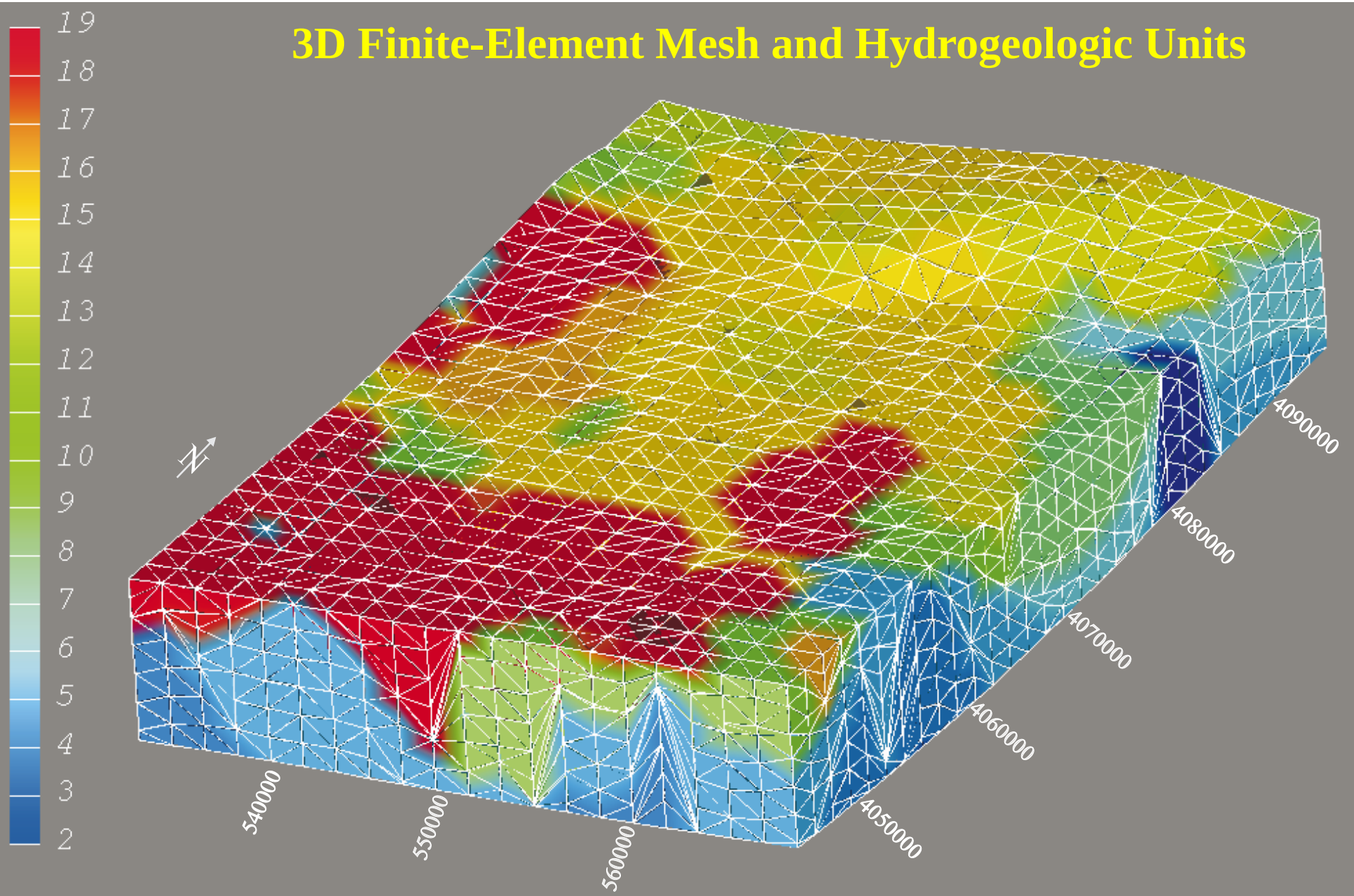
Possible explanations:

- faults that contain nontransmissive fault gouge or that juxtapose transmissive tuff against nontransmissive tuff
- a different type of lithology that is less subject to fracturing
- a change in the direction of the regional stress field and a resultant change in the intensity, interconnectedness, and orientation of open fractures on either side of the area with the large hydraulic gradient
- an apparent large gradient resulting from a disconnected, perched or semi-perched water body
- a highly permeable buried fault that drains water from tuff units into a deeper regional carbonate aquifer

Hydrogeologic Units Sampled at 1,500 m Spacing



3D Finite-Element Mesh and Hydrogeologic Units

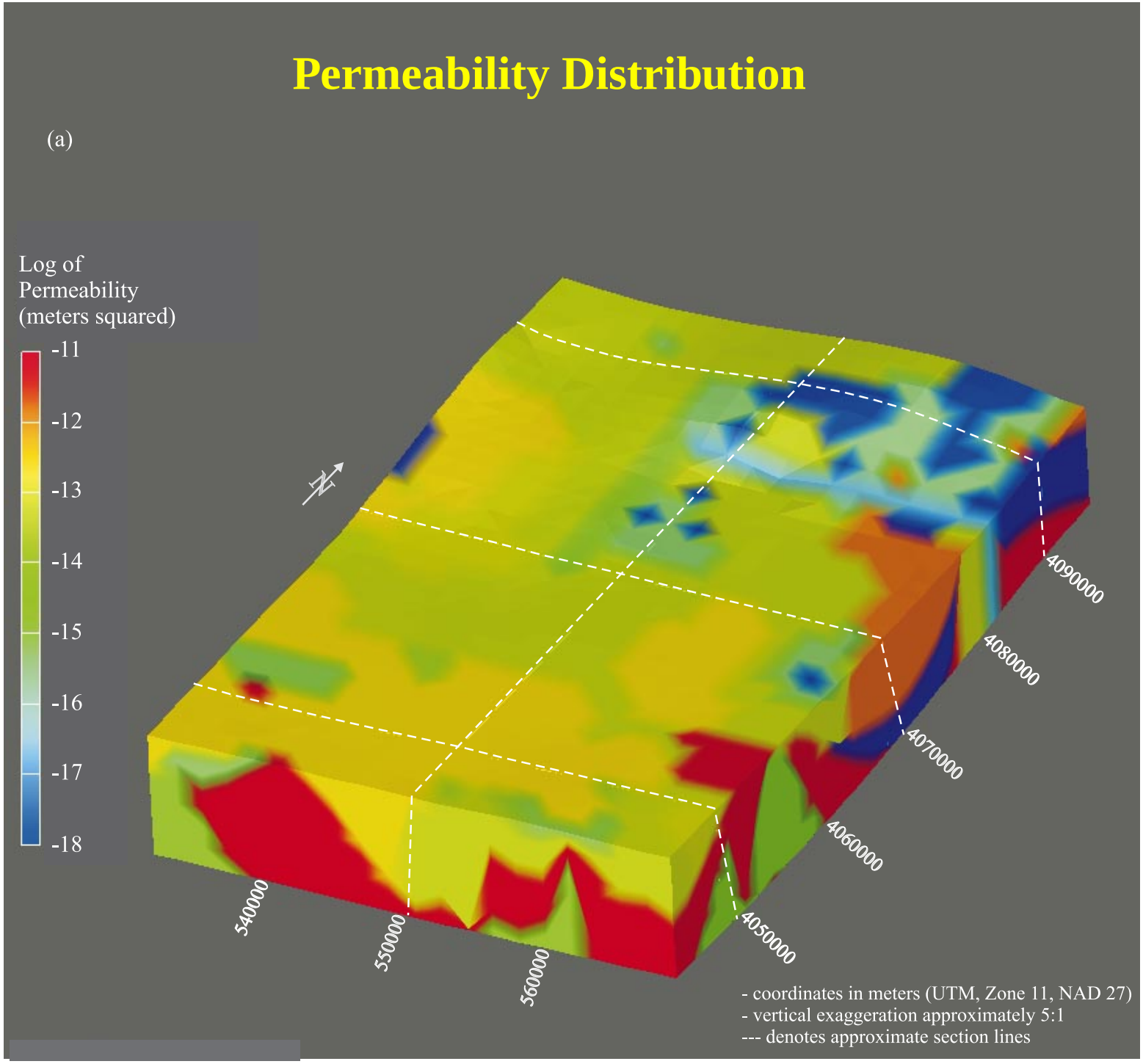


- coordinates in meters (UTM, zone 11, NAD 27)
- vertical exaggeration approximately 5:1

Hydrogeologic-Unit Permeability Values (meters^2)

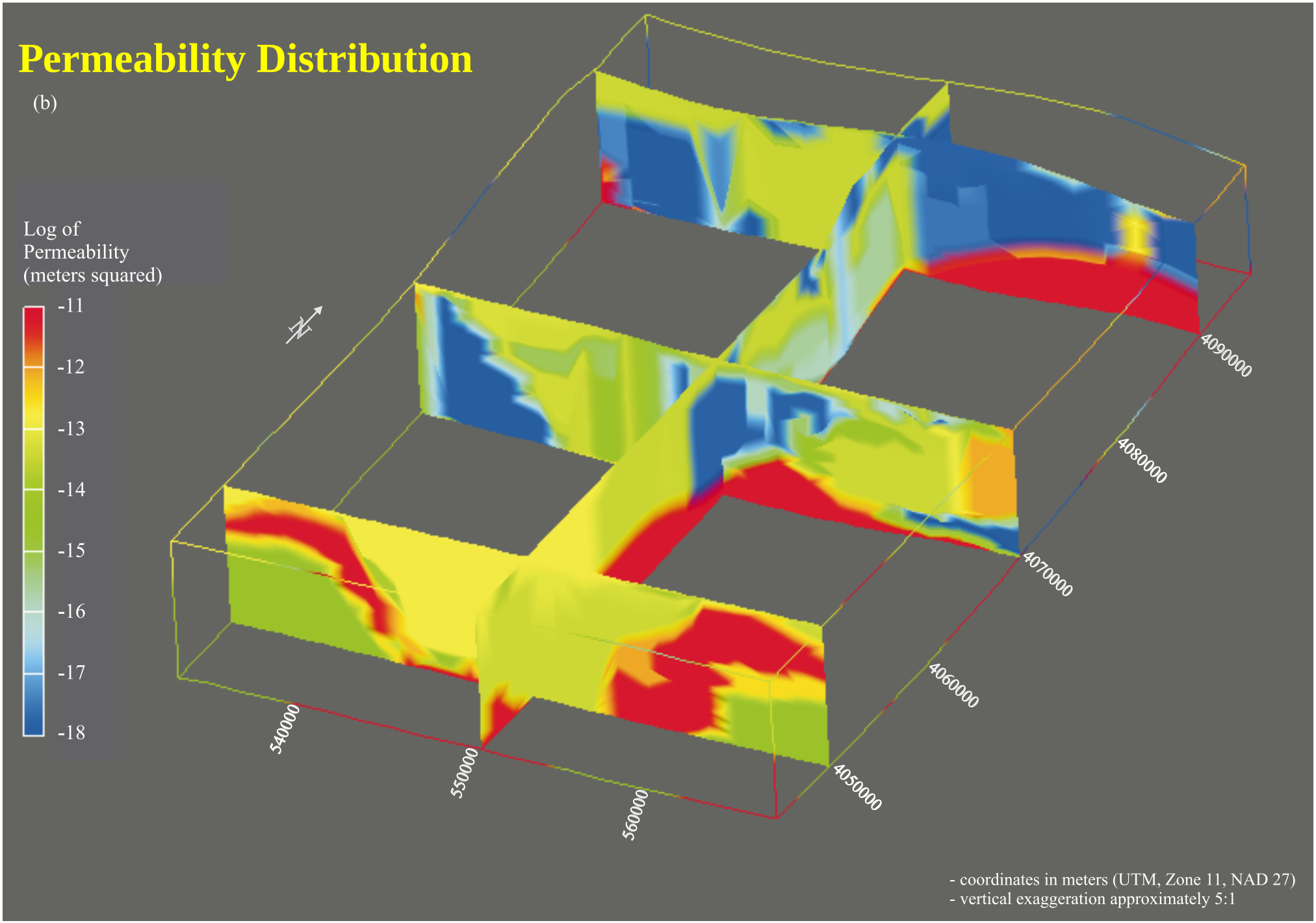
Hydrogeologic Unit	Permeability		Permeability Specified in Model
	High	Low	
Valley-Fill Aquifer	6.0×10^{-12}	9.2×10^{-14}	8.8×10^{-14}
Valley-Fill Confining Unit	3.9×10^{-12}	1.2×10^{-17}	3.0×10^{-16}
Lava-Flow Aquifer	1.2×10^{-13}	1.1×10^{-18}	4.5×10^{-14}
Upper Volcanic Aquifer	1.8×10^{-13}	0.0×10^{-00}	1.6×10^{-14}
Upper Volcanic Confining Unit	3.9×10^{-14}	3.0×10^{-18}	1.0×10^{-18}
Middle Volcanic Aquifer	4.5×10^{-14}	0.0×10^{-00}	1.6×10^{-14}
Middle Volcanic Confining Unit	2.6×10^{-16}	0.0×10^{-00}	1.9×10^{-16}
Lower Volcanic Aquifer	no data	no data	5.0×10^{-13}
Lower Volcanic Confining Unit	4.0×10^{-16}	8.3×10^{-18}	1.0×10^{-16}
Lower Valley-Fill Confining Unit	3.5×10^{-13}	3.5×10^{-20}	2.9×10^{-14}
Tertiary Limestone Aquifer	no data	no data	1.0×10^{-14}
Granitic Confining Unit	4.6×10^{-13}	2.3×10^{-20}	3.5×10^{-14}
Upper Carbonate Aquifer	4.6×10^{-12}	5.8×10^{-16}	6.7×10^{-13}
Upper Clastic Confining Unit	no data	no data	5.5×10^{-19}
Lower Carbonate Aquifer	5.4×10^{-15}	1.1×10^{-18}	4.4×10^{-12}
Lower Clastic Confining Unit	5.5×10^{-19}	3.9×10^{-20}	2.0×10^{-15}

Permeability Distribution



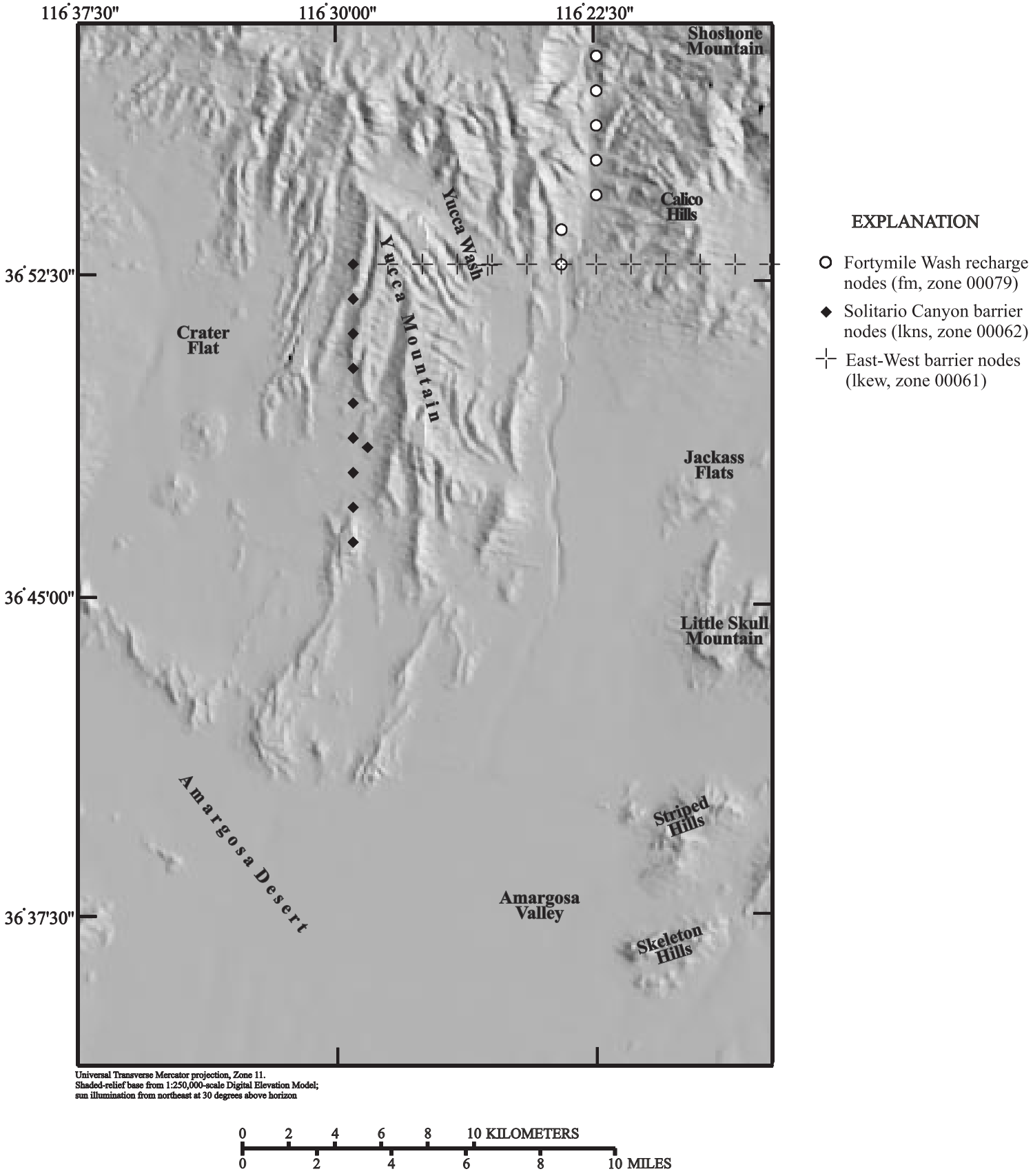
Permeability Distribution

(b)



- coordinates in meters (UTM, Zone 11, NAD 27)
- vertical exaggeration approximately 5:1

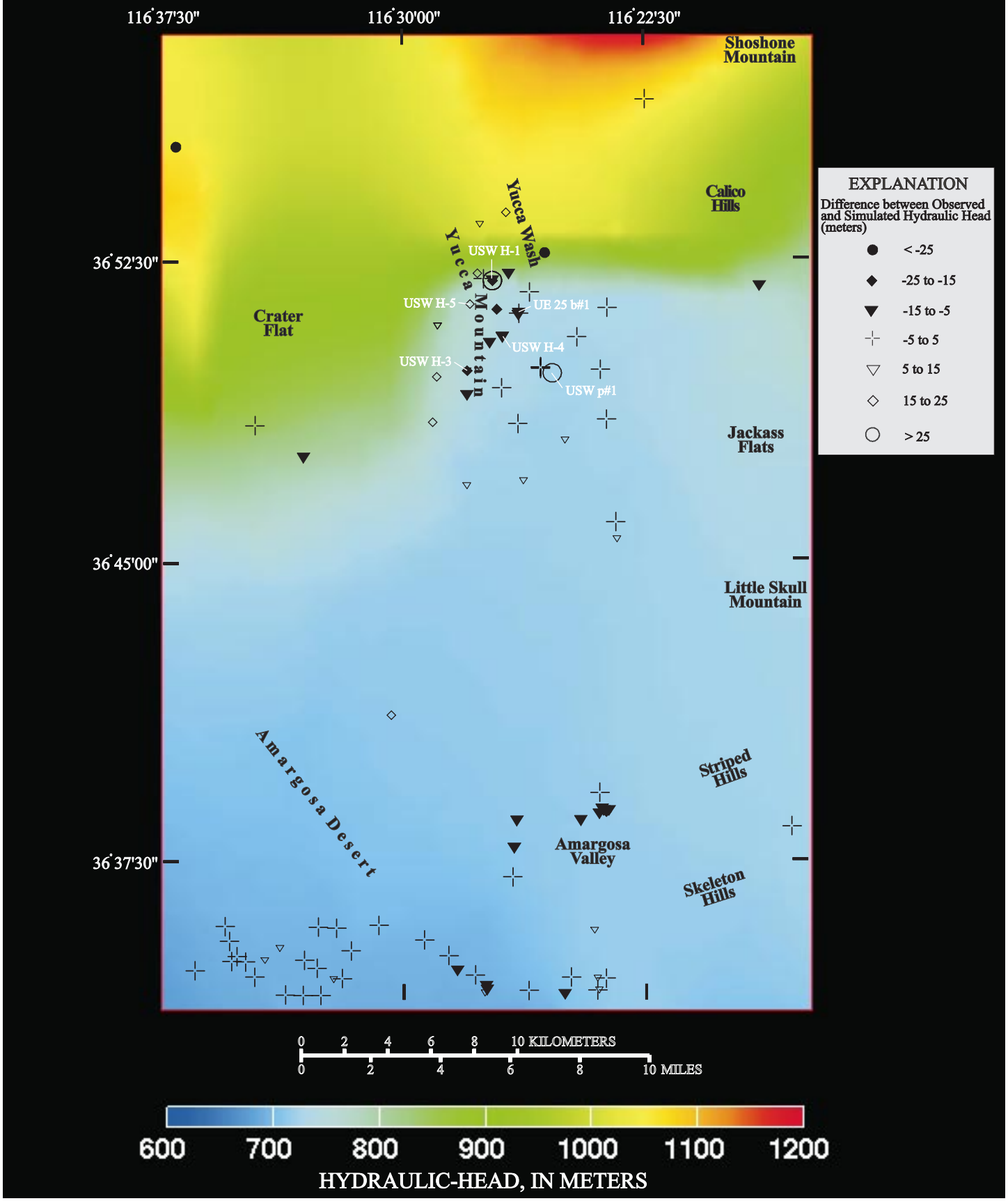
Additional Zones Used in the Model



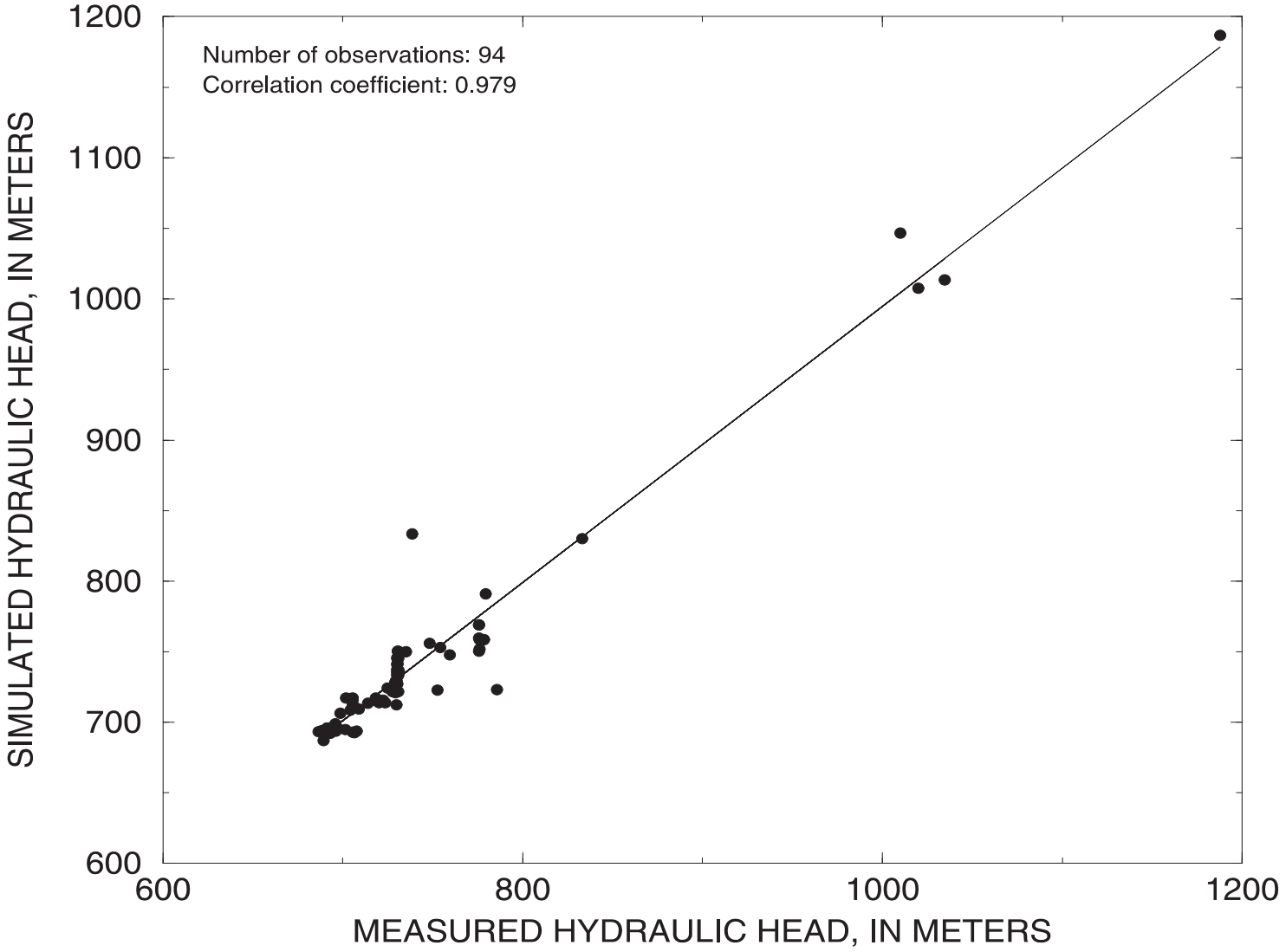
Ranking of Parameters by Scaled Sensitivities

Parameter Name	Parameter Description	Scaled Sensitivity
fm	Fortymile Wash recharge	139.1
lkns	Solitario Canyon Fault Zone	66.1
mva	Middle Volcanic Aquifer	28.8
qal	Valley Fill Aquifer	22.6
b	Lava-Flow Aquifer	21.5
uca	Upper Carbonate Aquifer	18.9
lca	Lower Carbonate Aquifer	18.0
mvcu	Middle Volcanic Confining Unit	15.2
ecu	Upper Clastic Confining Unit	13.9
lvcu	Lower Volcanic Confining Unit	12.0
gran	Granitic Confining Unit	10.8
lkew	East-West Barrier to Flow (LHG)	8.7
lcu	Lower Valley-Fill Confining Unit	3.8
uva	Upper Volcanic Aquifer	1.5
uvcu	Upper Volcanic Confining Unit	0.7
qcu	Lower Clastic Confining Unit	0.4
tpla	Valley-Fill Confining Unit	0.3
lva	Lower Volcanic Aquifer	0.2
tlim	Tertiary Limestone Aquifer	0.2

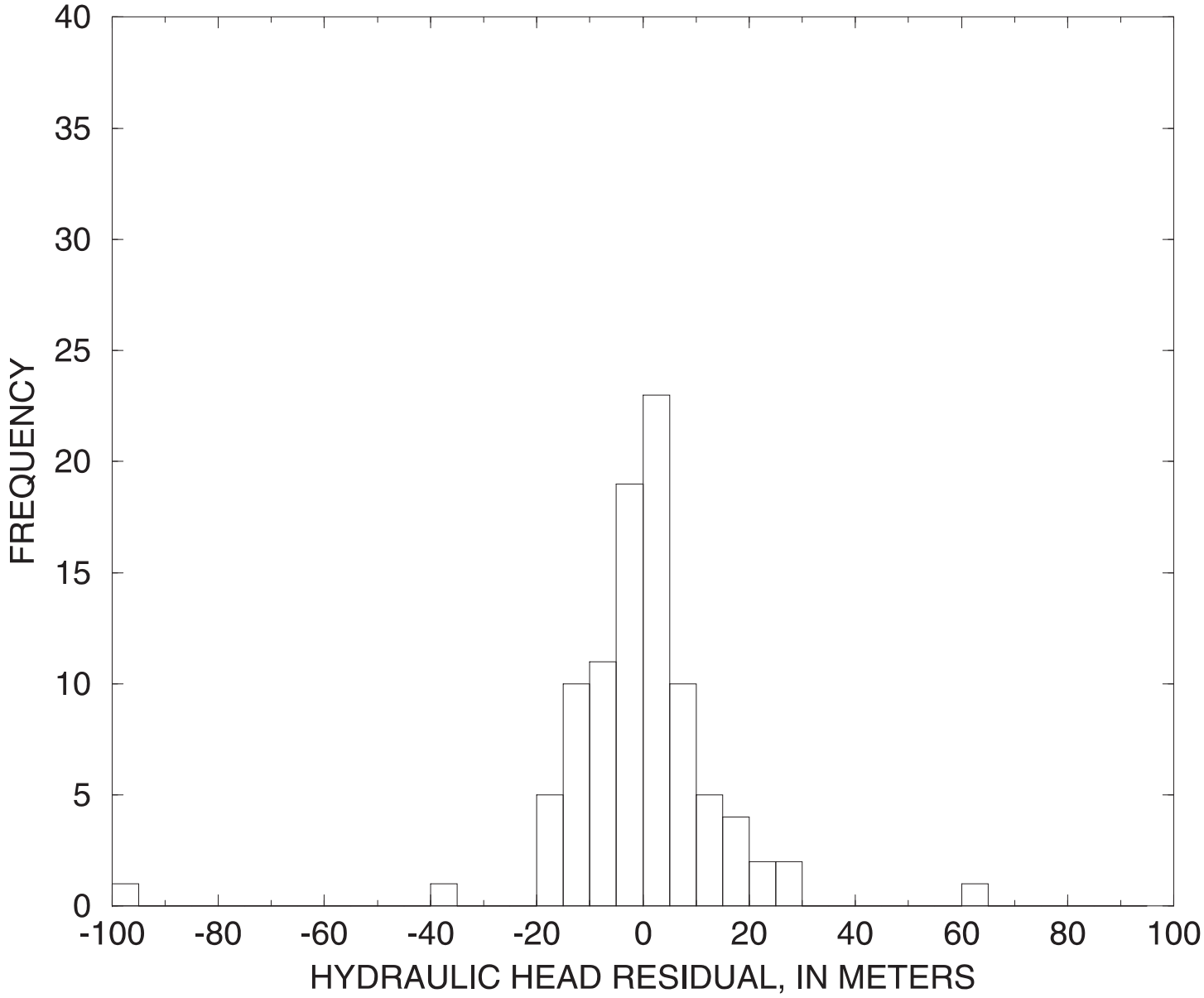
Simulated Hydraulic Head and Residuals



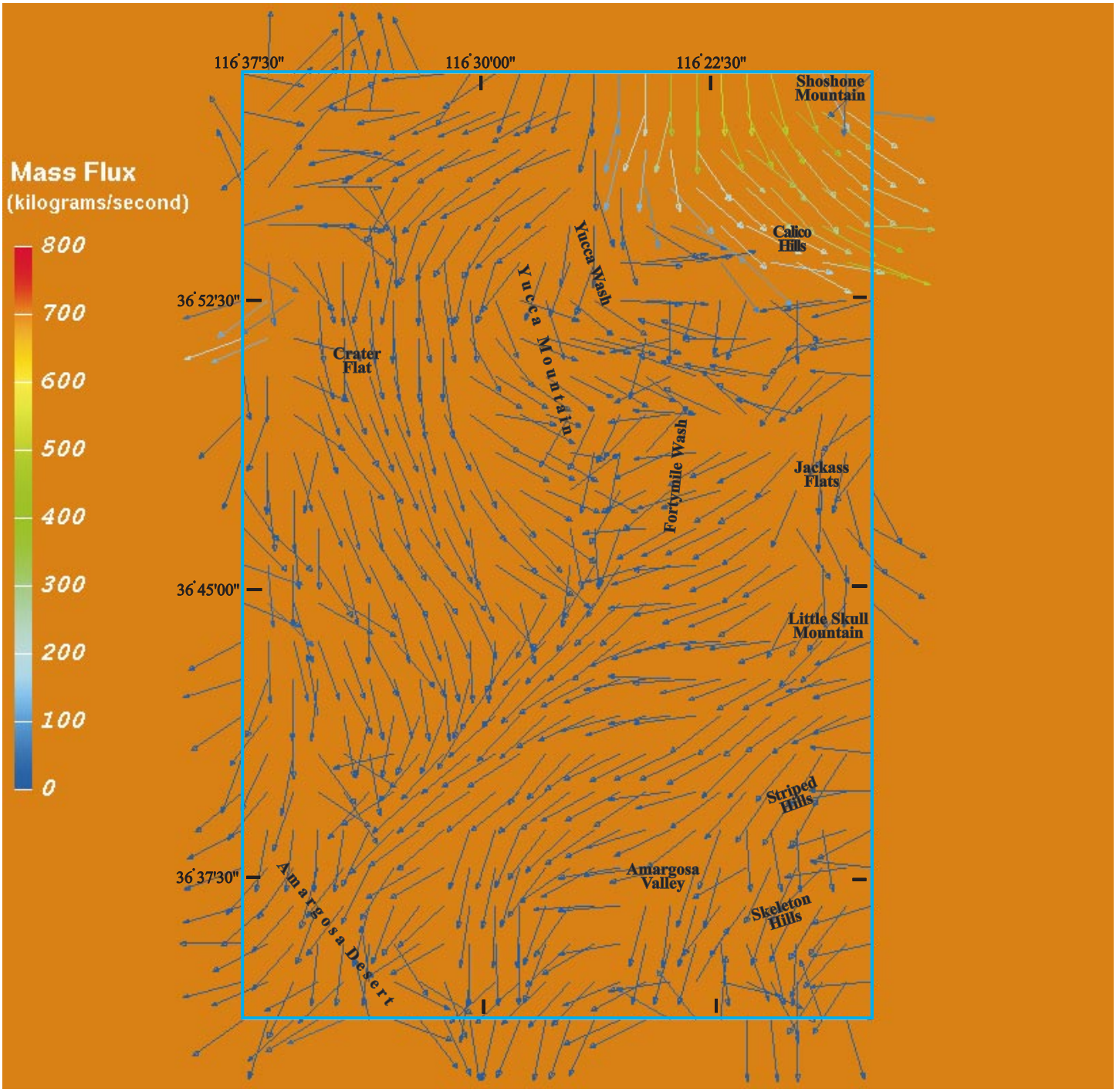
Simulated vs. Observed Hydraulic Head



Histogram of Residuals for Hydraulic Head



Vectors of Simulated Ground-Water Flow



Limitations of the Model

- Model discretization is coarse, and as a result causes incomplete definition of hydrogeologic units
- Permeability is known to vary spatially within individual hydrogeologic units
- An average temperature for the entire saturated zone contained within the site model has not been calculated
- Hydraulic-head boundary conditions are based on a process of extrapolation and interpolation of extant data
- The steady-state assumption may be invalid in areas in which ground-water withdrawals are occurring
- No flow is specified along the base of the model
- The representation of the large hydraulic gradient remains inconclusive