Examples of Modeling: Groundwater Impact Evaluation Re-initiation of copper mining in the historic Robinson District near Ely Nevada

PTI Environmental Services. 1994. Hydrogeochemistry of the Robinson Mining District, White Pine County, Nevada. Prepared for Magma Nevada Mining Company, Tucson AZ.

Wells and springs in the Robinson District

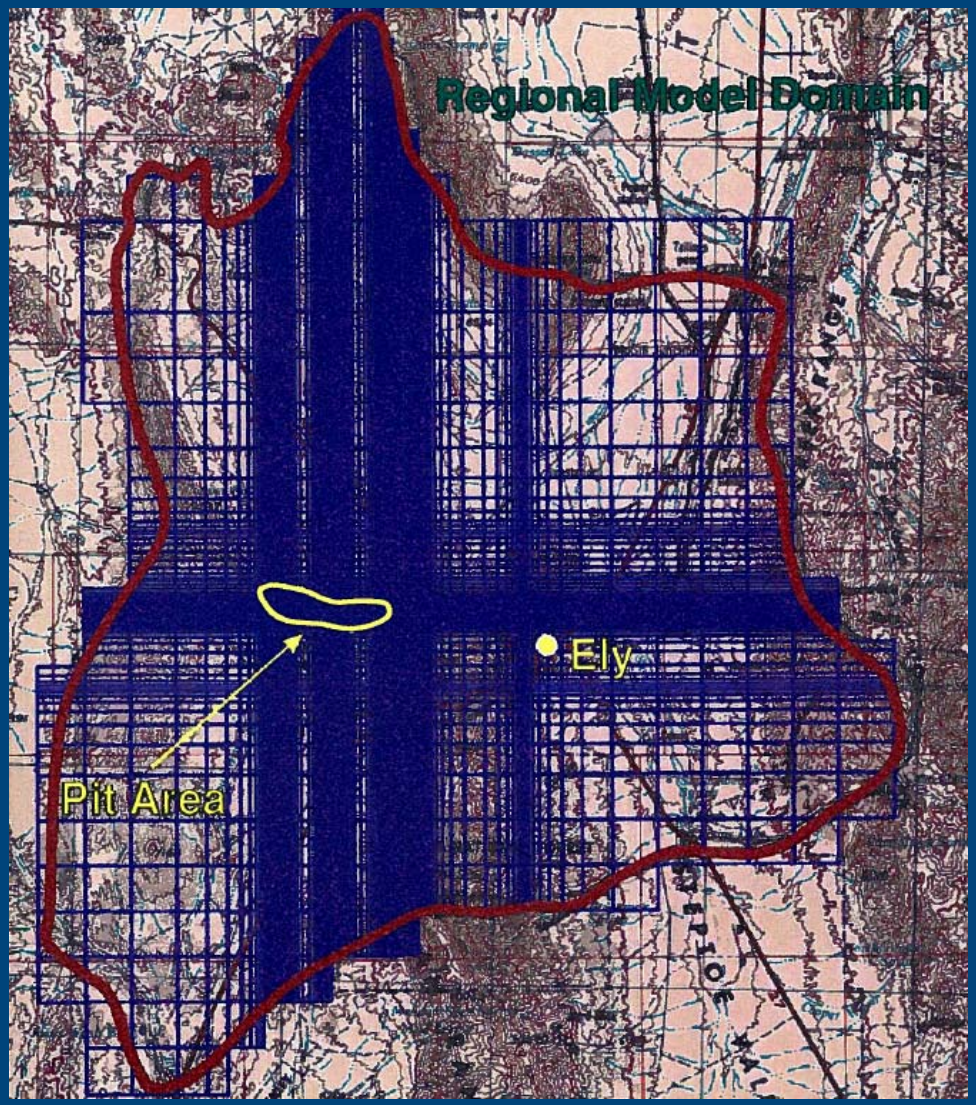
Model objectives

- Predict impact of mine dewatering and operations on water quantity and quality impacts to springs and creeks near mining district, particularly Murry Springs, water supply for Ely, Nevada
- Predict infilling rates for pit lakes for pit lake water quality predictions
- Evaluate tailings disposal scenarios in Liberty Pit

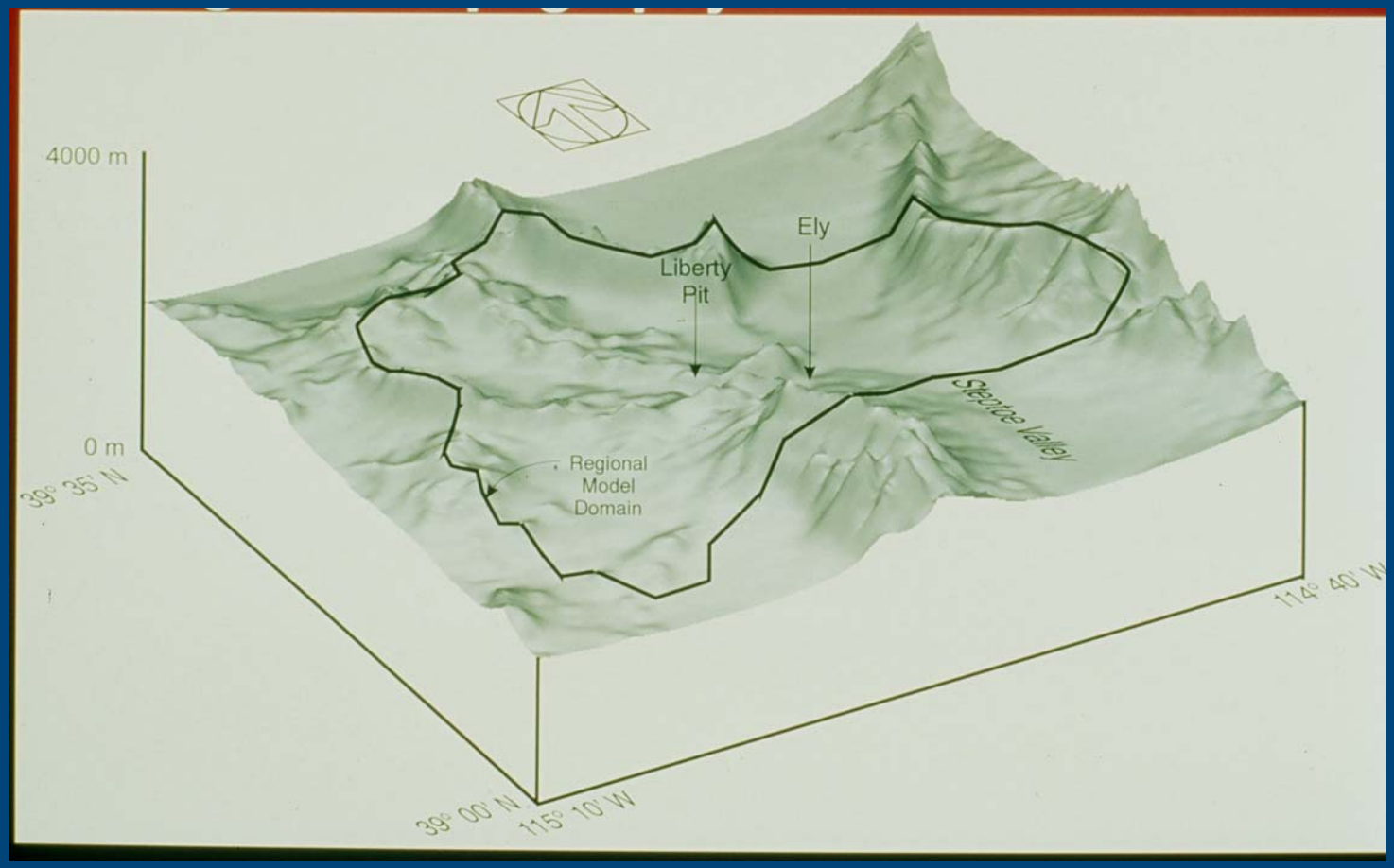
Groundwater modeling steps

- Compile regional and local hydrogeologic data
- Develop conceptual flow model
- Configure model grid
- Estimate input parameters from existing data
- Determine reasonable boundary conditions
- Estimate areal recharge
- Develop and calibrate steady-state model
- Calibrate transient model
- Make predictions: impacts from dewatering and potential for contaminant transport to springs, pit lake infilling, tailings disposal scenarios

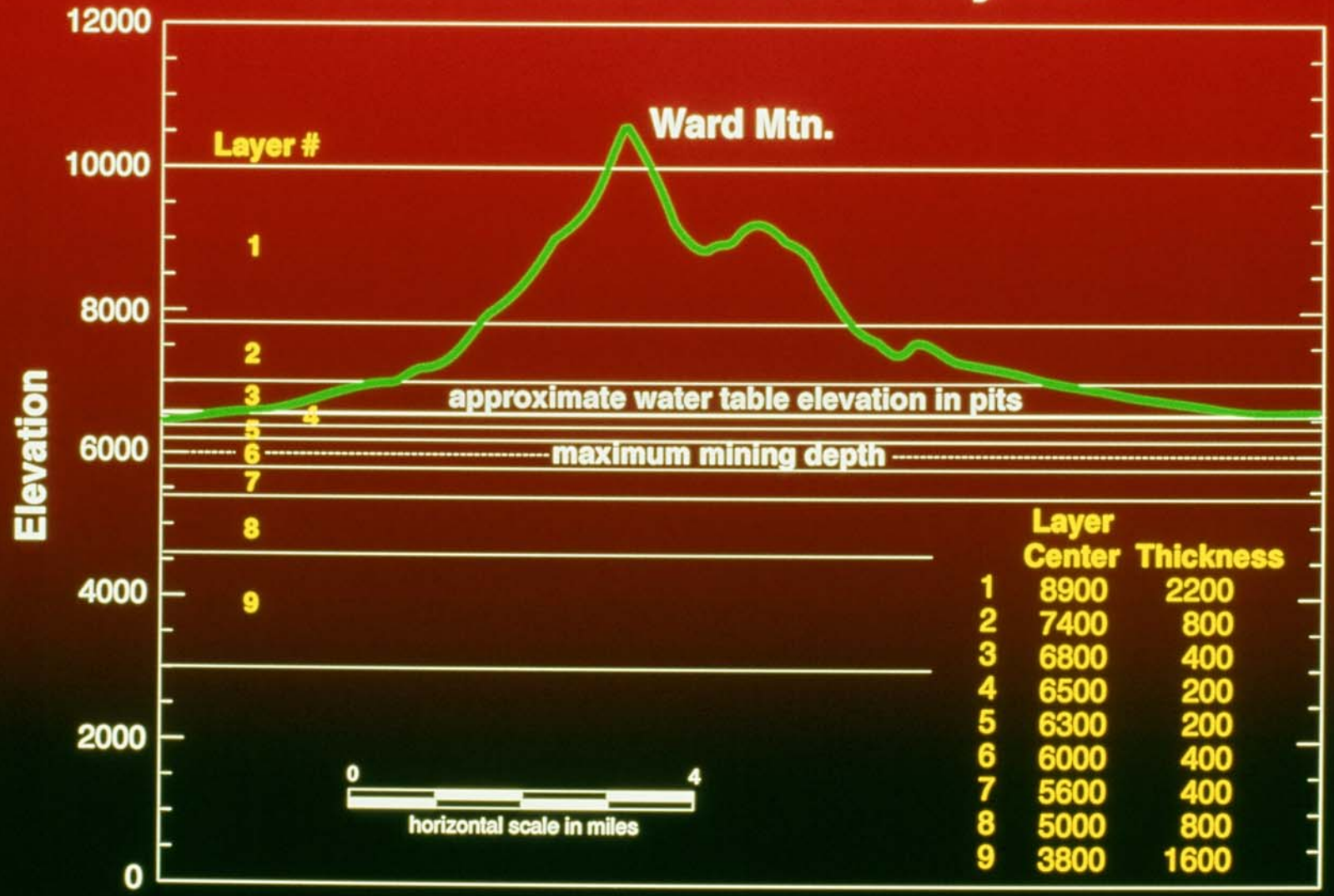
Model domain and MODFLOW grid



Groundwater model: Regional topography and model domain

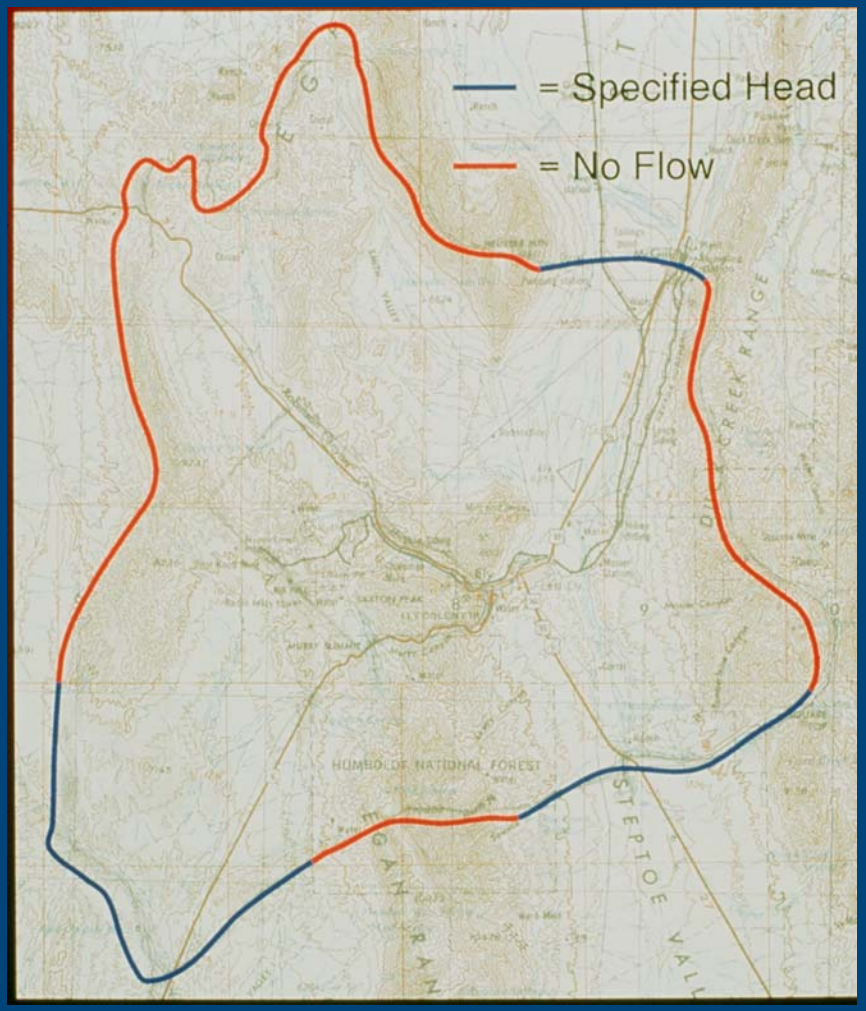


Groundwater Model Layers

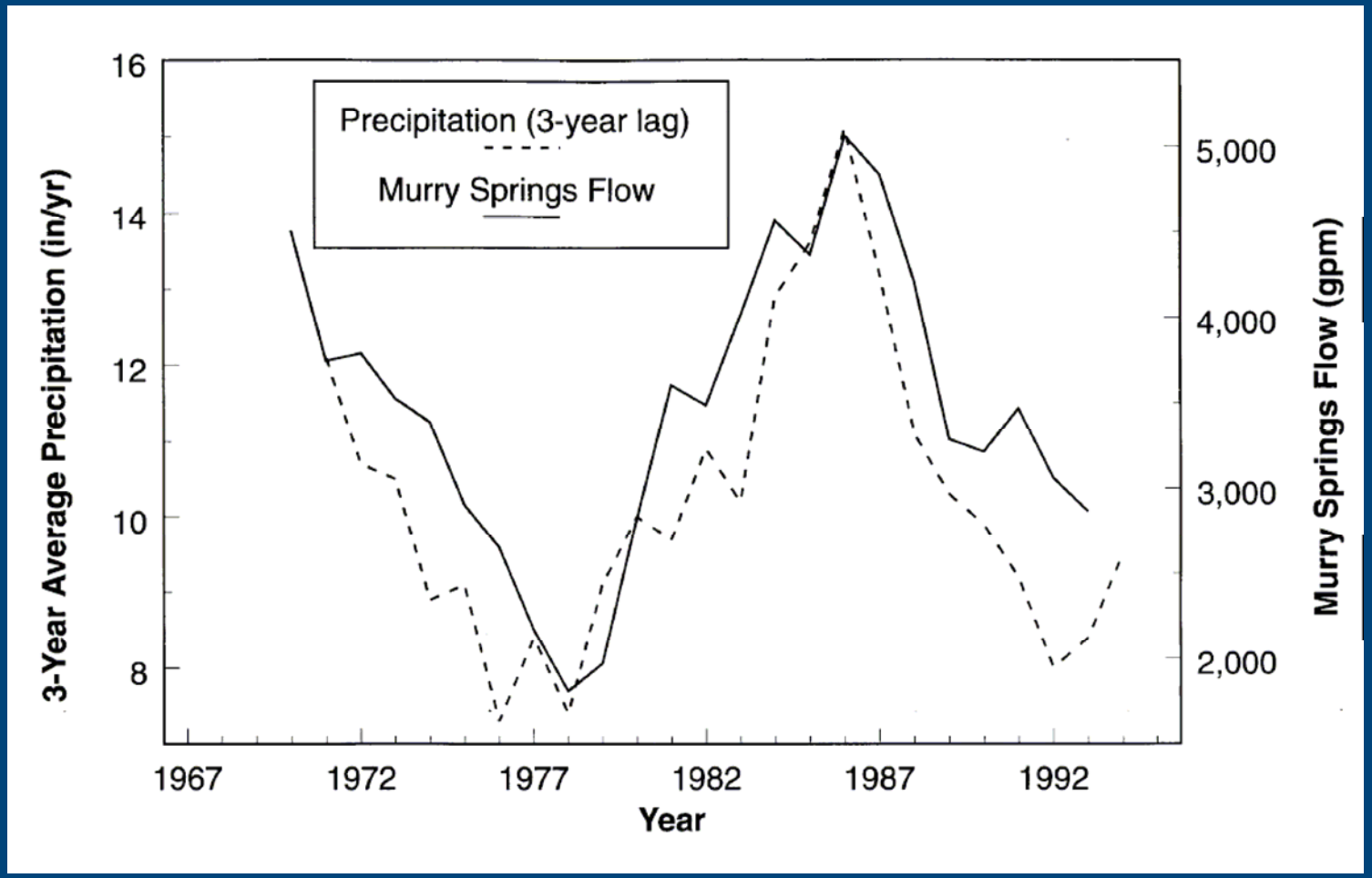


Layer	Center	Thickness
1	8900	2200
2	7400	800
3	6800	400
4	6500	200
5	6300	200
6	6000	400
7	5600	400
8	5000	800
9	3800	1600

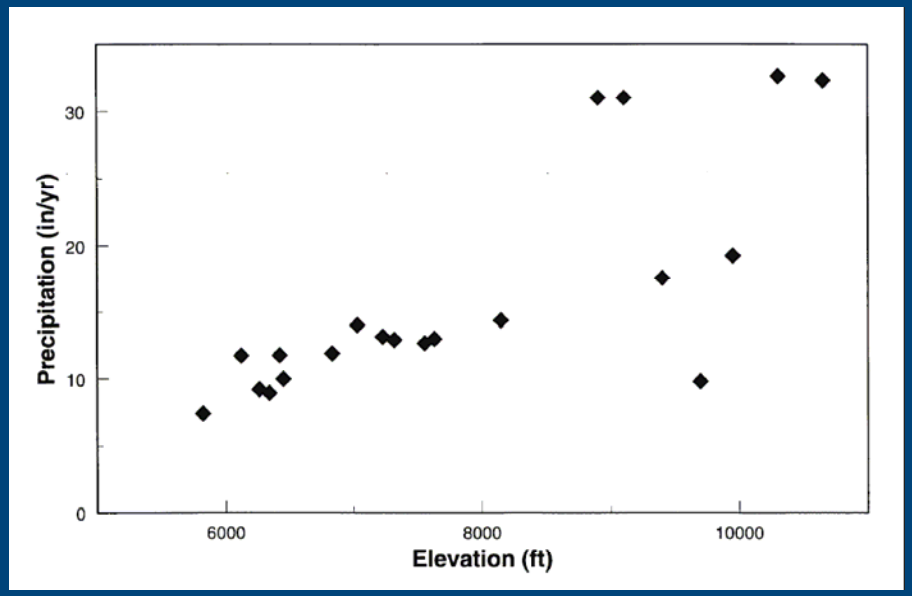
Regional model layers – Boundary conditions

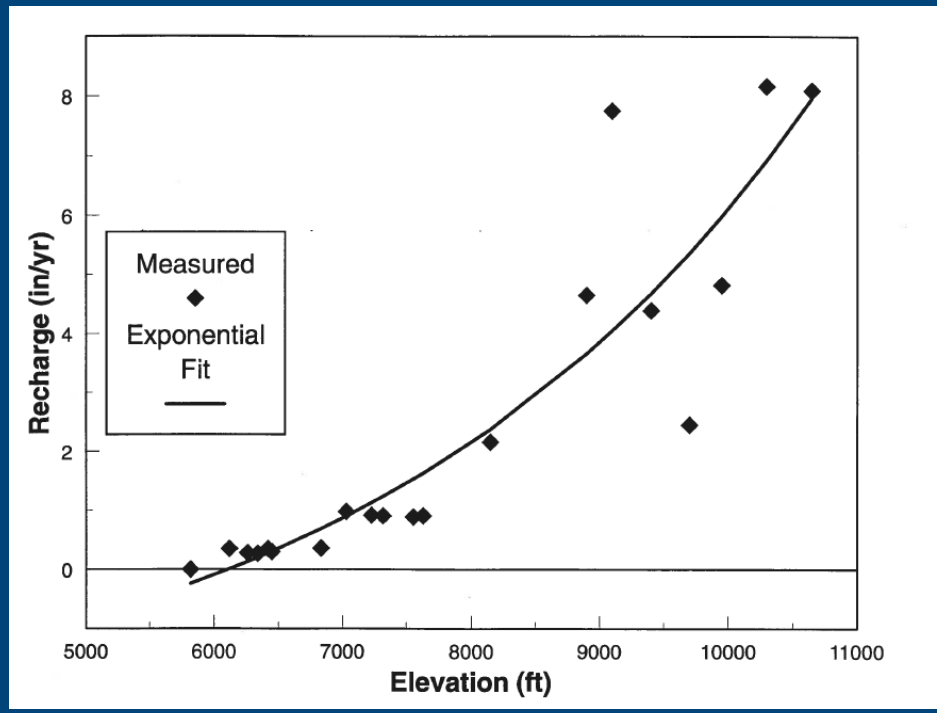


Example of data evaluated: Discharge at Murry Springs v. average precipitation

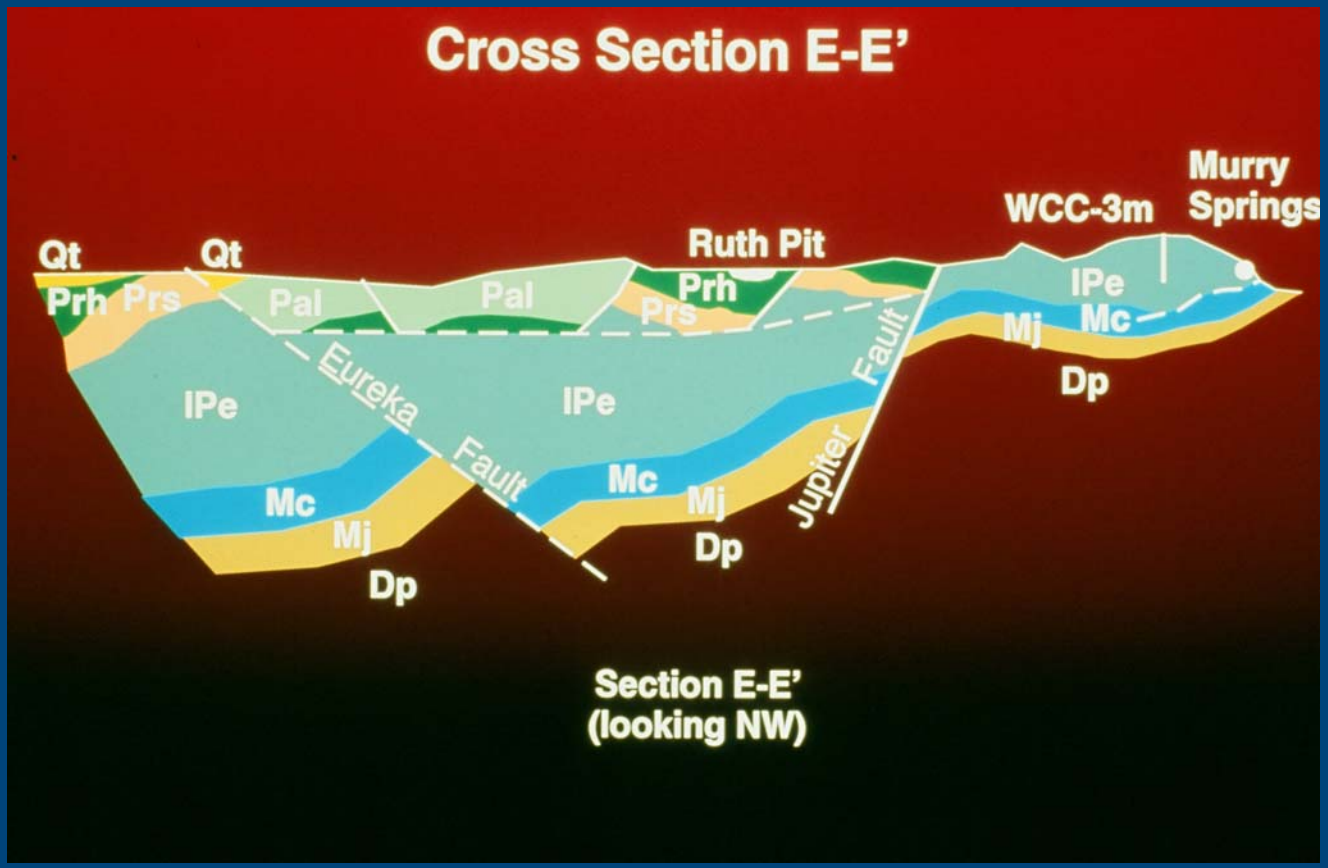


Estimate recharge from precipitation data using method of Maxey and Eakin (1949)



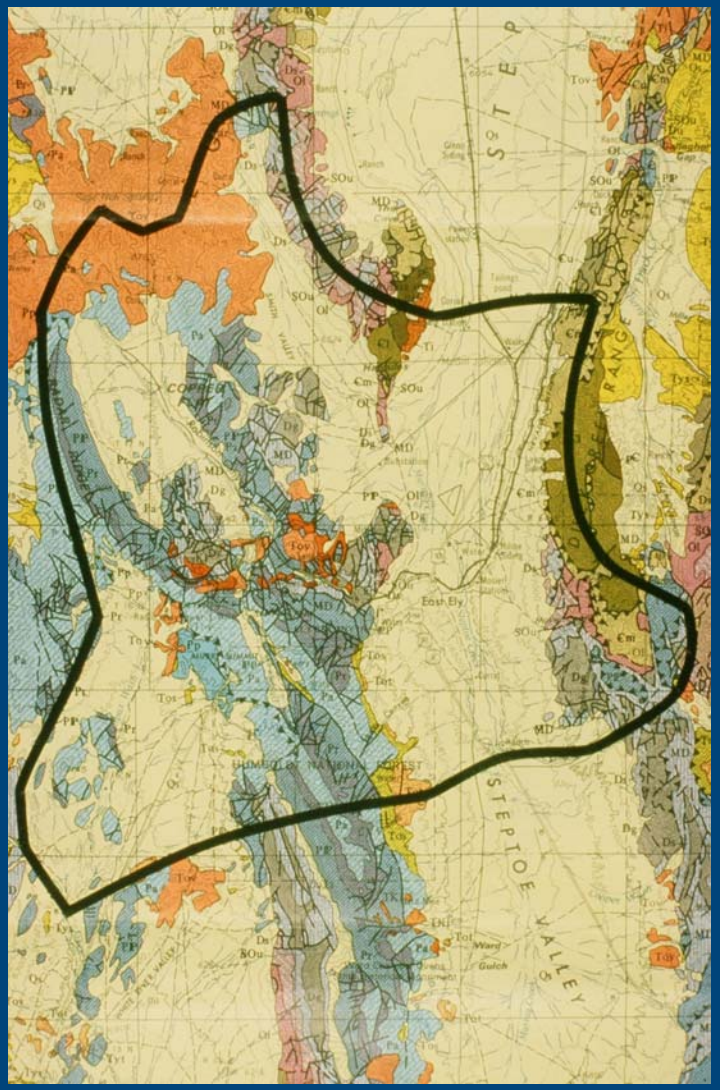


Geologic Cross section through Mining District

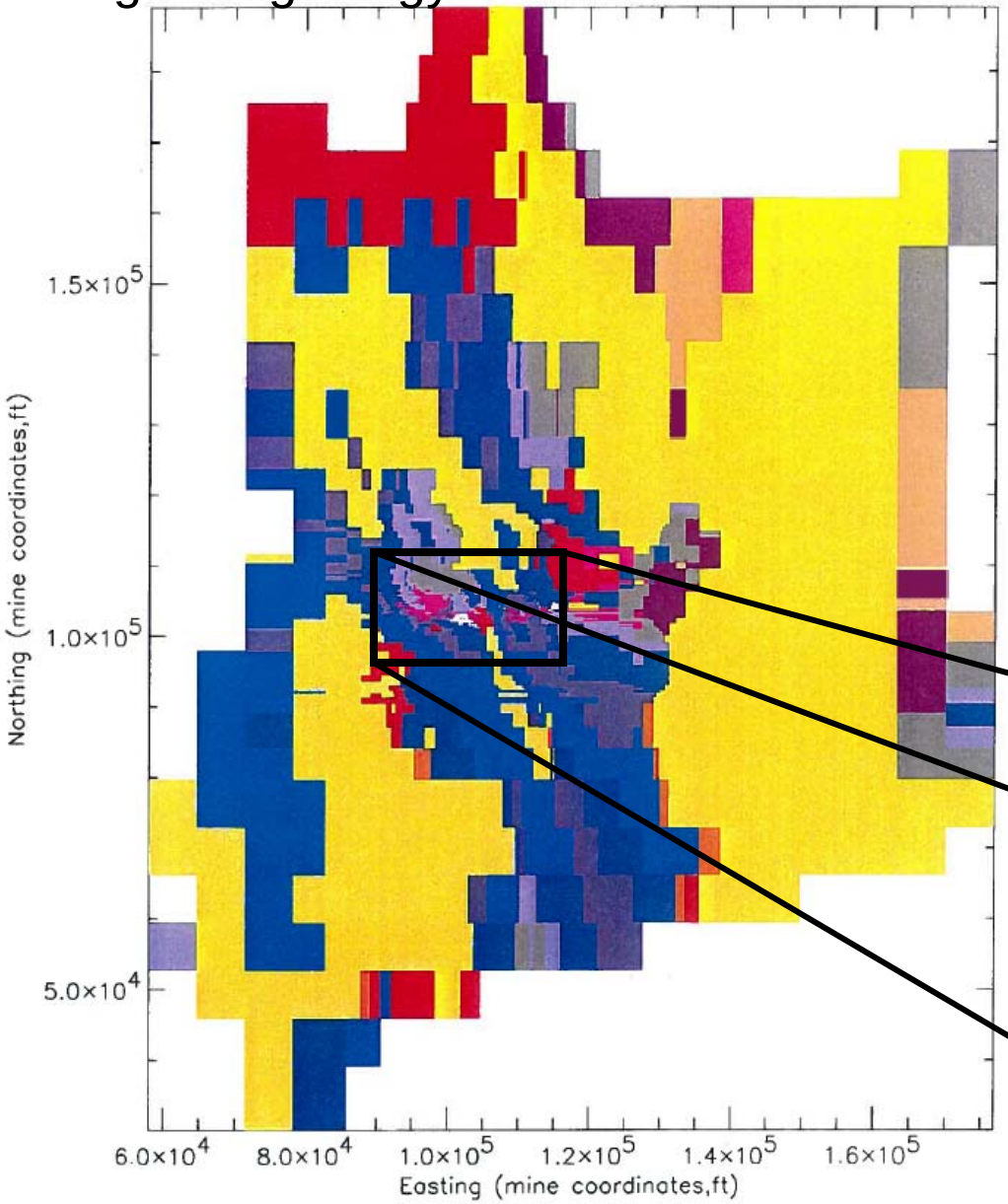


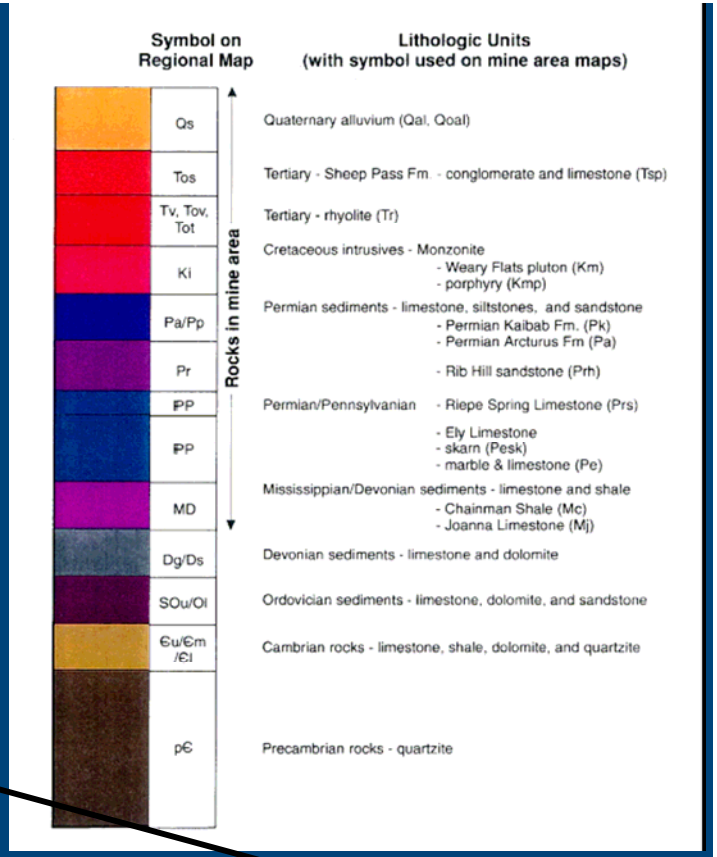
Regional geology

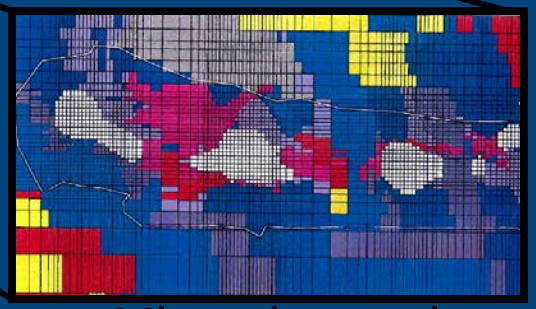
Local geology from Mine block model



Regional geology







Mine site geology

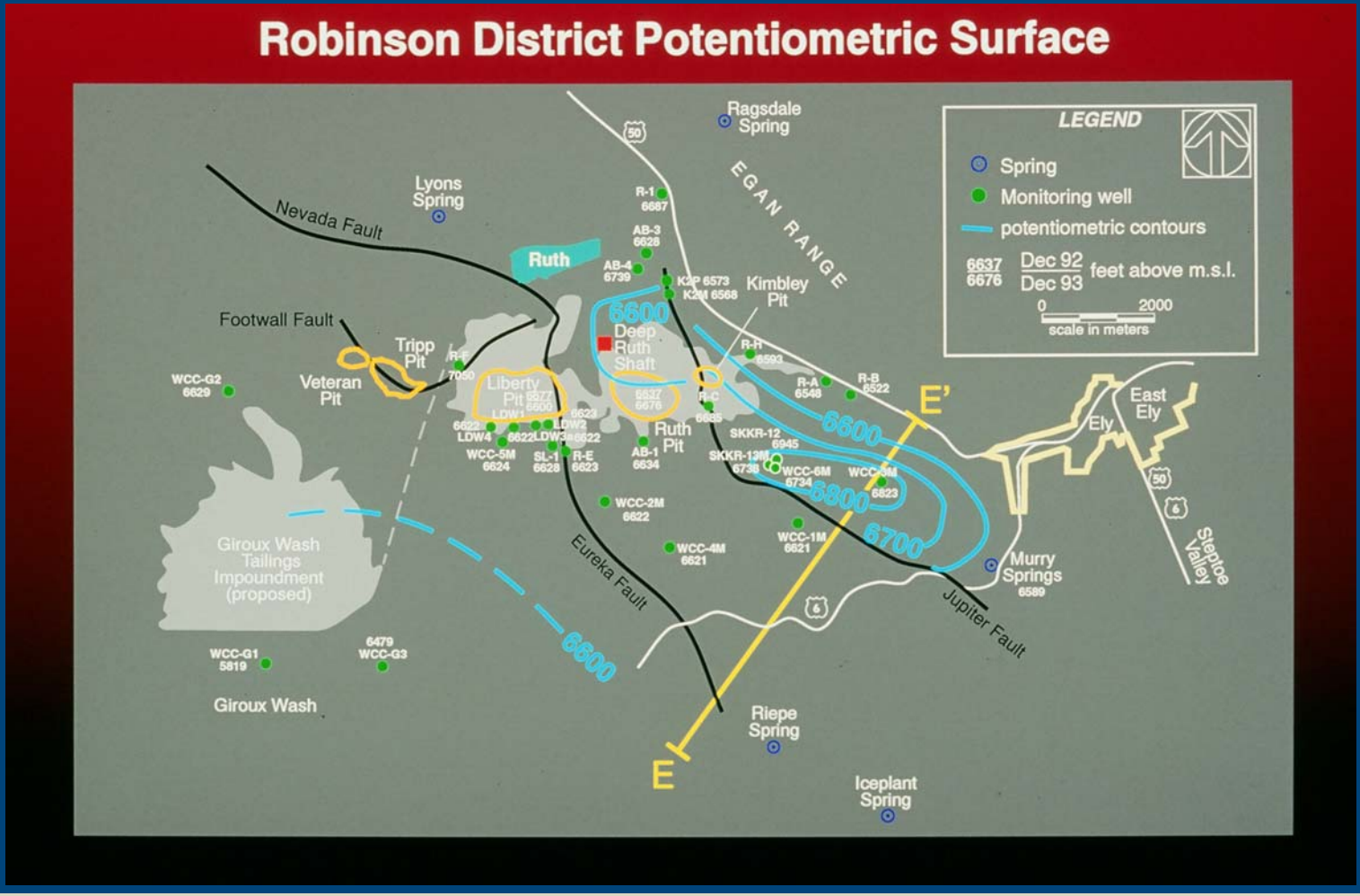
Calibrated hydraulic conductivities for geologic units

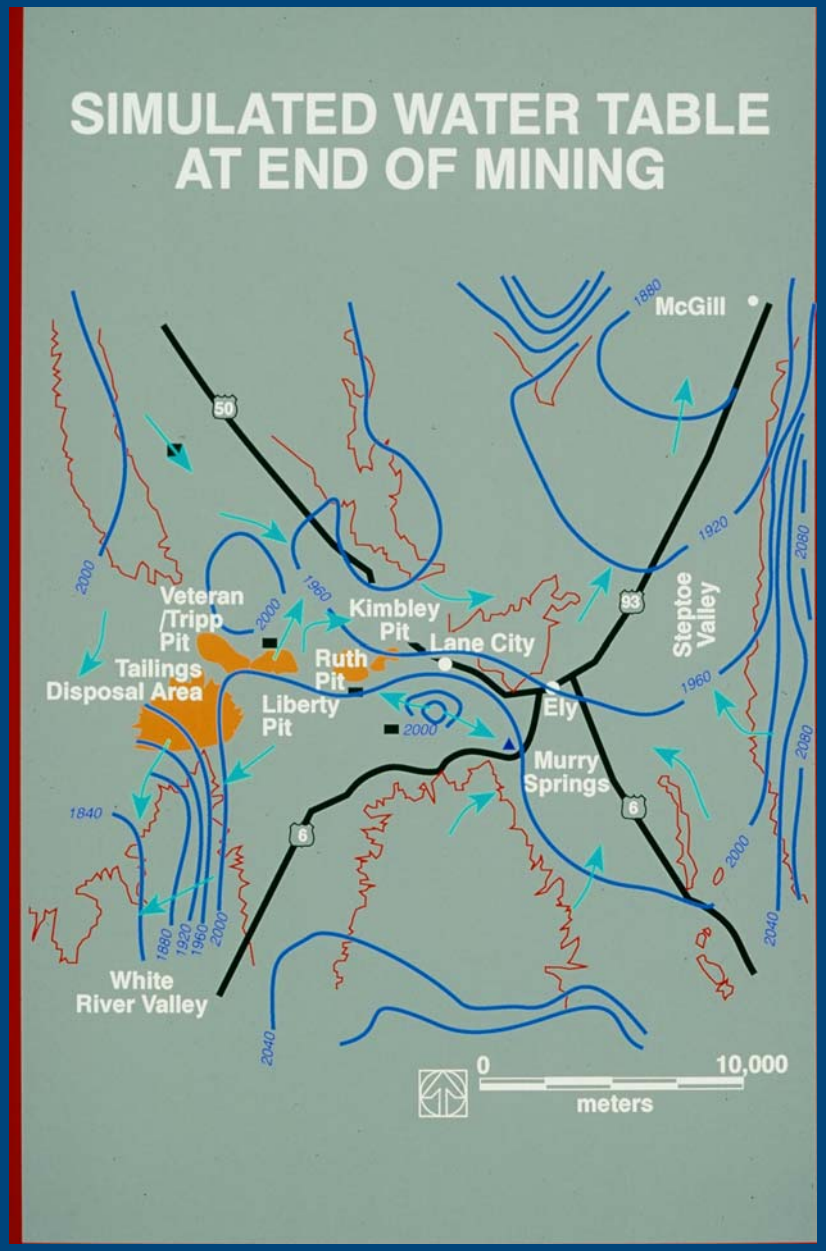
TABLE 6-6. MODEL HYDRAULIC CONDUCTIVITIES

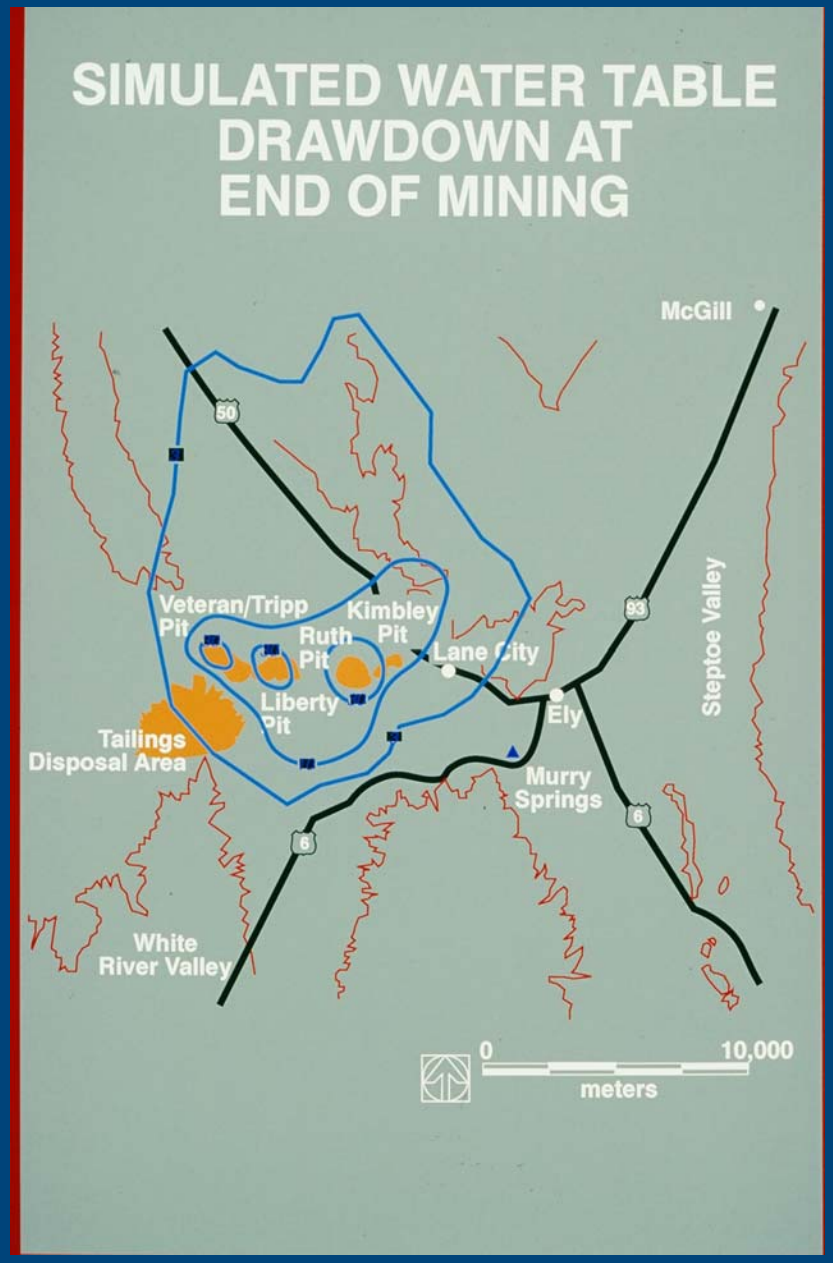
Lithology	Symbol(s)	Model Lithology Number	K (cm/s)	Reference Hydraulic Conductivity Ranges K (cm/s)			Ref.
UNALTERED							
Limestone	Ce,Cr,Cw	1	4e-03	4e-04	to	9e-03	a
Limestone	Dg,Ol,Opl,Opm,Opu	2	4e-03	4e-04	to	9e-03	a
Dolomite	Ds,Dsi,Oes,Sl	3	7e-04	4e-04	to	9e-03	a
Shale	Cd,Cmn,Cp,MDp,Mc,Ok	4	5e-07		<	1e-07	b
Siltstone	Pau/Pal/Pall	5	2e-05		<	1e-04	c
Limestone	Pk,Mj,Pe,Prs	6	7e-03	4e-04	to	9e-03	a
Sandstone	Prh	7	2e-05	3e-06	to	2e-04	d
Alluvium	Qal/Qoal	8	2e-03	7e-06	to	4e+01	e
Quartzite	Cpmq,Oe,PCp	9	2e-06				
Conglomerate	Tsp	10	7e-05				
Volcanics	Tra,Tro,Try,Twt	11	1e-06	5e-07	to	2e-05	f
Intrusive	Km	12	2e-06		<	2e-05	g
Pit Lake Cells	H20	13	2e+01				
UNDERGROUND WORKINGS							
Limestone	(all ages + dolomite)	14	7e-03				
Shale	Cd,Cmn,Cp,MDp,Mc,Ok	15	1e-06				
Siltstone	Pau/Pal/Pall	16	4e-05				
Sandstone	Prh	17	4e-05				
Quartzite	Cpmq,Oe,PCp	25	4e-06				
Volcanics	Tra,Tro,Try,Twt	26	3e-06				
Intrusive	Km	18	4e-06				
METAMORPHOSED							
Limestone	(all ages + dolomite)	19	7e-06			4e-06	h
Shale	Cd,Cmn,Cp,MDp,Mc,Ok	20	2e-07				
Siltstone	Pau/Pal/Pall	21	2e-05				
Sandstone	Prh	22	7e-07				
Intrusive (mine area)	Km	24	9e-06				

a. Dames & Moore 1982, 1988, 1990 (Ely & near McGill: 4×10^{-4}–5×10^{-3} cm/s), HSI 1991, 1992 (Arcturus/Ely and Arcturus/Guilmette: 6×10^{-3}–9×10^{-3} cm/s), Winograd and Thordardson 1975 (Nevada Test Site: 7×10^{-4}–7×10^{-3} cm/s)
b. HLA 1981 (electrical resistivity study of White Pine County), Plume & Carlton 1988
c. Dames & Moore 1988, 1990 (Arcturus fm.: 10^{-4} cm/s), HSI 1991, 1992 (Arcturus/Ely and Arcturus/Guilmette: 6×10^{-3}–9×10^{-3} cm/s)
d. WESTEC 1991 (Giroux Wash: 3×10^{-6}–2×10^{-4} cm/s)
e. Bunch & Harrill 1984 (White Pine County: 7×10^{-6}–7×10^{-4} cm/s), Dames & Moore 1982, 1988, 1990 (Steptoe Valley, Robinson Canyon: 2×10^{-6}–10^{-3} cm/s), Frick 1985 (Steptoe Valley: 10^{-3}–40 cm/s), LeedsHill 1981 (Steptoe Valley: 2–20 cm/s), Plume & Carlton 1988 (Steptoe Valley: 7×10^{-6}–5×10^{-3} cm/s), WESTEC 1991 (Giroux Wash: 7×10^{-6}–2×10^{-4} cm/s)
f. WESTEC 1991 (Giroux Wash: 5×10^{-7}–2×10^{-4} cm/s)
g. Dames & Moore 1988, 1990 (Robinson District monzonite: 2×10^{-4} cm/s)
h. Dames & Moore 1988, 1990 (metamorphosed Ely: 4×10^{-4} cm/s)

Model calibrated to reproduce current measured groundwater levels and discharge from springs



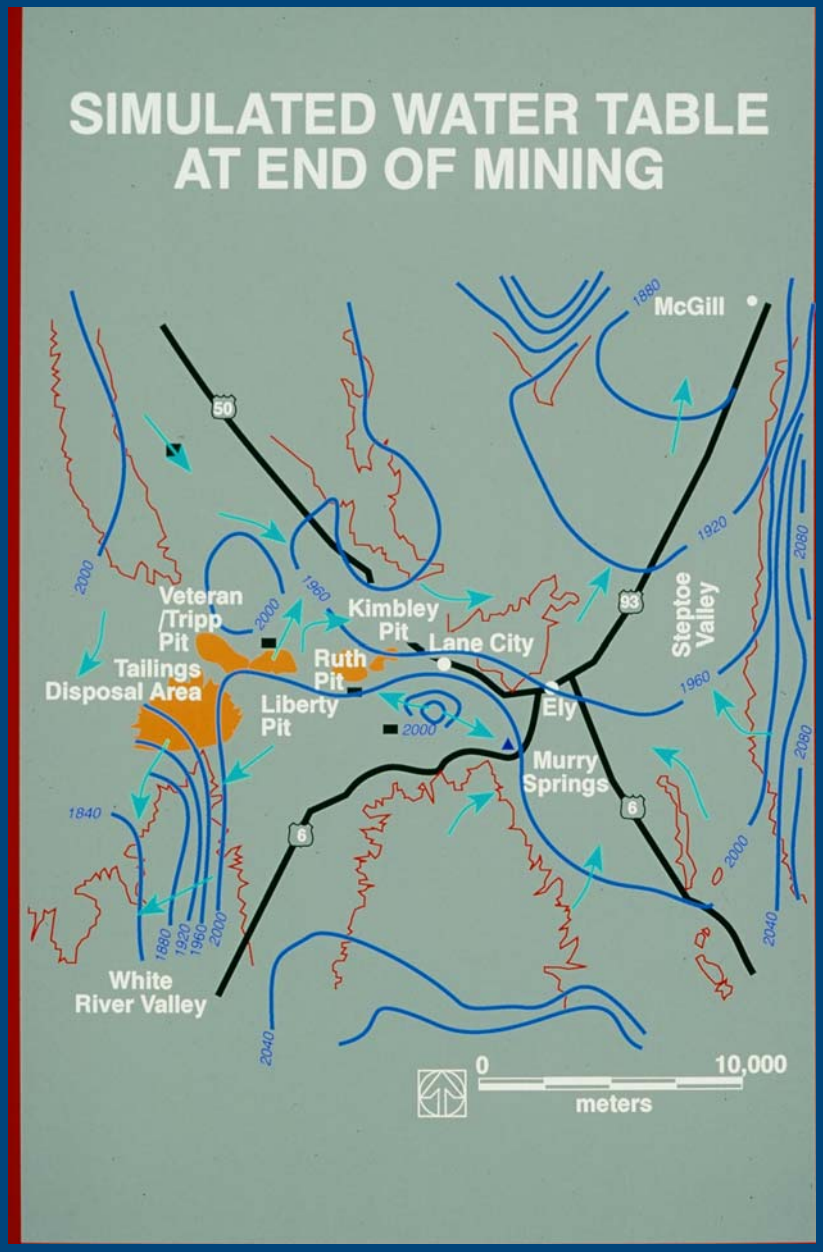

SIMULATED WATER TABLE
AT END OF MINING
McGill
Veteran
/Tripp
Pit
Tailings
Disposal Area
Kimbley
Pit
Ruth
Pit
Lane City
Liberty
Pit
Ely
Murry
Springs
Steptoe
Valley
White
River Valley
50
93
6
1880
1920
1960
2000
2040
2080
1840
0
10,000
meters


SIMULATED WATER TABLE
DRAWDOWN AT
END OF MINING
McGill
Veteran/Tripp
Pit
Kimbley
Pit
Ruth
Pit
Lane City
Liberty
Pit
Ely
Tailings
Disposal Area
Murry
Springs
Steptoe Valley
White
River Valley
50
93
6
0
10,000
meters

Particle tracking

MODPATH (Particle tracking) indicate no flow paths from mine facilities (lakes, waste rock or tailings impoundment) to Murry Springs

Contaminant transport modeling not needed to evaluate potential for water quality impacts



Model uncertainty

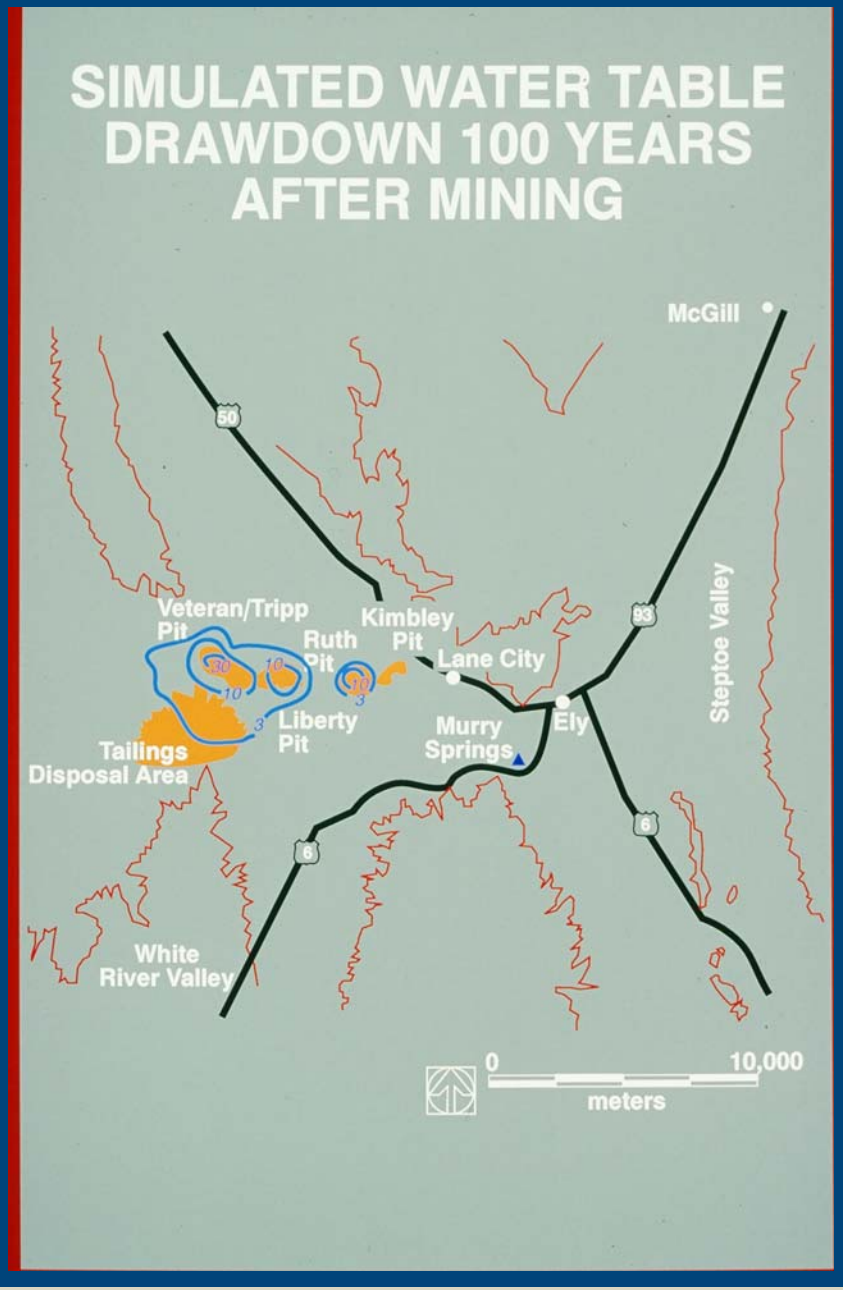
- Sensitivity analysis was conducted using range of values for K and recharge
- Model was found to be most sensitive to K for a few regionally extensive and higher K geologic units
- Simulations conducted by varying input parameters within reasonable (literature values) ranges did not alter model results sufficiently to change conclusion that there will be no impact to springs

Conclusions

Pit lakes projected to create cones of depression as the result of evaporative losses, in perpetuity

Murry Springs outside of cone of depression/capture zone – flows not affected by dewatering or long-term presence of lakes

Mine not predicted to impact spring water quality



Robinson groundwater model evaluation

Evaluation criteria	Yes	No
Conceptual site model clearly presented	X	
Public domain code	X	
Model boundaries, domain, input parameters clearly described and reasonable	X	
Parameter estimator used		X
Model calibrated to existing data (steady state and transient)	X	
Sensitivity analysis conducted	X	
Model well-documented	X	
Model revaluated as dewatering/mining progressed		X