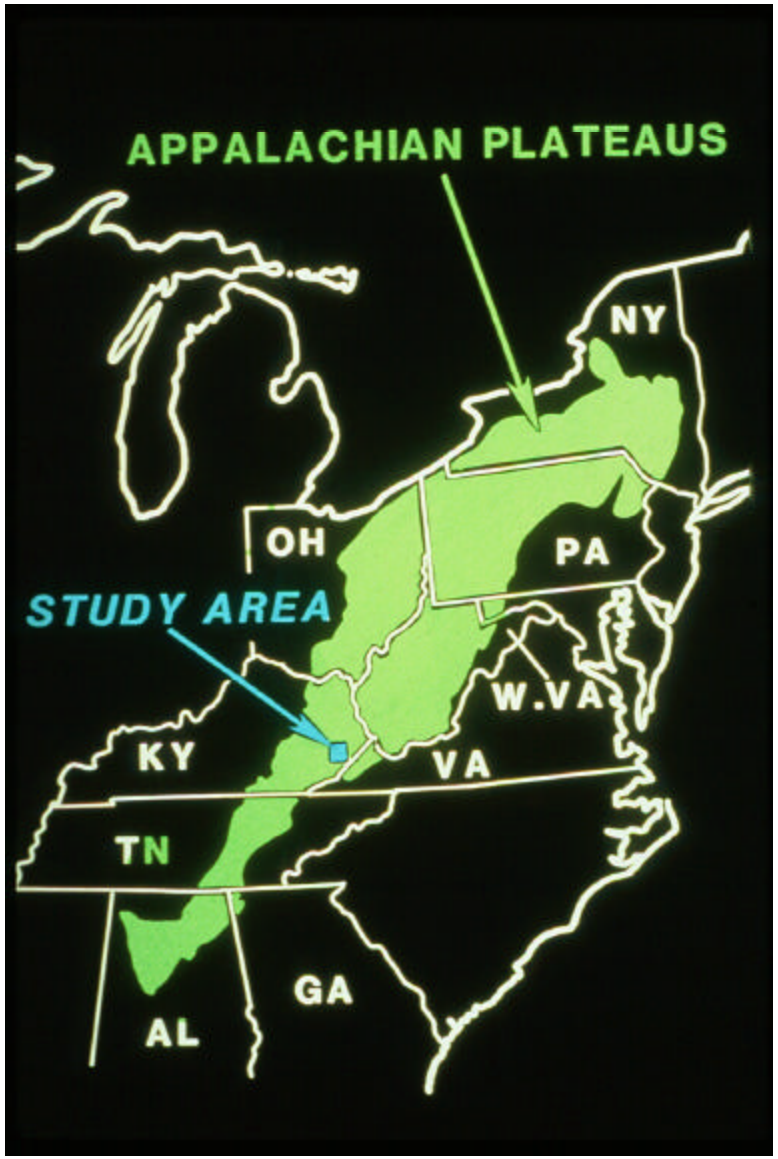
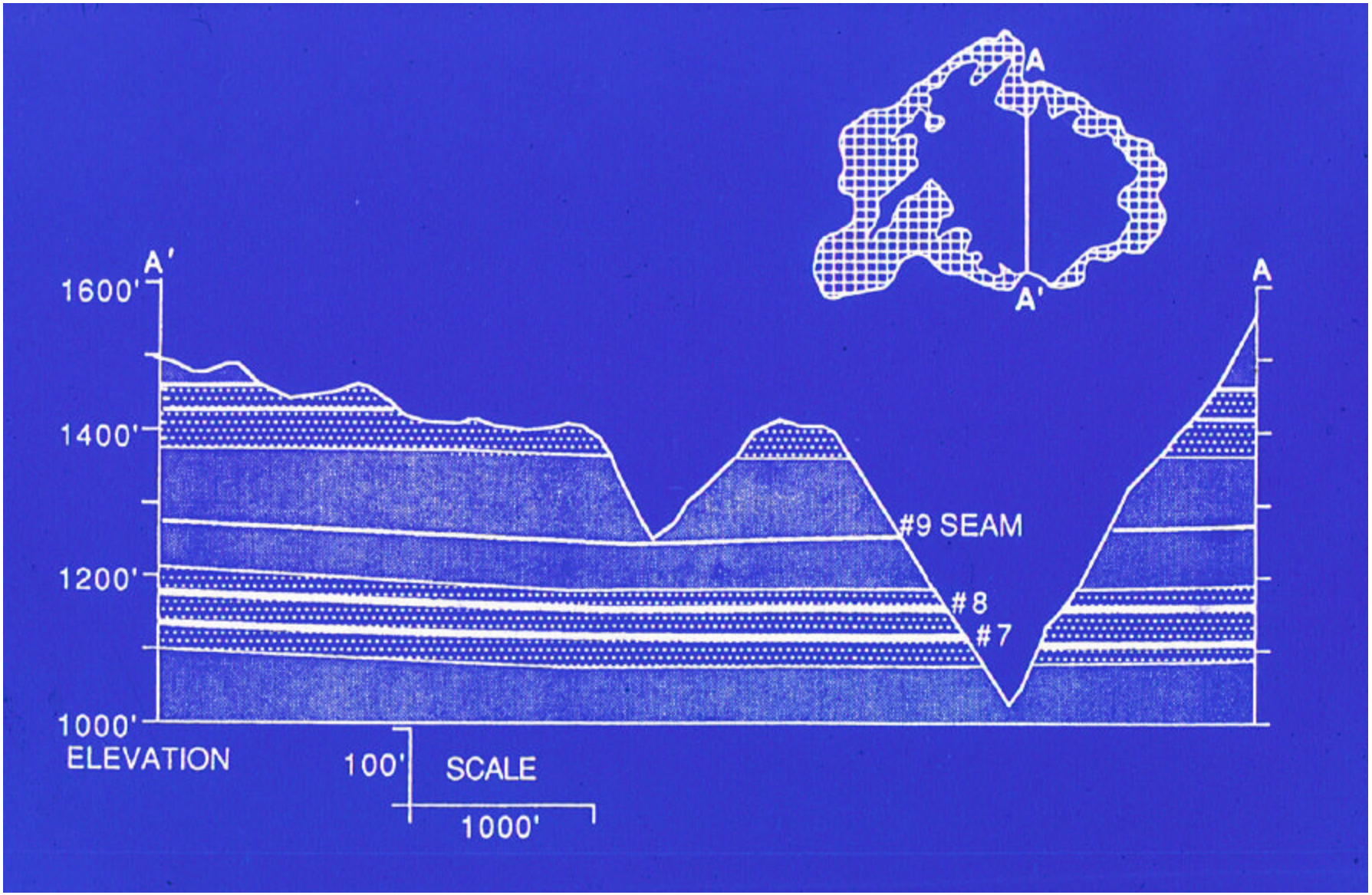
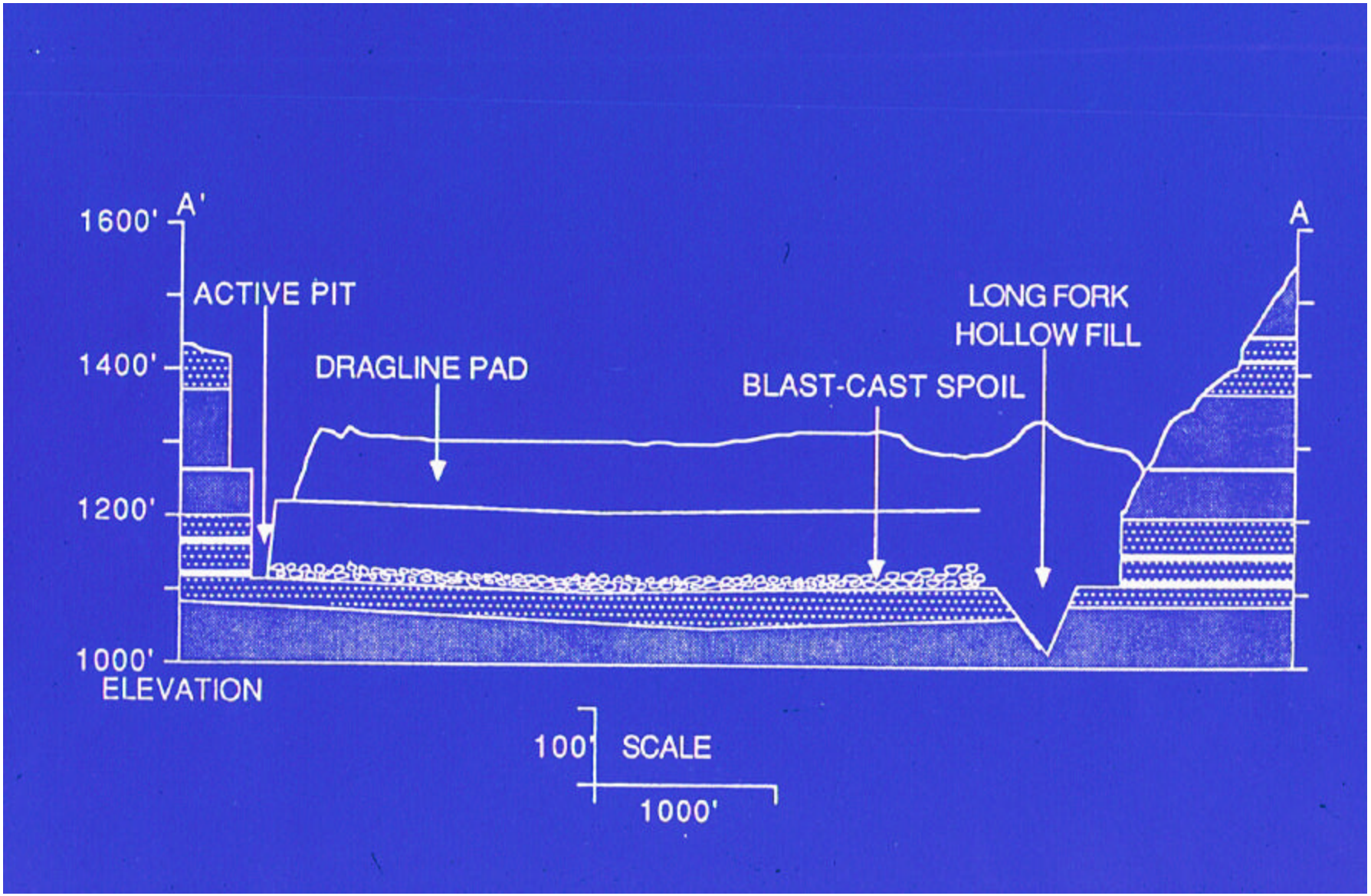
Coal-Field Hydrology

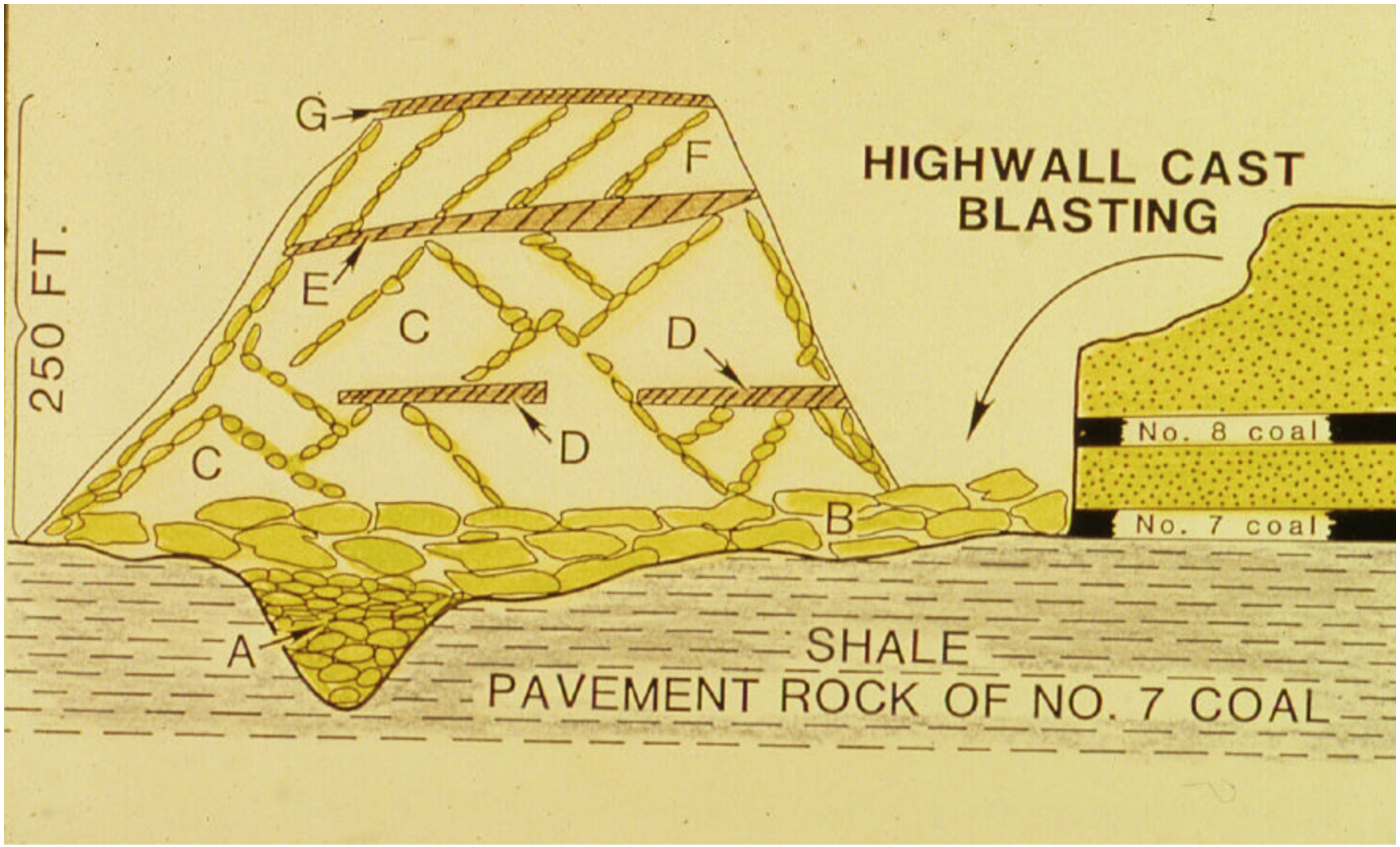
David R. Wunsch, Ph.D.

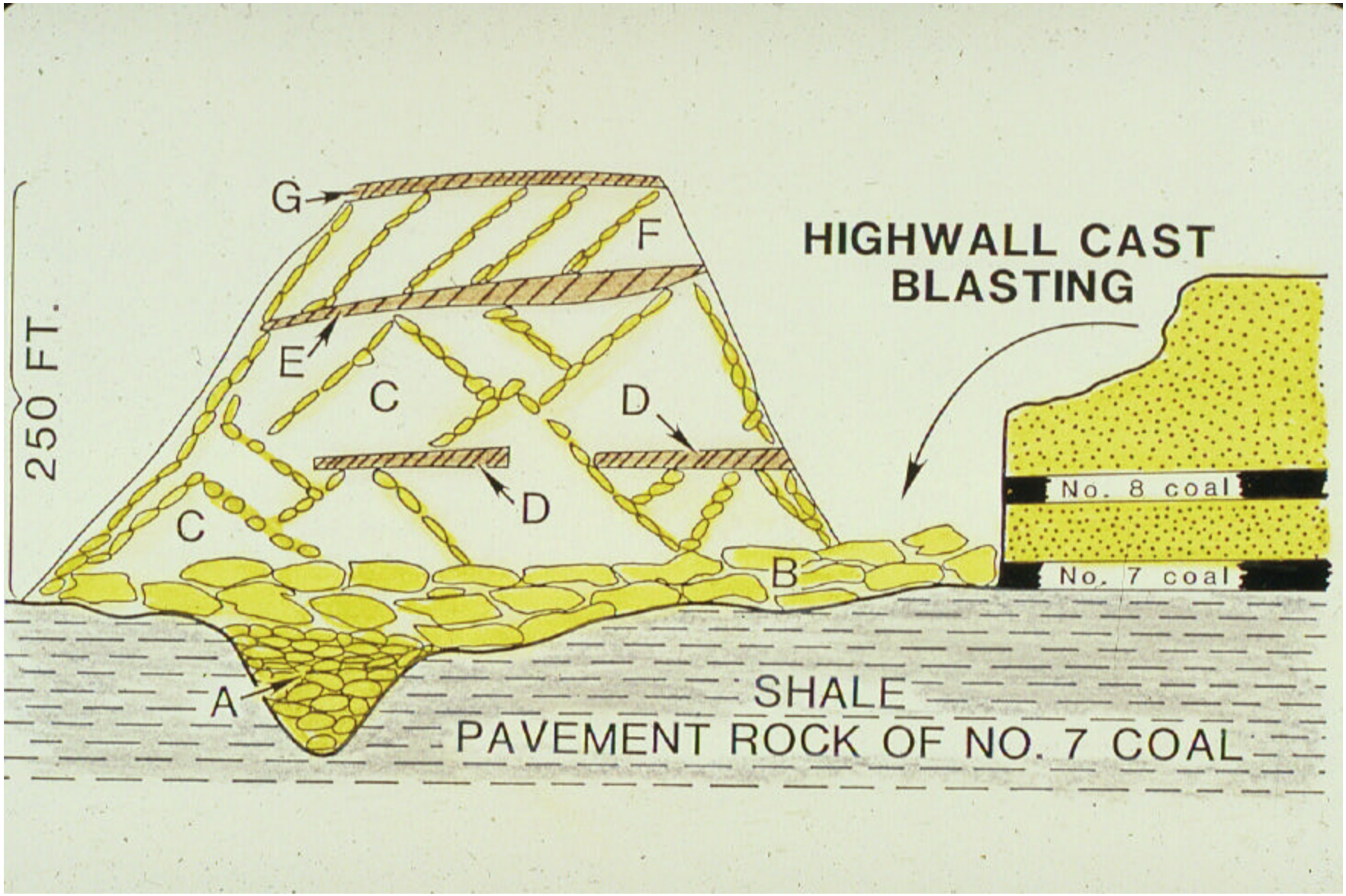
KGS


APPALACHIAN PLATEAUS
NY
OH
PA
STUDY AREA
W.VA
KY
VA
TN
GA
AL

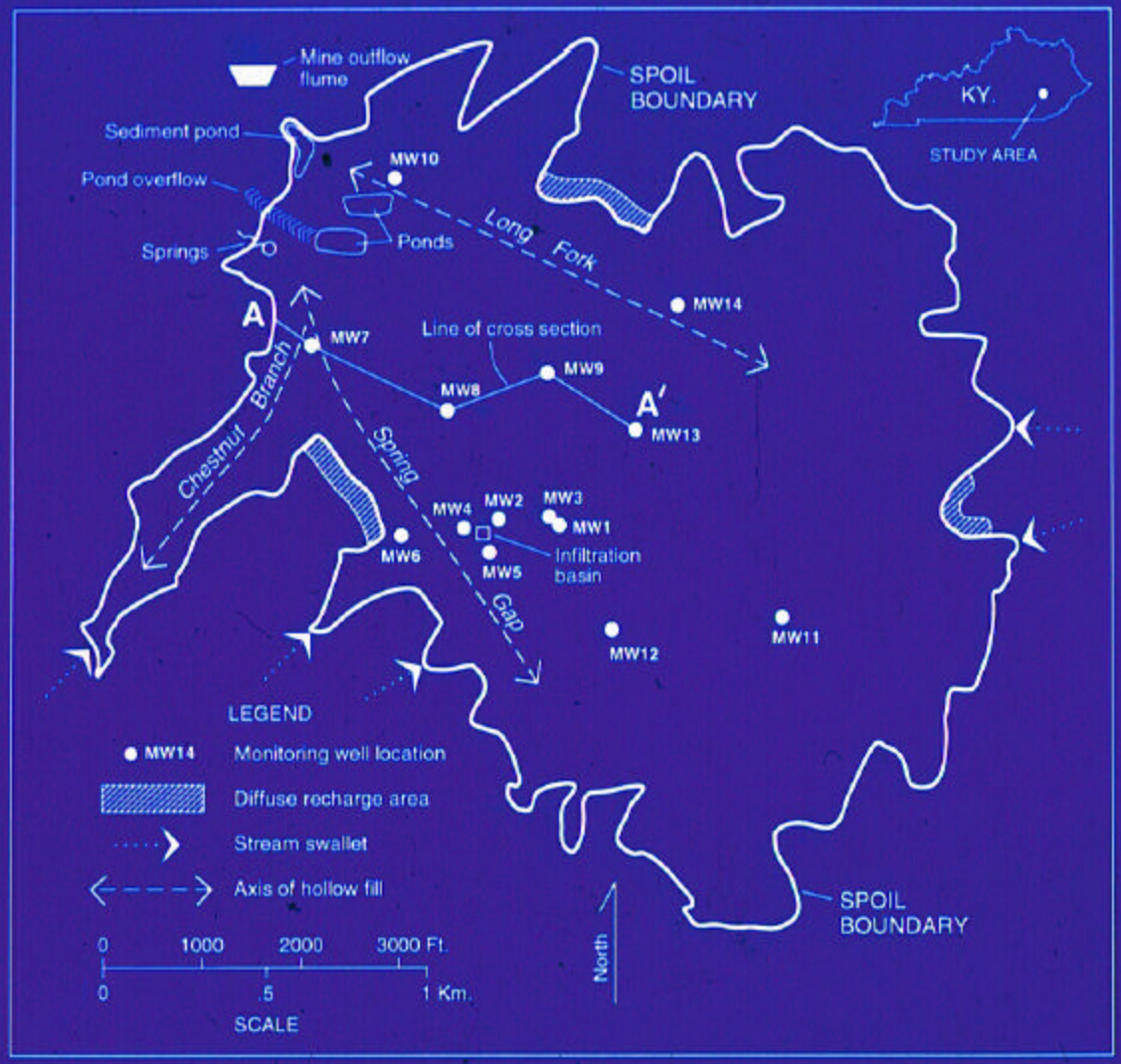

A
A'
A'
A
1600'
1400'
1200'
1000'
ELEVATION
#9 SEAM
#8
#7
100'
SCALE
1000'

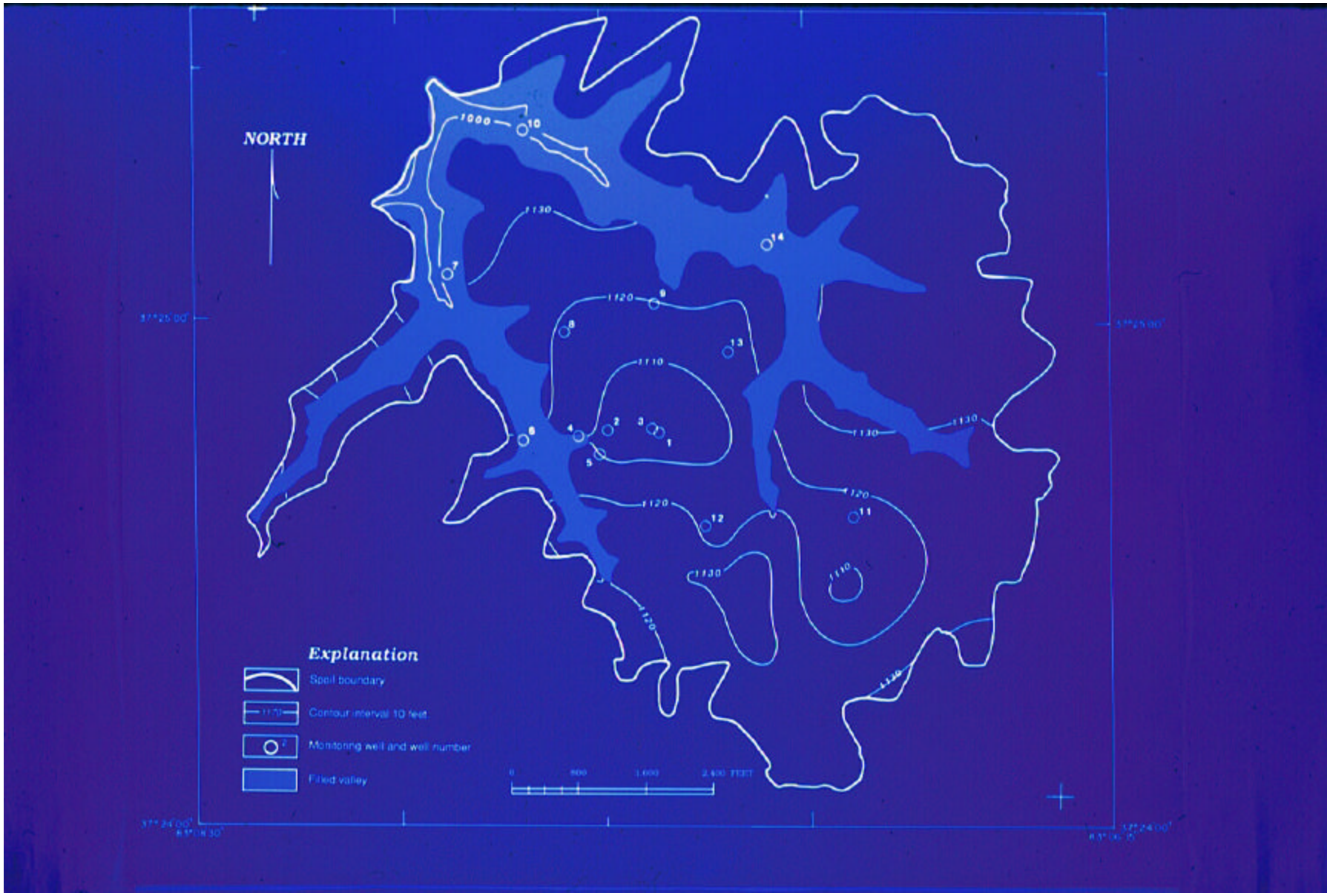

A'
A
1600'
1400'
1200'
1000'
ELEVATION
ACTIVE PIT
DRAGLINE PAD
BLAST-CAST SPOIL
LONG FORK
HOLLOW FILL
100'
SCALE
1000'

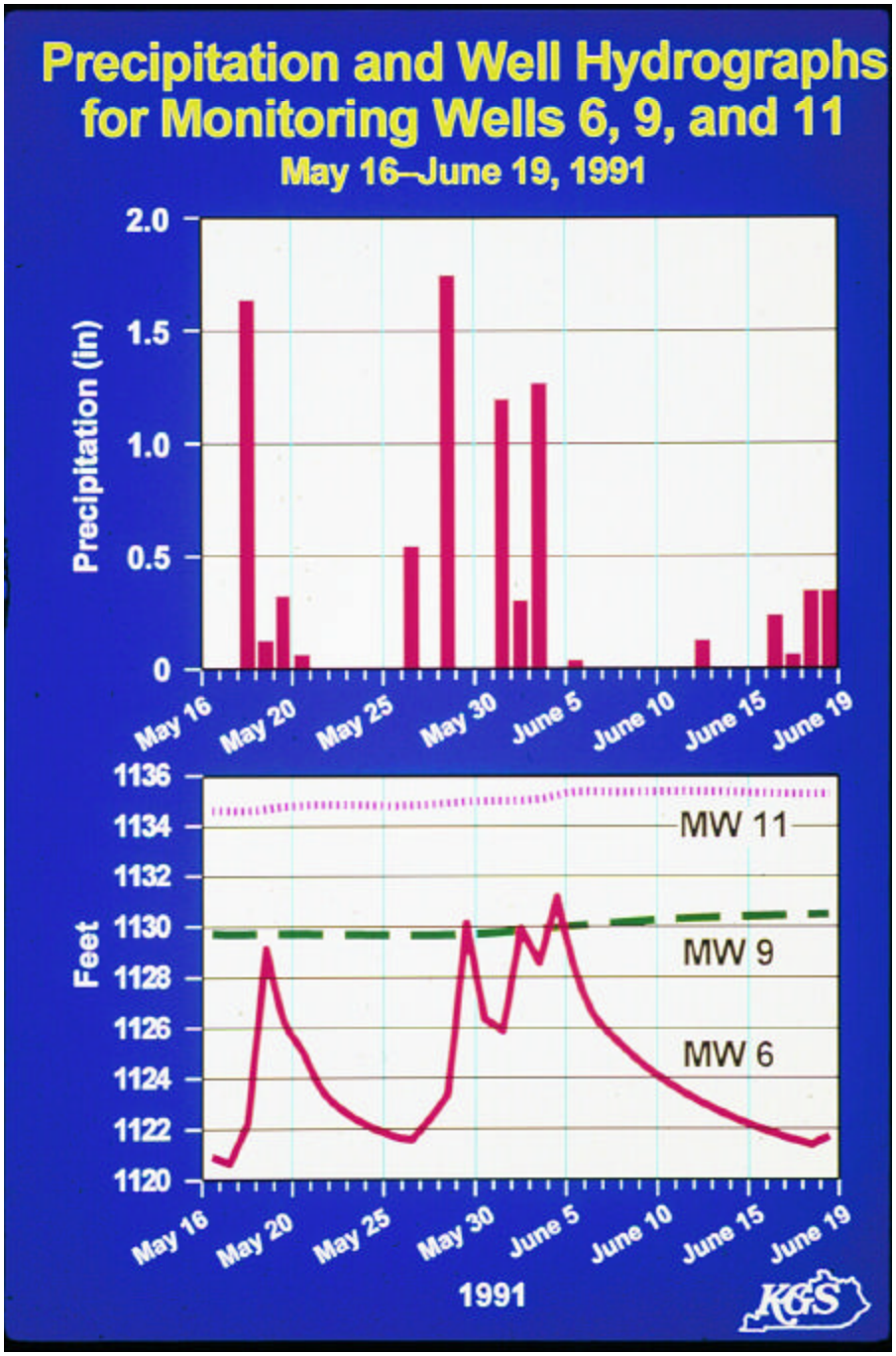

HIGHWALL CAST BLASTING
250 FT.
G
F
E
C
D
D
C
B
A
No. 8 coal
No. 7 coal
SHALE
PAVEMENT ROCK OF NO. 7 COAL

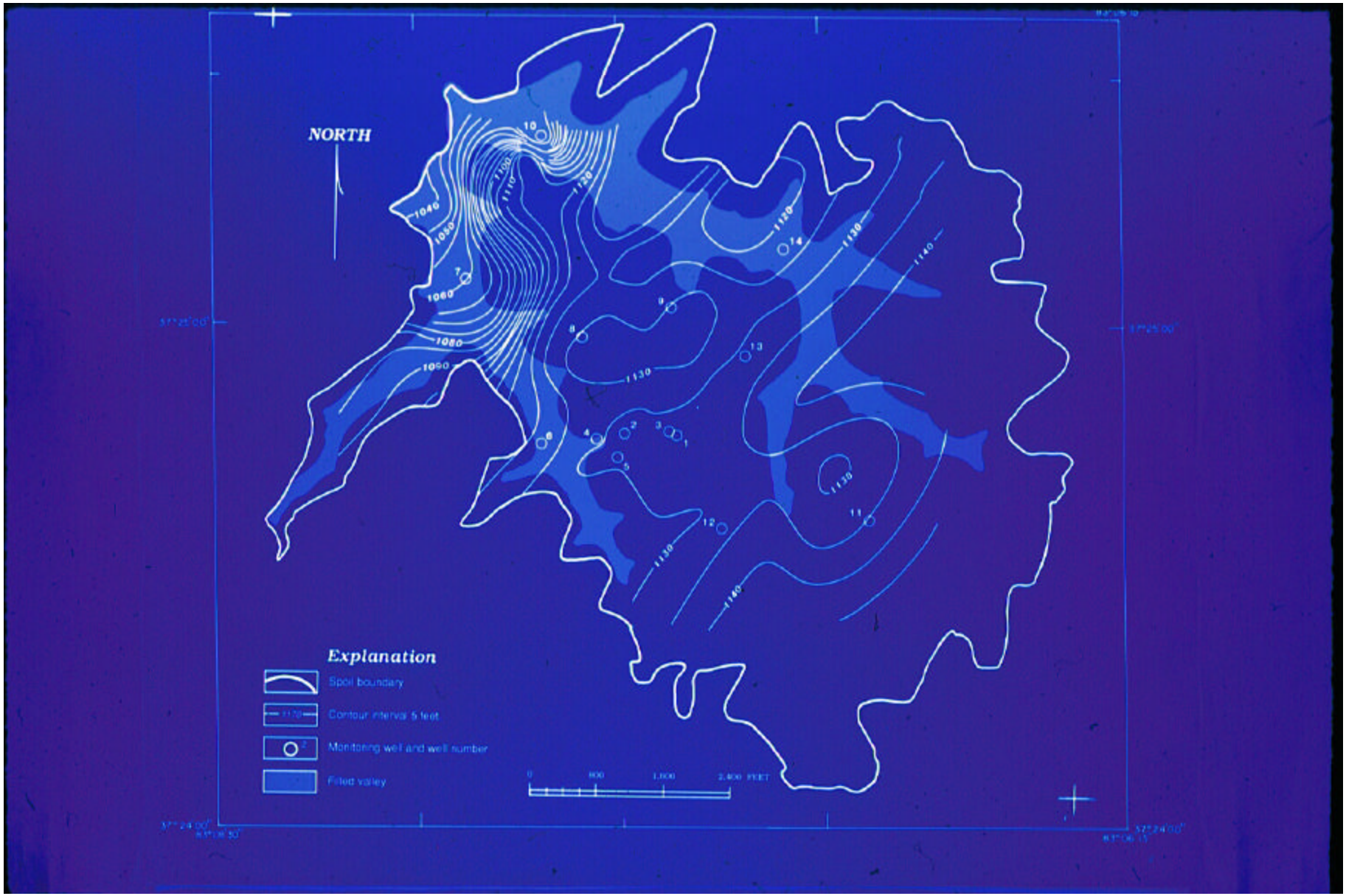

HIGHWALL CAST BLASTING
250 FT.
G
F
E
C
D
D
C
B
A
No. 8 coal
No. 7 coal
SHALE
PAVEMENT ROCK OF NO. 7 COAL

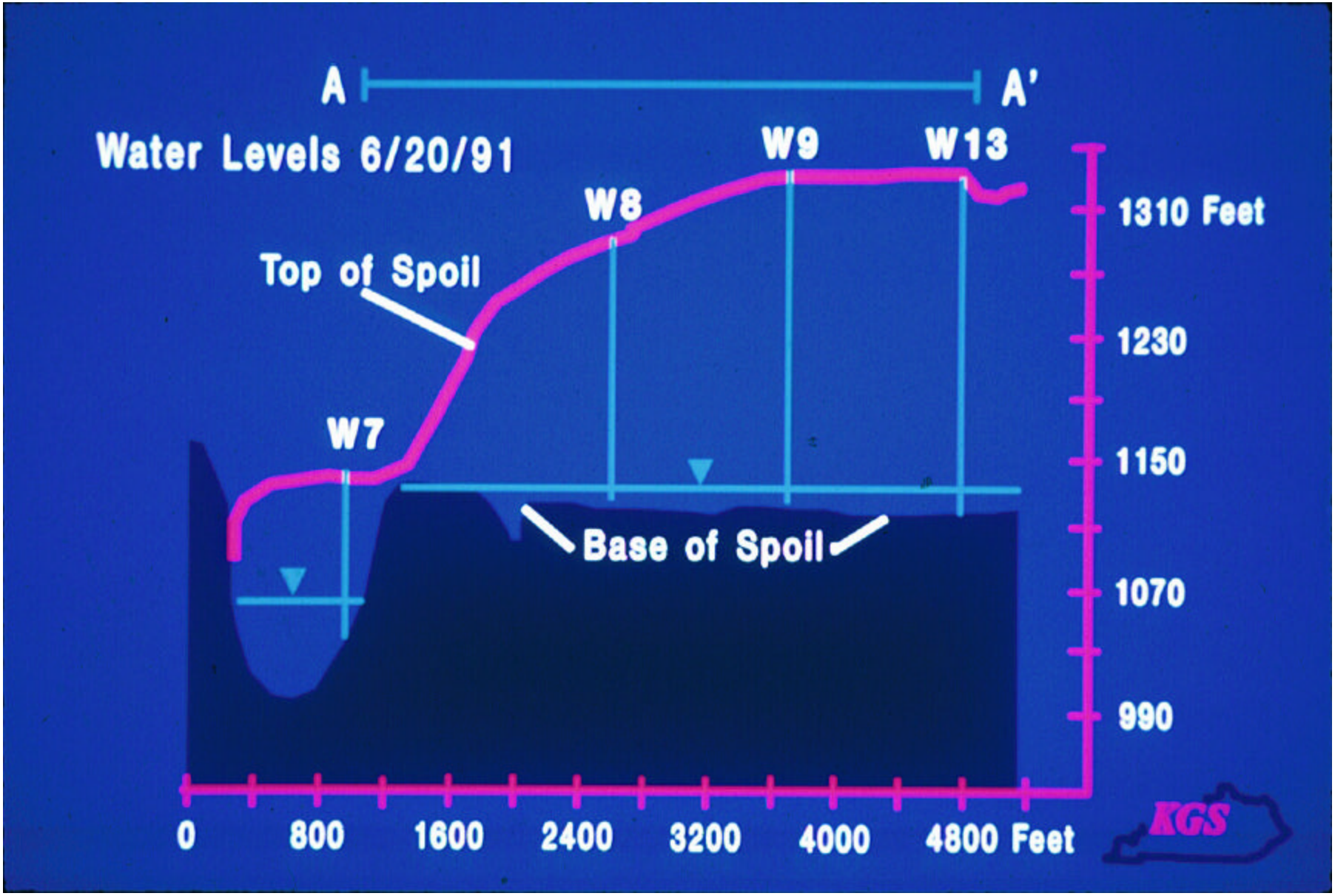
VOLVO


Mine outflow flume
SPOIL BOUNDARY
KY.
STUDY AREA
Sediment pond
Pond overflow
Springs
Ponds
MW10
Long Fork
MW14
A
MW7
Line of cross section
MW9
MW8
A′
MW13
Chestnut Branch
Spring Gap
MW4
MW2
MW3
MW1
MW6
MW5
Infiltration basin
MW12
MW11
LEGEND
MW14 Monitoring well location
Diffuse recharge area
Stream swallet
Axis of hollow fill
0 1000 2000 3000 Ft.
0 .5 1 Km.
SCALE
North
SPOIL BOUNDARY


NORTH
1000
1130
1120
1110
1130
1120
1110
1130
1120
1130
1120
1110
1130
10
14
7
9
8
13
6
4
2
3
1
5
12
11
Explanation
Spoil boundary
Contour interval 10 feet
Monitoring well and well number
Filled valley
0
500
1,000
2,000 FEET


Precipitation and Well Hydrographs
for Monitoring Wells 6, 9, and 11
May 16–June 19, 1991
Precipitation (in)
2.0
1.5
1.0
0.5
0
May 16
May 20
May 25
May 30
June 5
June 10
June 15
June 19
Feet
1136
1134
1132
1130
1128
1126
1124
1122
1120
MW 11
MW 9
MW 6
1991
K&S


NORTH
1040
1050
1060
1080
1090
1100
1110
1120
1130
1140
Explanation
Spoil boundary
Contour interval 5 feet
Monitoring well and well number
Filled valley
0
800
1,600
2,400 FEET


A
A'
Water Levels 6/20/91
W7
W8
W9
W13
Top of Spoil
Base of Spoil
1310 Feet
1230
1150
1070
990
0
800
1600
2400
3200
4000
4800 Feet
KGS

Saturated Thickness in Monitoring Wells in June 1991

Wells Placed Over Hollow Fills			*Spoil-Interior Wells*		
Well ID	*Saturated Thickness*	*Water Elevation*	*Well ID*	*Saturated Thickness*	*Water Elevation*
			2	21.0	1,132.0
			3	10.1	1,131.6
			5	23.1	1,132.4
4	24.5	1,128.4	8	10.6	1,131.1
6	23.7	1,121.6	9	9.5	1,130.4
7	27.1	1,059.5	11	17.6	1,135.3
10	37.1	1,048.8	12	16.7	1,133.1
14	38.0	1,123.0	13	14.7	1,131.5
n=5 range=23.7–38.0 median=27.1 mean=30.1			n=8 range=9.5–23.1 median=15.7 mean=15.4		

Hydraulic Conductivity in Monitoring Wells, Measured by Slug Tests

Well No.	*Hydraulic Conductivity (cm/sec)*	*Hydraulic Conductivity (ft/sec)*
MW 4	7.0×10^{-5}	2.0×10^{-6}
MW 5	$>8.2 \times 10^{-4}$	$>2.7 \times 10^{-5}$
MW 7	2.0×10^{-5}	8.0×10^{-6}
MW 8	$>7.3 \times 10^{-4}$	$>2.4 \times 10^{-5}$
MW 9	4.0×10^{-5}	1.0×10^{-6}
MW 10	$>9.0 \times 10^{-4}$	$>2.9 \times 10^{-5}$
MW 12	4.0×10^{-4}	1.0×10^{-5}
MW 13	$>5.8 \times 10^{-4}$	$>1.9 \times 10^{-5}$
MW 14	2.0×10^{-4}	8.0×10^{-6}

KGS

HYDRAULIC CONDUCTIVITY OF MINE SPOIL (CM/S)

WUNSCH AND DINGER (1994)	2.0 x E-5 to >9.0 x E-4
OERTEL AND HOOD (1983)	4.6 x E-5 to 2.1 x E-2
HERRING AND SHANKS (1980)	4.6 x E-5 to 4.8 x E-2

KGS

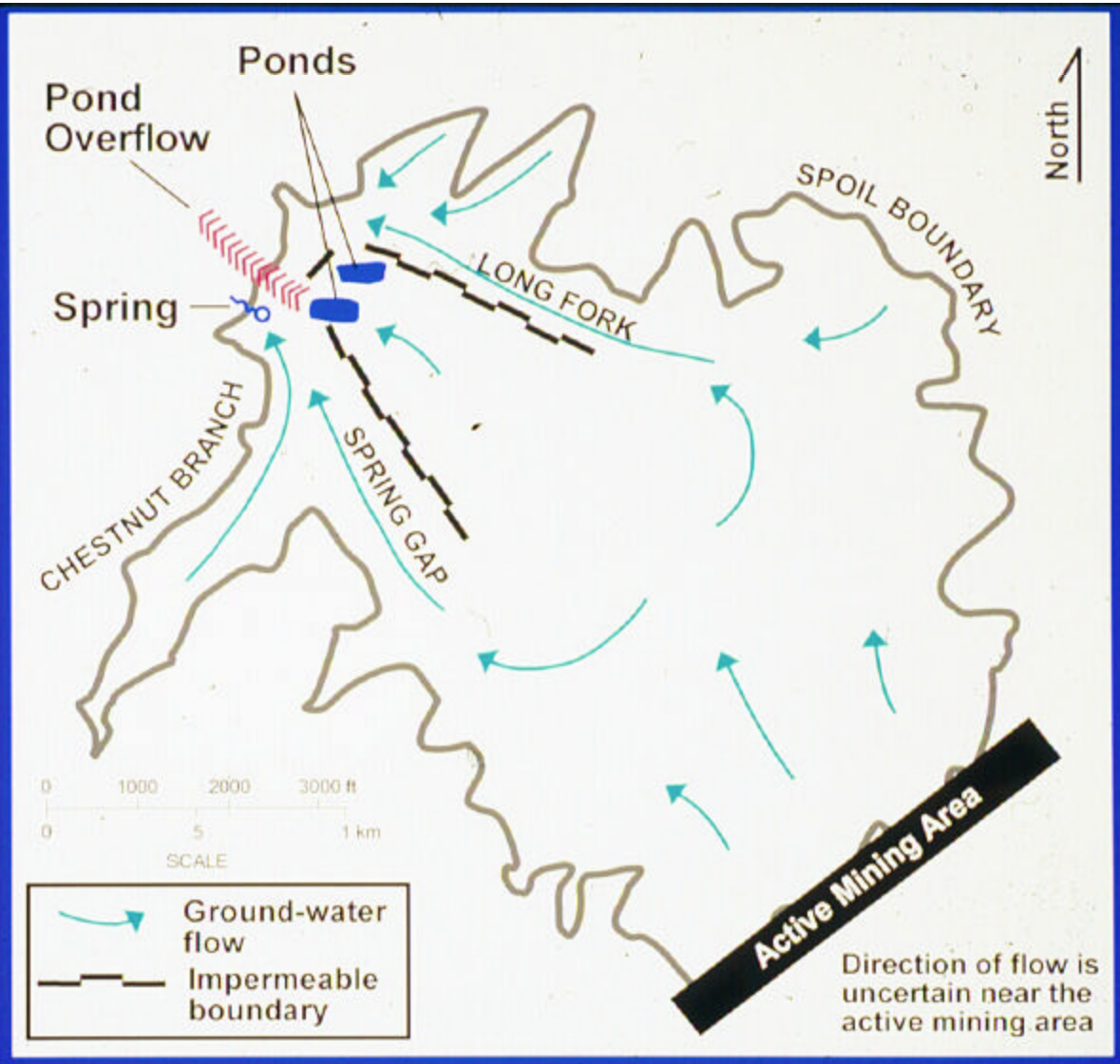
Mass-balance calculations:

$$Qt = Qpo + Qcb + (Qsp - Qcb) + Qlf$$

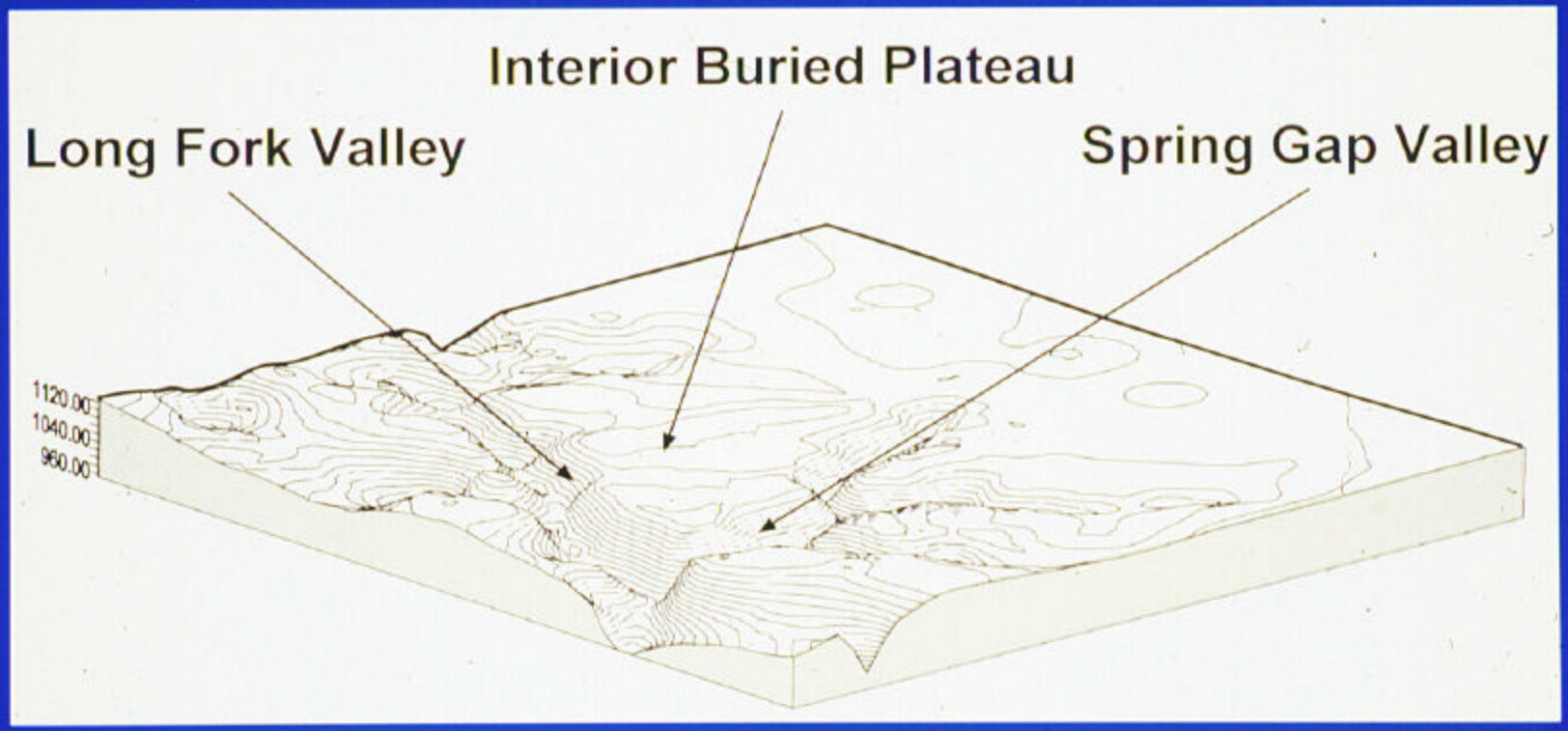
where:

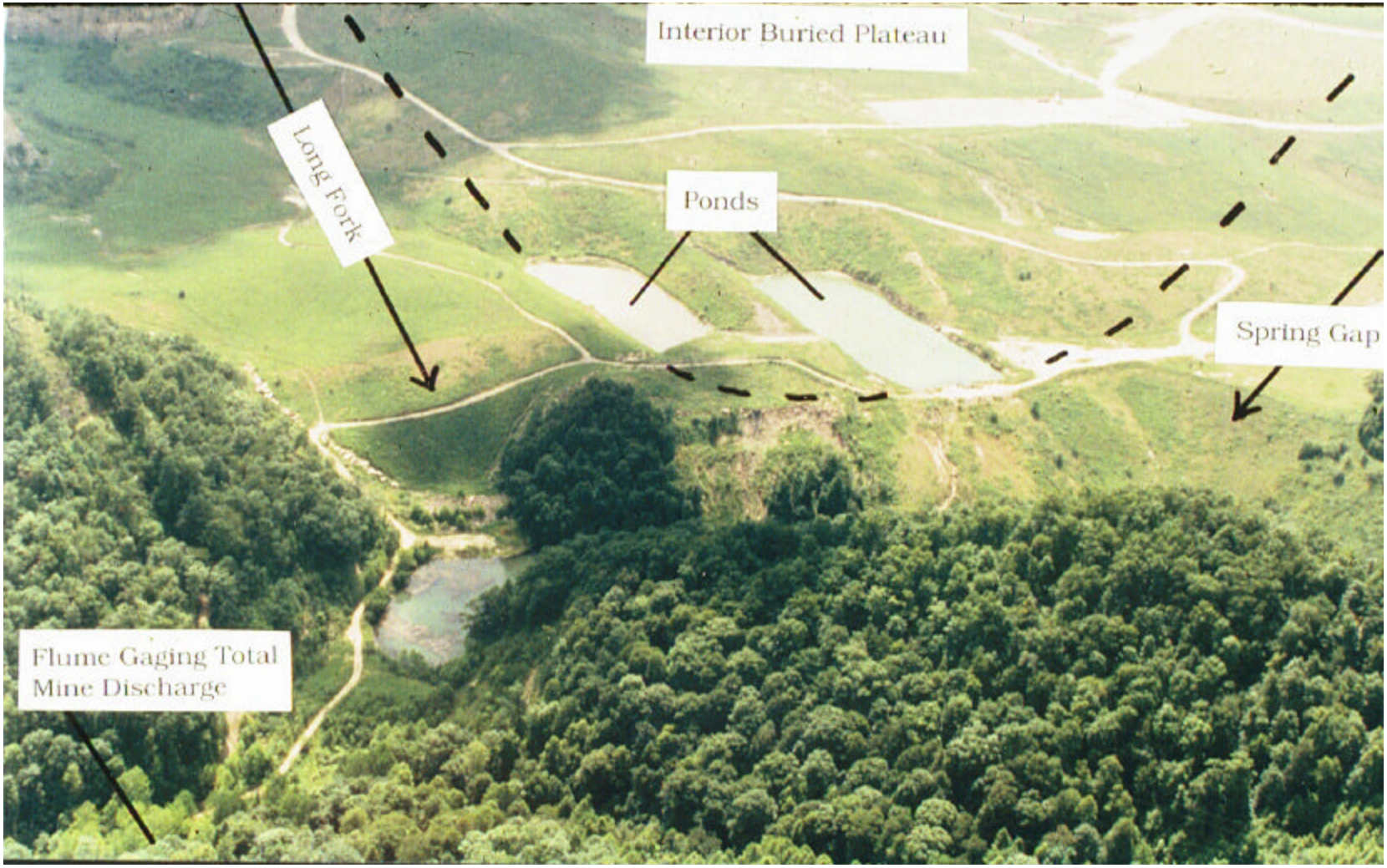
Qt = measured total mine discharge at Long Fork flume
Qpo = measured discharge of the pond overflow
Qcb = measured discharge from Chestnut Branch
Qsp = measured discharge at Spring Gap Spring
Qlf = calculated total mine discharge at Long Fork Spring

Conceptual Model of Ground-Water Flow in the Spoil at the Star Fire Site



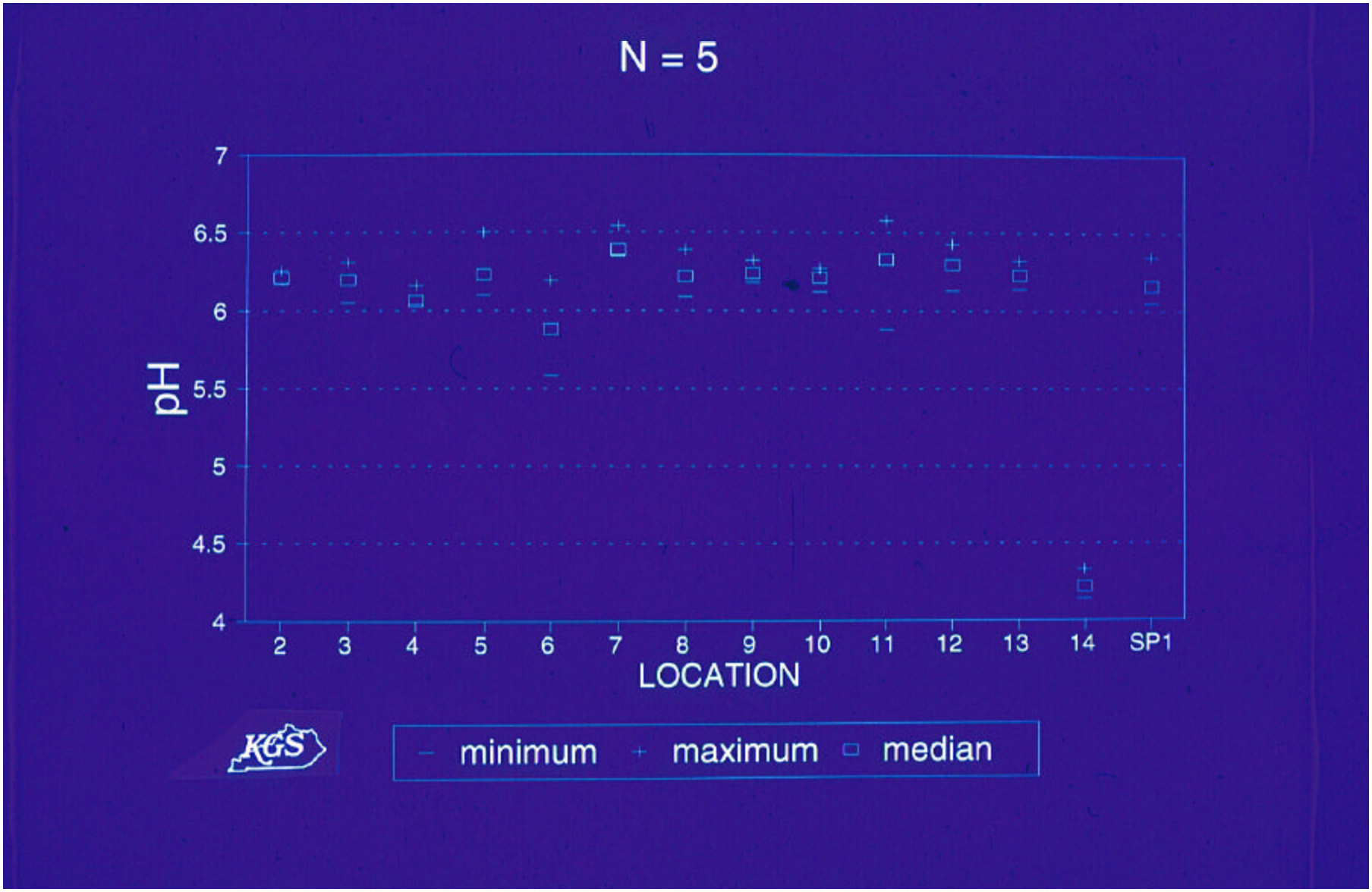
Digital Terrain Model Showing the Bedrock Topography Buried Beneath the Spoil

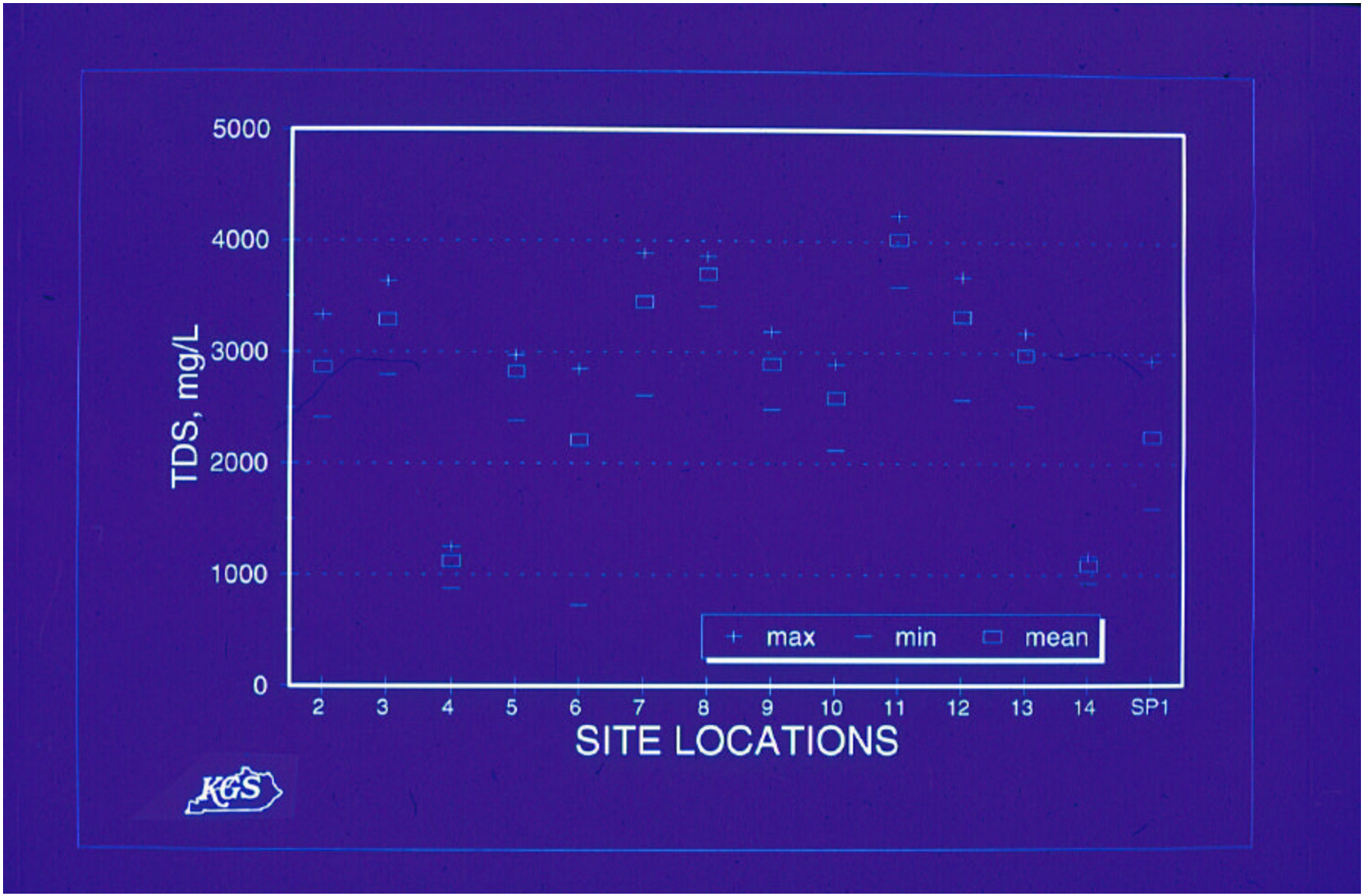



Interior Buried Plateau
Long Fork
Ponds
Spring Gap
Flume Gaging Total
Mine Discharge

Pond Overflow
Spring Discharge

3500


N = 5
pH
7
6.5
6
5.5
5
4.5
4
2
3
4
5
6
7
8
9
10
11
12
13
14
SP1
LOCATION
KGS
minimum
maximum
median


5000
4000
3000
2000
1000
0
TDS, mg/L
2
3
4
5
6
7
8
9
10
11
12
13
14
SP1
SITE LOCATIONS
max
min
mean
KGS

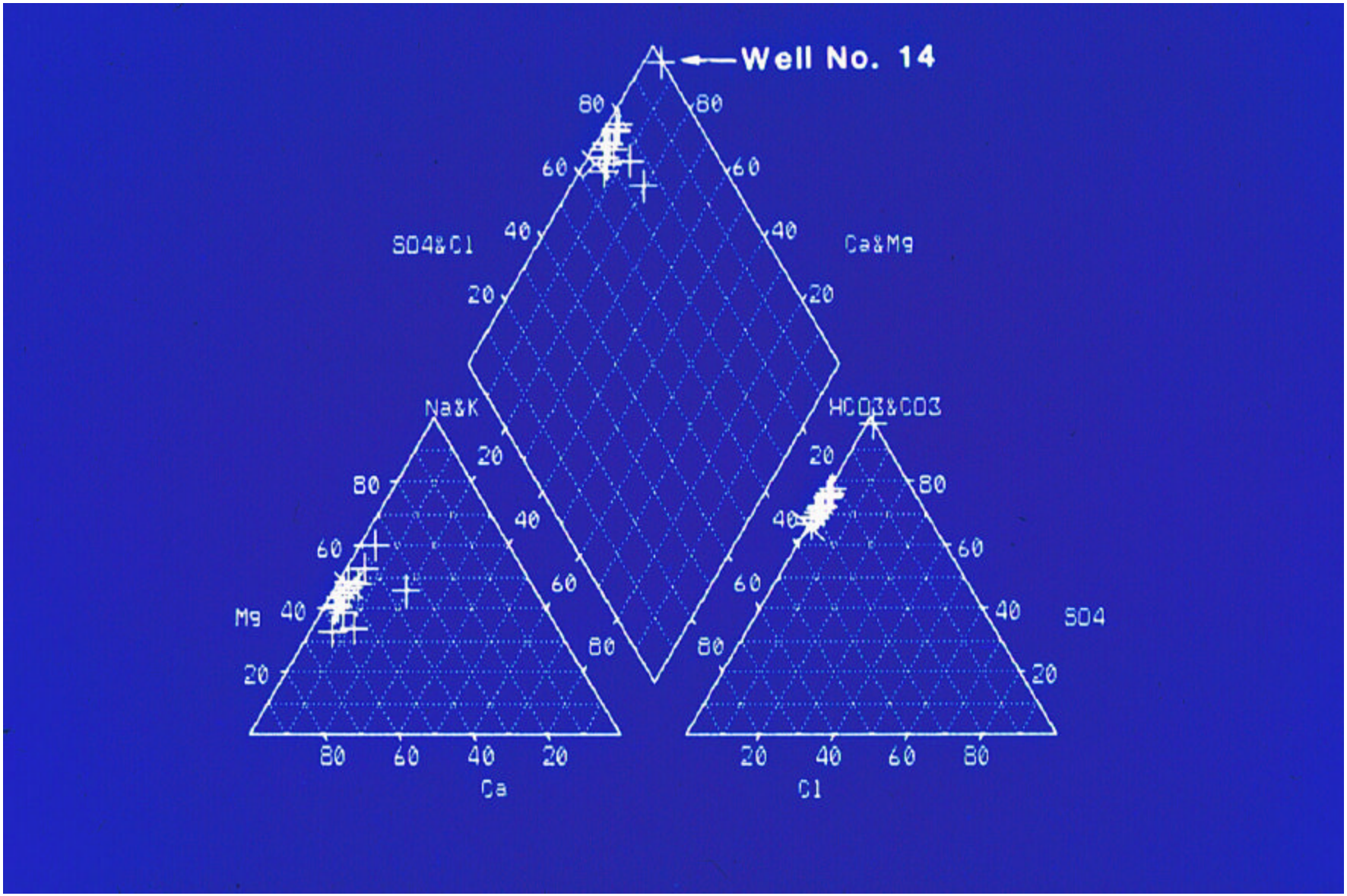
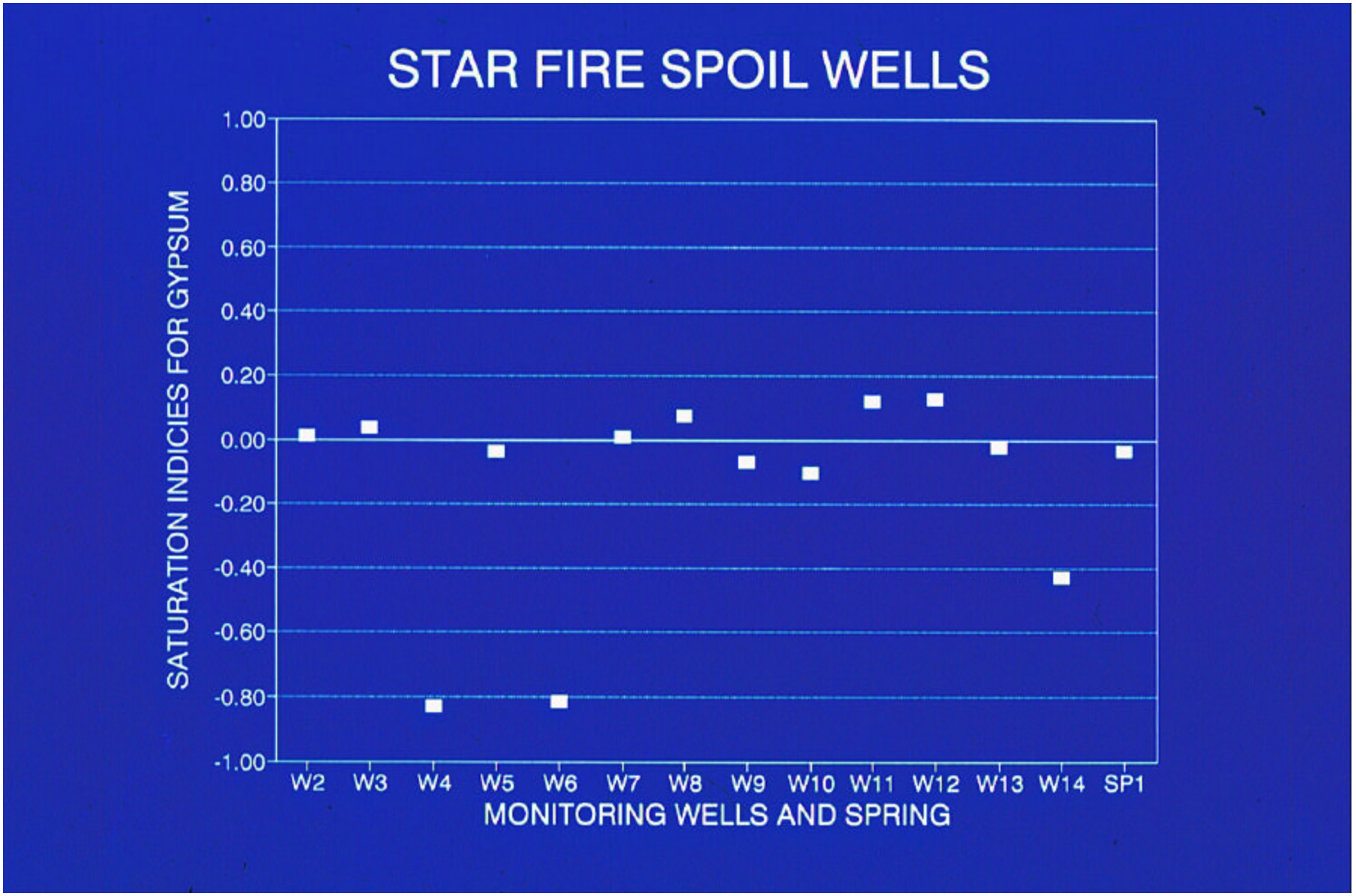
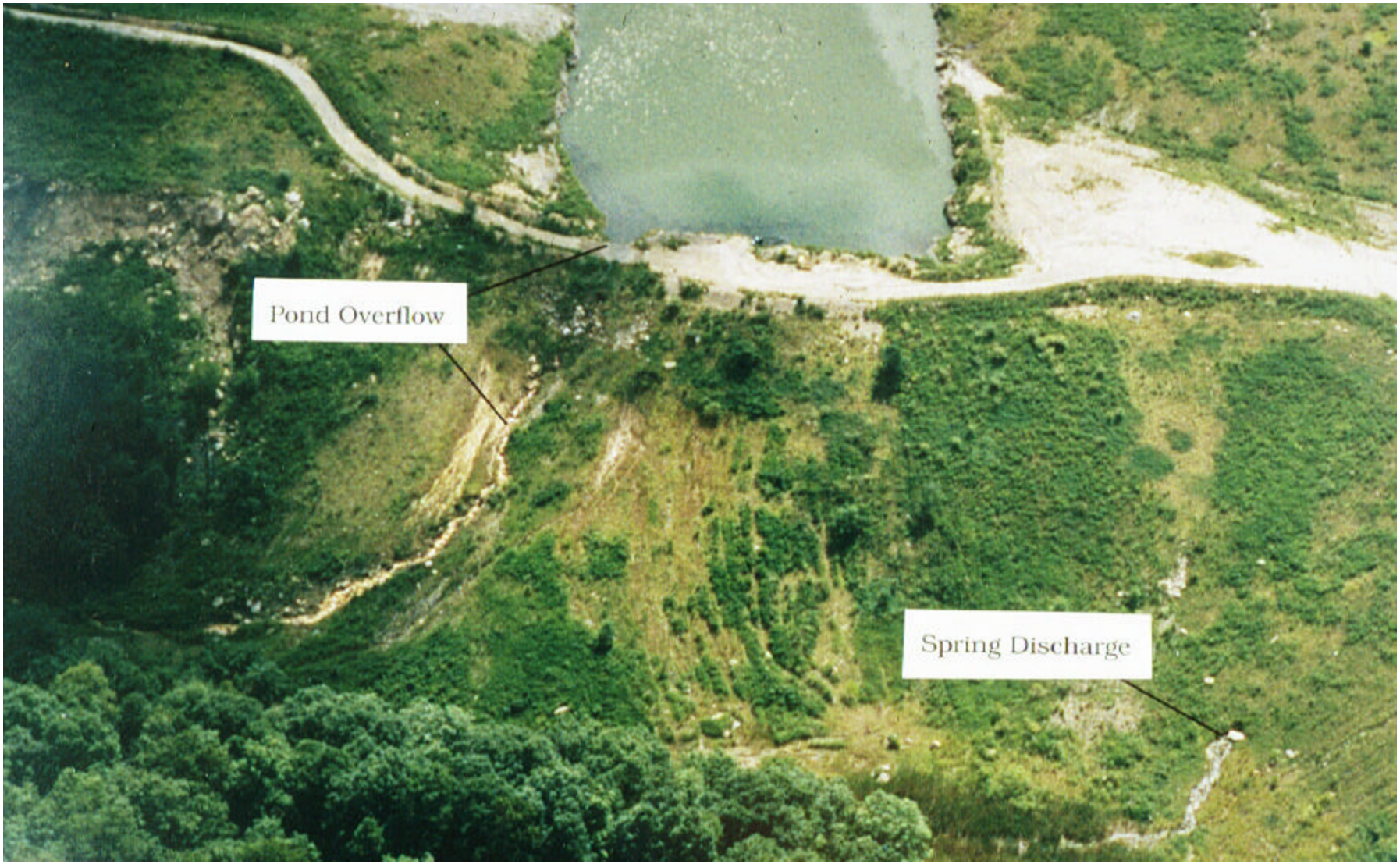

Well No. 14
SO4&Cl
Ca&Mg
Na&K
HCO3&CO3
Mg
SO4
Ca
Cl
80
60
40
20

Table 6. Saturation indicies for selected minerals shown in log IAP/K using the model PHREEQE (Parkhurst and others,1980). IAP= ion activity product, K= equilibrium constant.

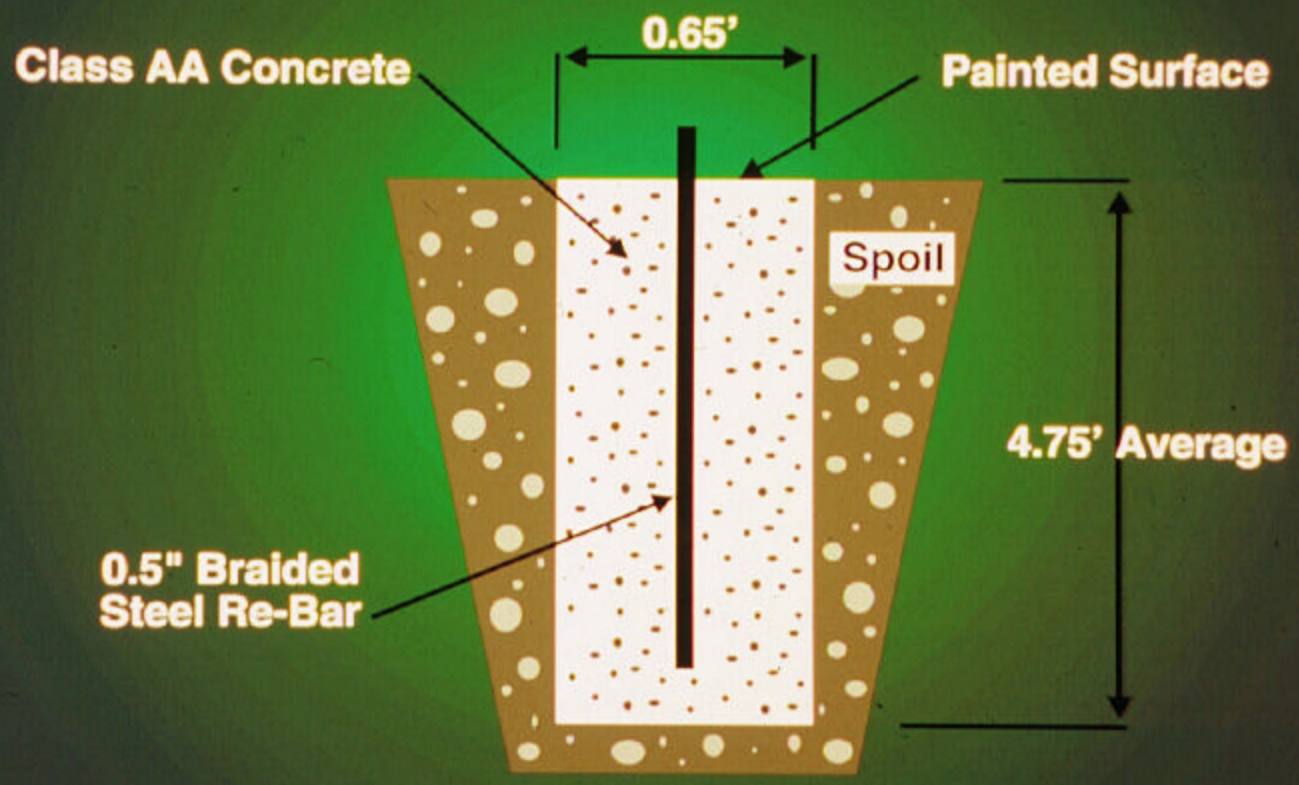
Well #:	Calcite	Dolomite	Gypsum	Chlorite
MW#2	-0.3618	-0.8095	0.0116	-10.9561
MW#3	-0.2230	-0.6151	0.0364	-10.8265
MW#4	-1.2823	-2.4945	-0.8279	-15.3130
MW#5	-0.2750	-0.6708	-0.0378	-10.2089
MW#6	-1.5691	-3.0704	-0.8140	-17.2109
MW#7	-0.2747	-0.3551	0.0095	-7.3621
MW#8	-0.0049	-0.1510	0.0754	-7.8246
MW#9	-0.2792	-0.5369	-0.0681	-9.2461
MW#10	-0.4647	-0.8510	-0.1012	-10.3842
MW#11	-0.5093	-0.9636	0.1195	-12.3585
MW#12	-0.2738	-0.7338	0.1251	-11.3047
MW#13	-0.4078	-0.8301	-0.0217	-9.9278
MW#14	-4.5345	-9.0036	-0.4288	-34.2911
SP 1	-2.4520	-4.9492	-0.0336	-11.5458


STAR FIRE SPOIL WELLS
SATURATION INDICIES FOR GYPSUM
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
W12
W13
W14
SP1
MONITORING WELLS AND SPRING

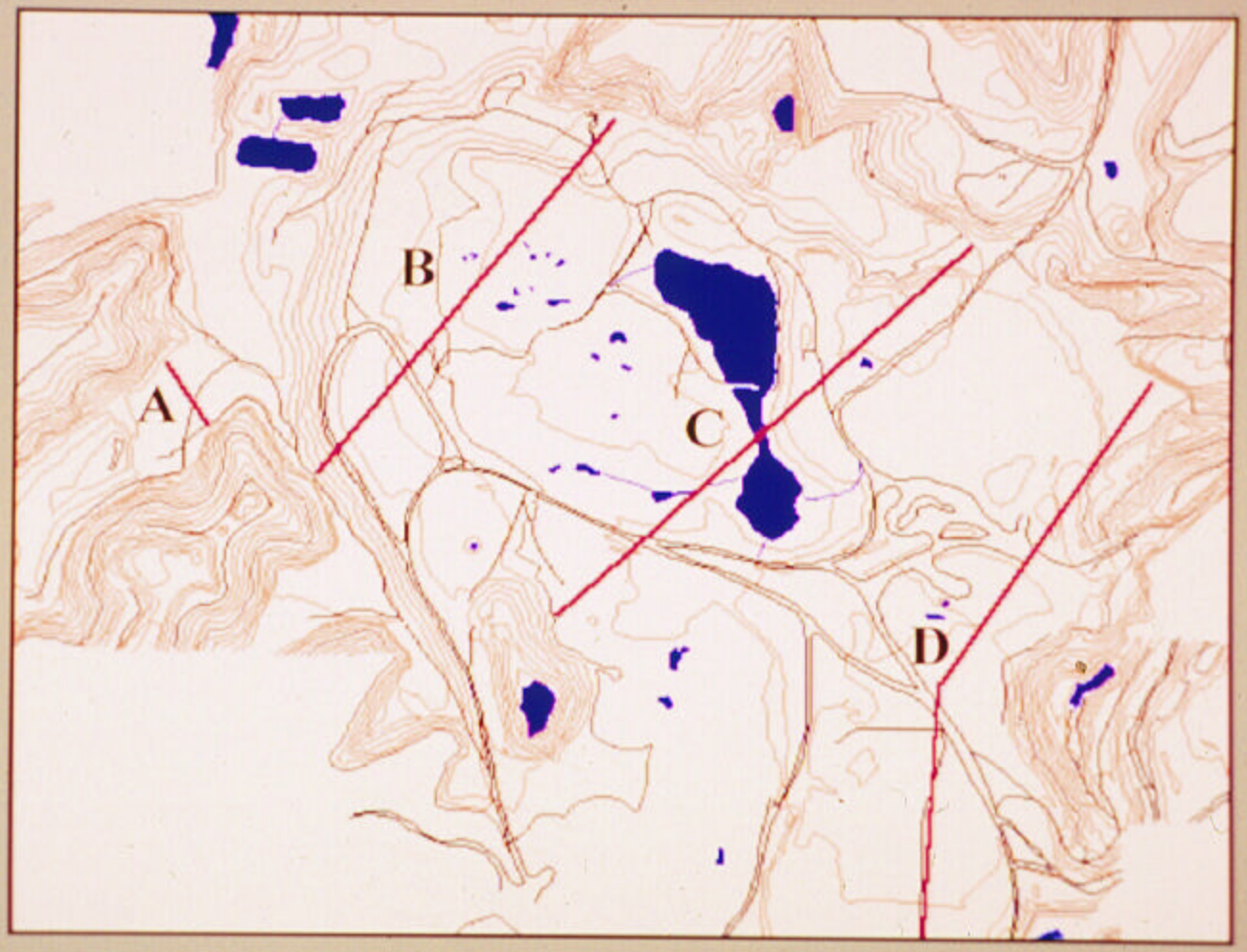

Pond Overflow
Spring Discharge

4

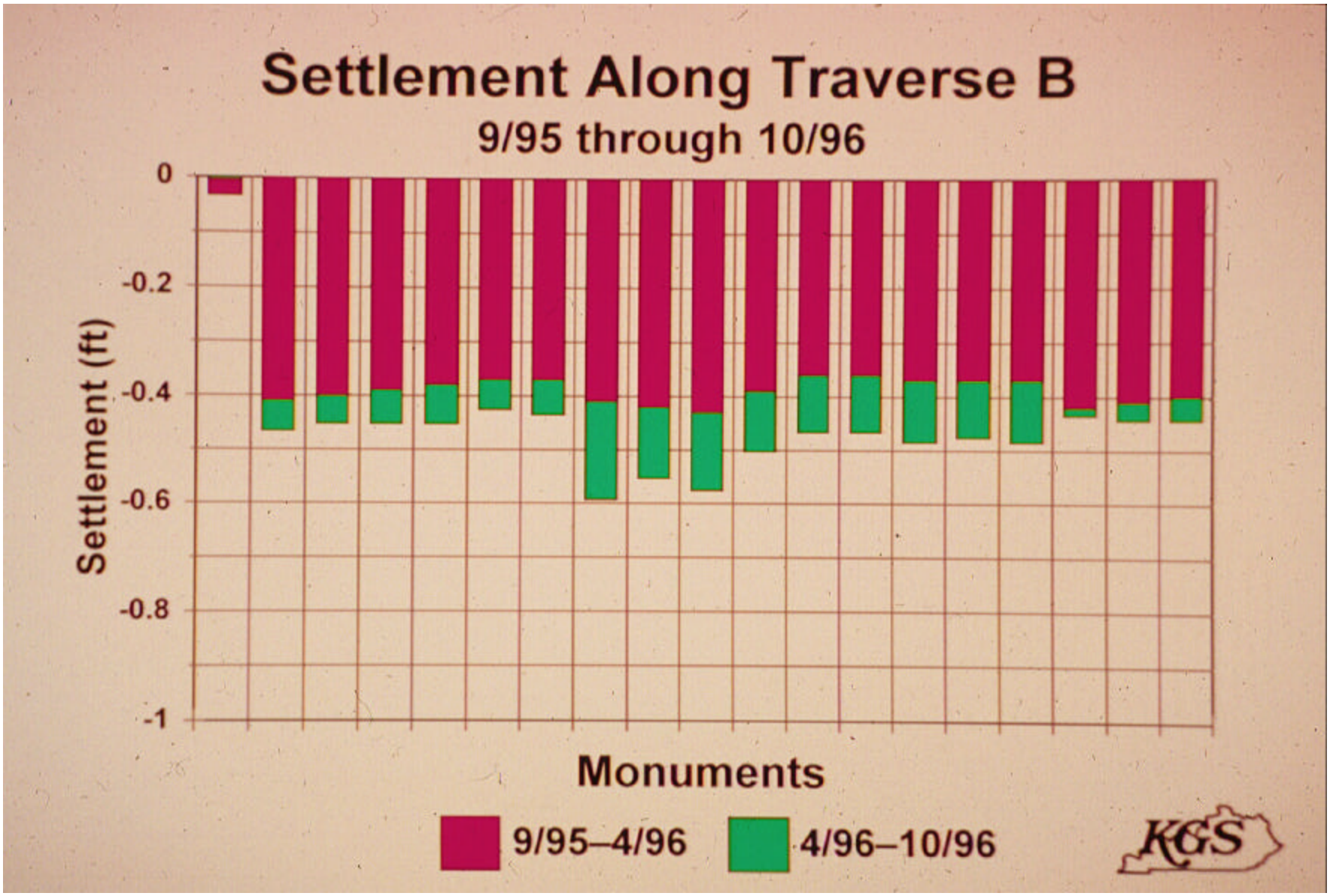
Typical Monument

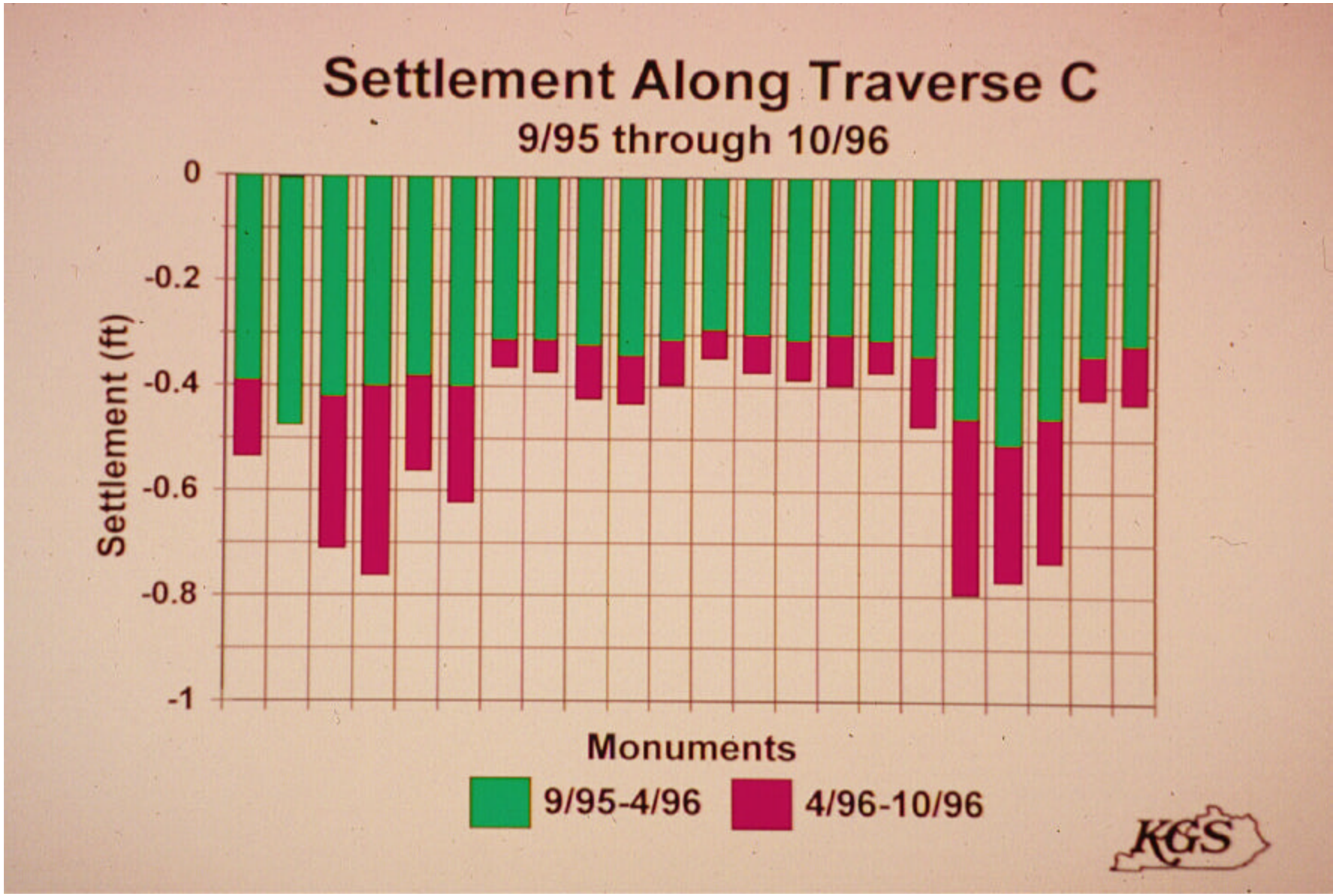


Star Fire Site



KGS


Settlement Along Traverse B
9/95 through 10/96
0
-0.2
-0.4
-0.6
-0.8
-1
Settlement (ft)
Monuments
9/95–4/96
4/96–10/96
KGS


Settlement Along Traverse C
9/95 through 10/96
0
-0.2
-0.4
-0.6
-0.8
-1
Settlement (ft)
Monuments
9/95-4/96
4/96-10/96
KGS

Hydrochemical Facies Model for Dissected, Coal-Bearing Strata in the Appalachian Coal Field

David R. Wunsch, Ph.D.
Kentucky Geological Survey

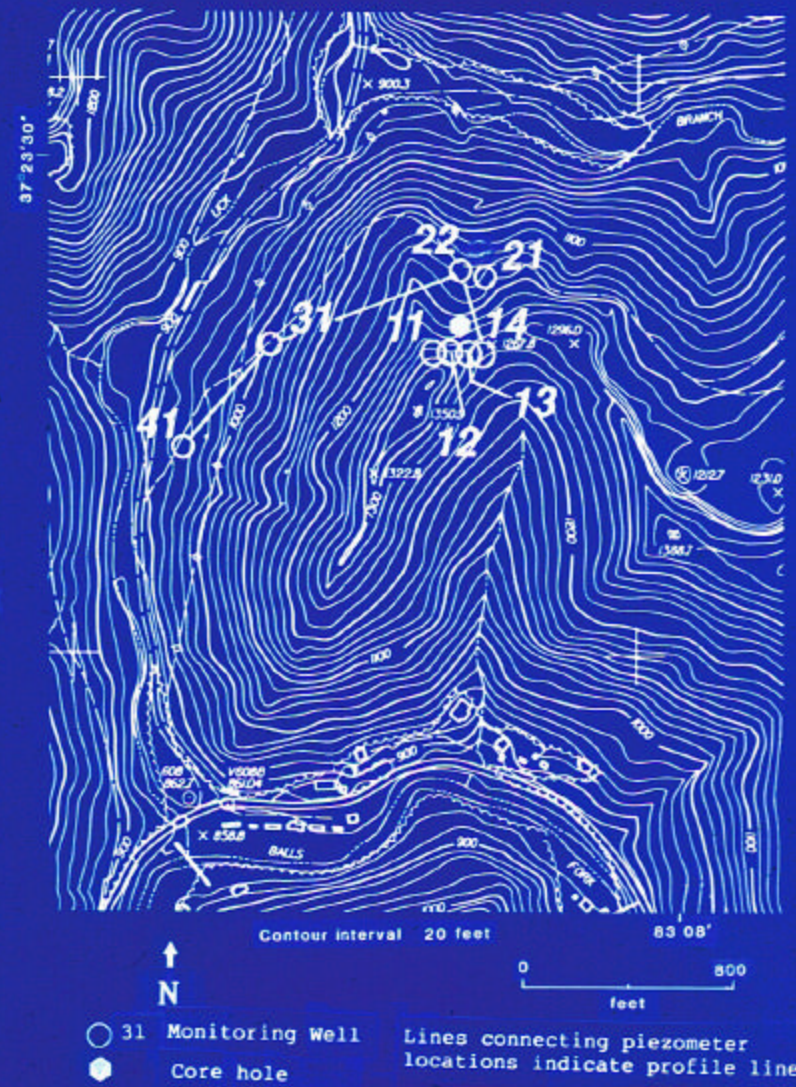
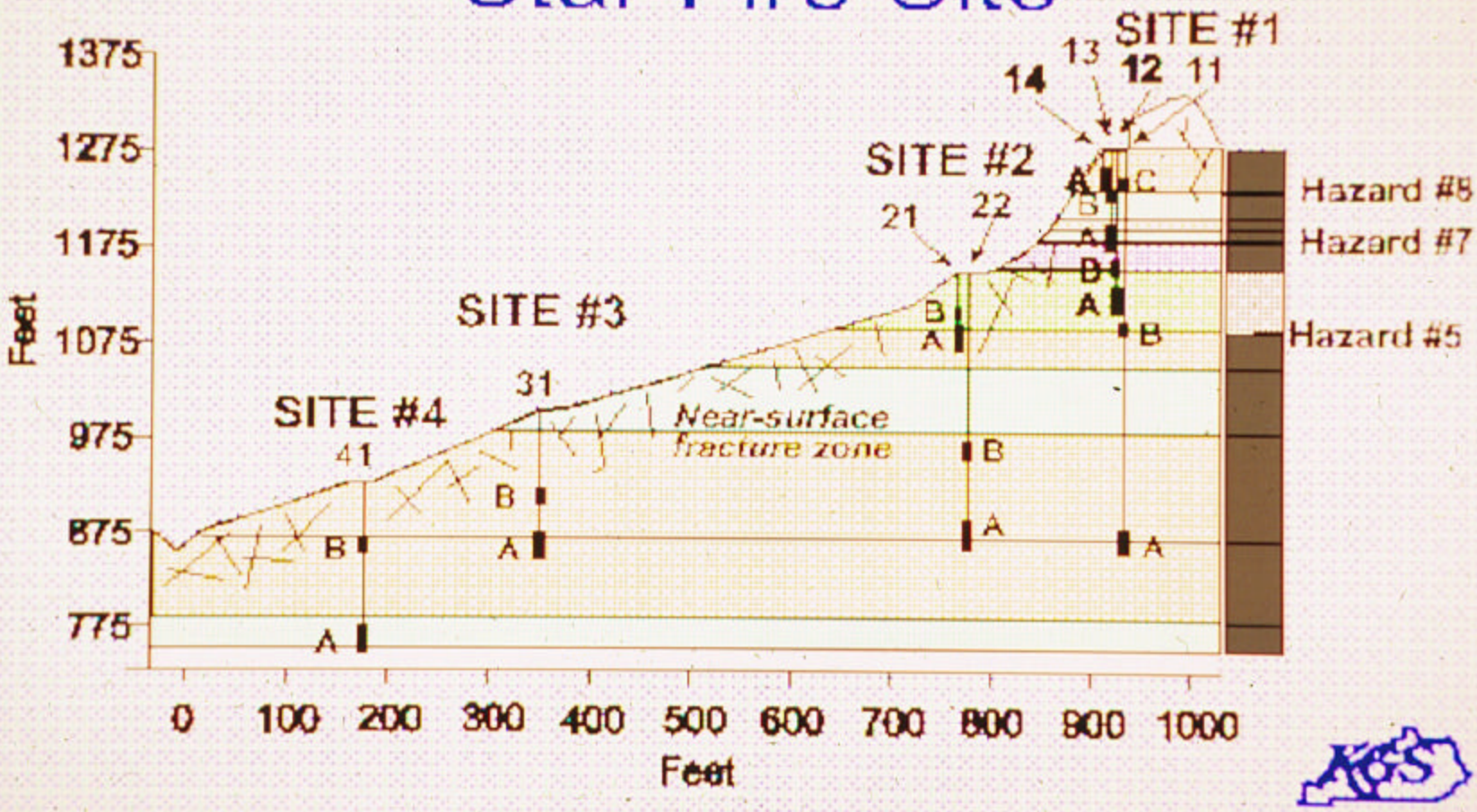
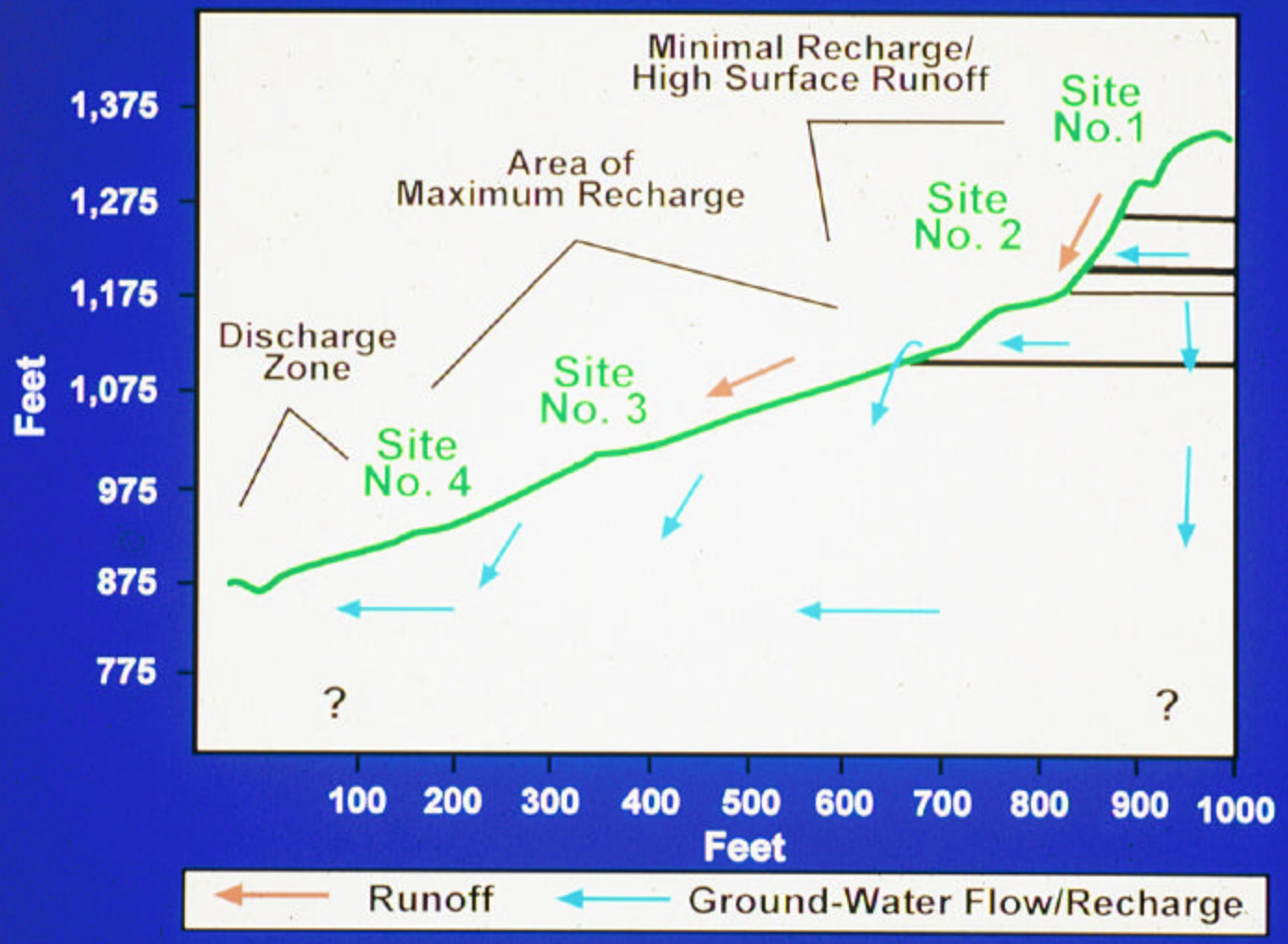
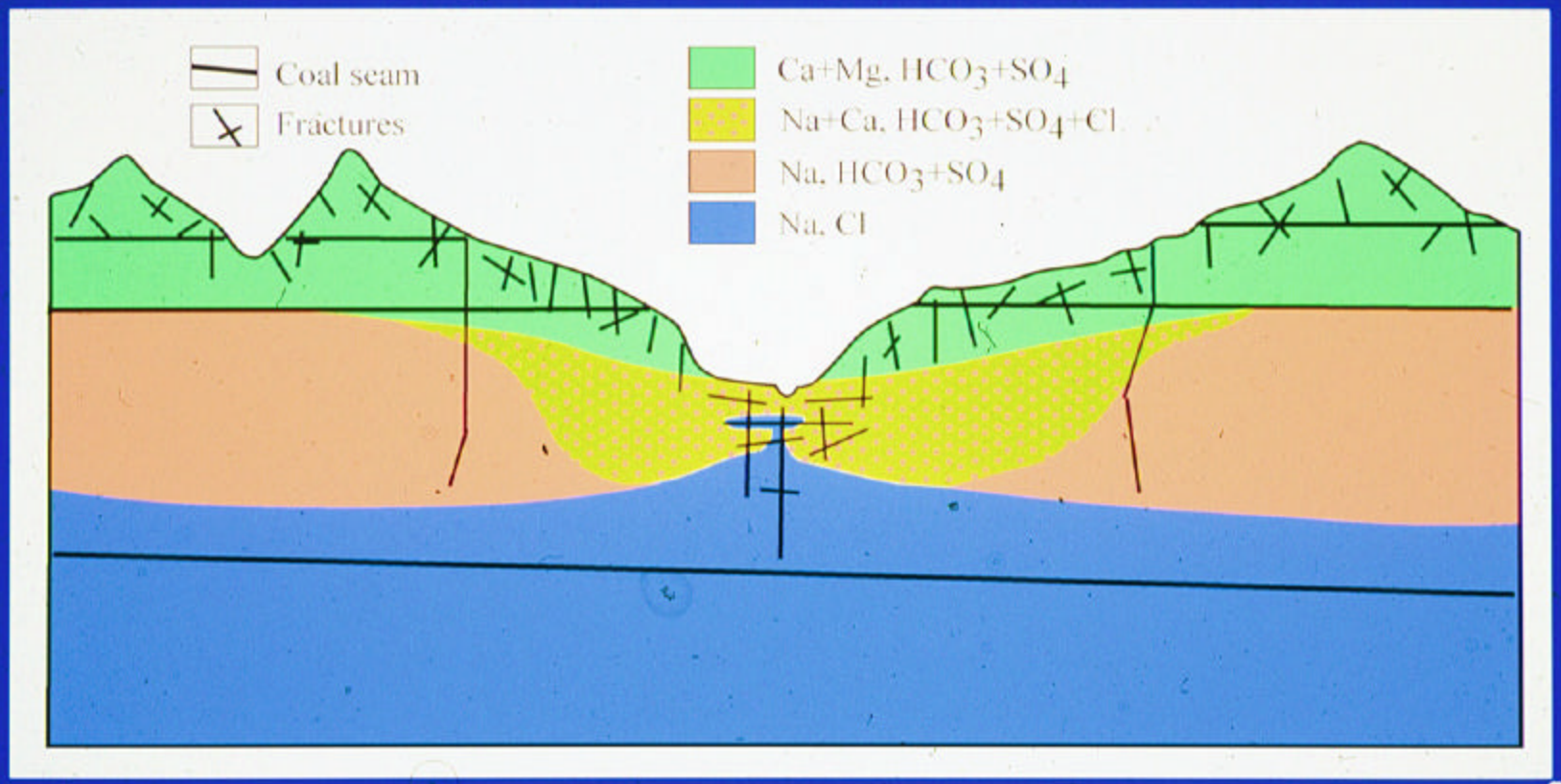


Figure 4. Location of piezometers at the study site.

Star Fire Site



Conceptual Model of Ground-Water Flow



Conceptual Model of Hydrochemical Facies