Mining and Mine Reforestation: Influences on Watershed Hydrology

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Objective

- Contrast hydrologic response of two reclamation techniques
  - Traditional (high compaction)
  - Loose-dumped spoil (minimal compaction)
- With
  - Pre-mining Appalachian hardwood forest

Comparisons Basis: Measured Data

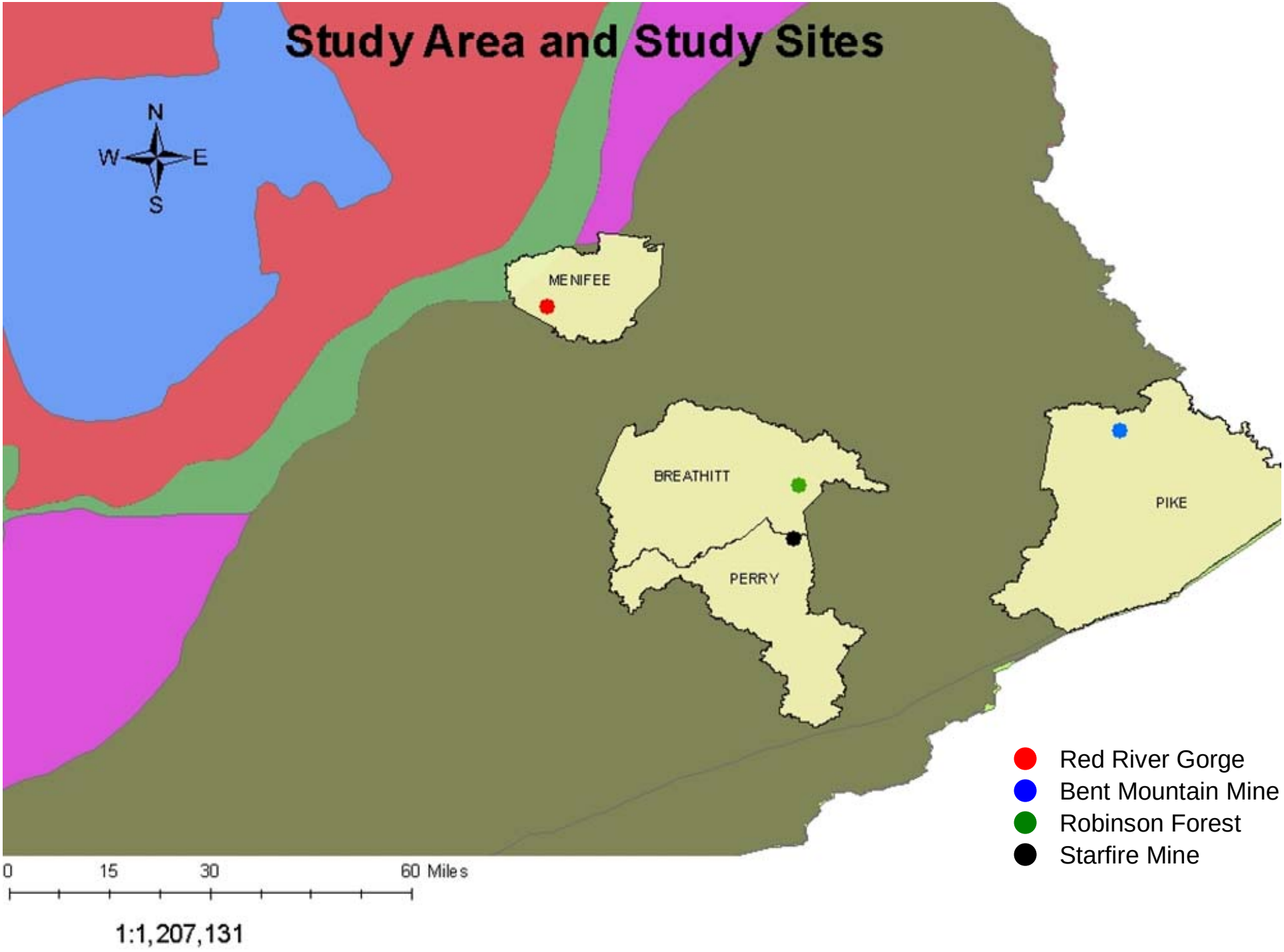
- Robinson Forest (80+ year growth)
- Standard reclamation (Starfire) – compacted spoil
- Bent Mountain test cells – loose-dumped spoil

Comparison Extended through SEDCAD Modeling

- Curve numbers
  - Forest
  - Compacted spoil
  - Loose-dumped spoil

Probably Hydrologic Consequence

- Reclaimed mined land hydrologic regime approximates pre-mining condition (forested)
  - Peak flow
  - Runoff volume
  - Hydrograph characteristics

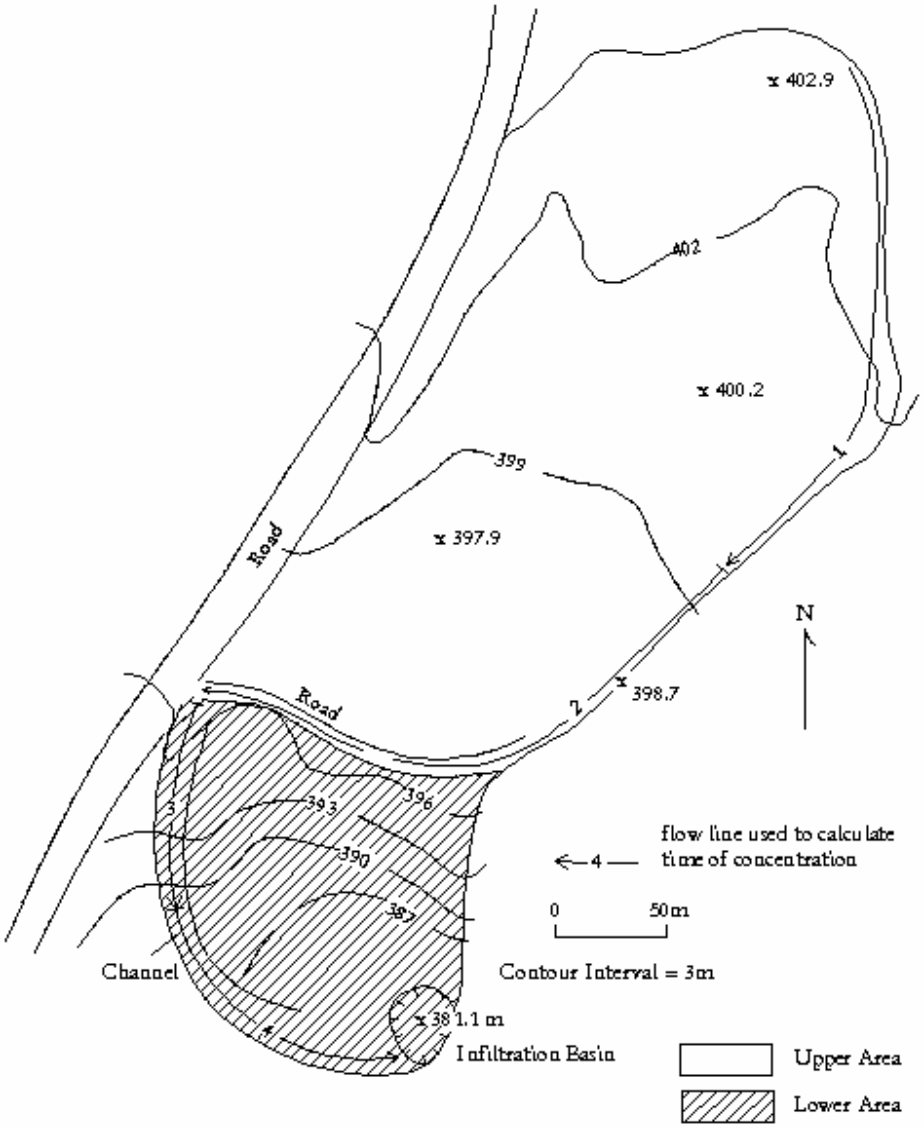

Study Area and Study Sites
N
W
E
S
MENIFEE
BREATHITT
PERRY
PIKE
Red River Gorge
Bent Mountain Mine
Robinson Forest
Starfire Mine
0
15
30
60 Miles
1:1,207,131

Forest Study Site Characteristics

- Drainage area: 81 ha
- Steep slopes (> 50%) with confined narrow valley
- Soils
  - Generally well drained
  - Infiltration rate ~ 120 mm/hr
- Hydrologic soil group A

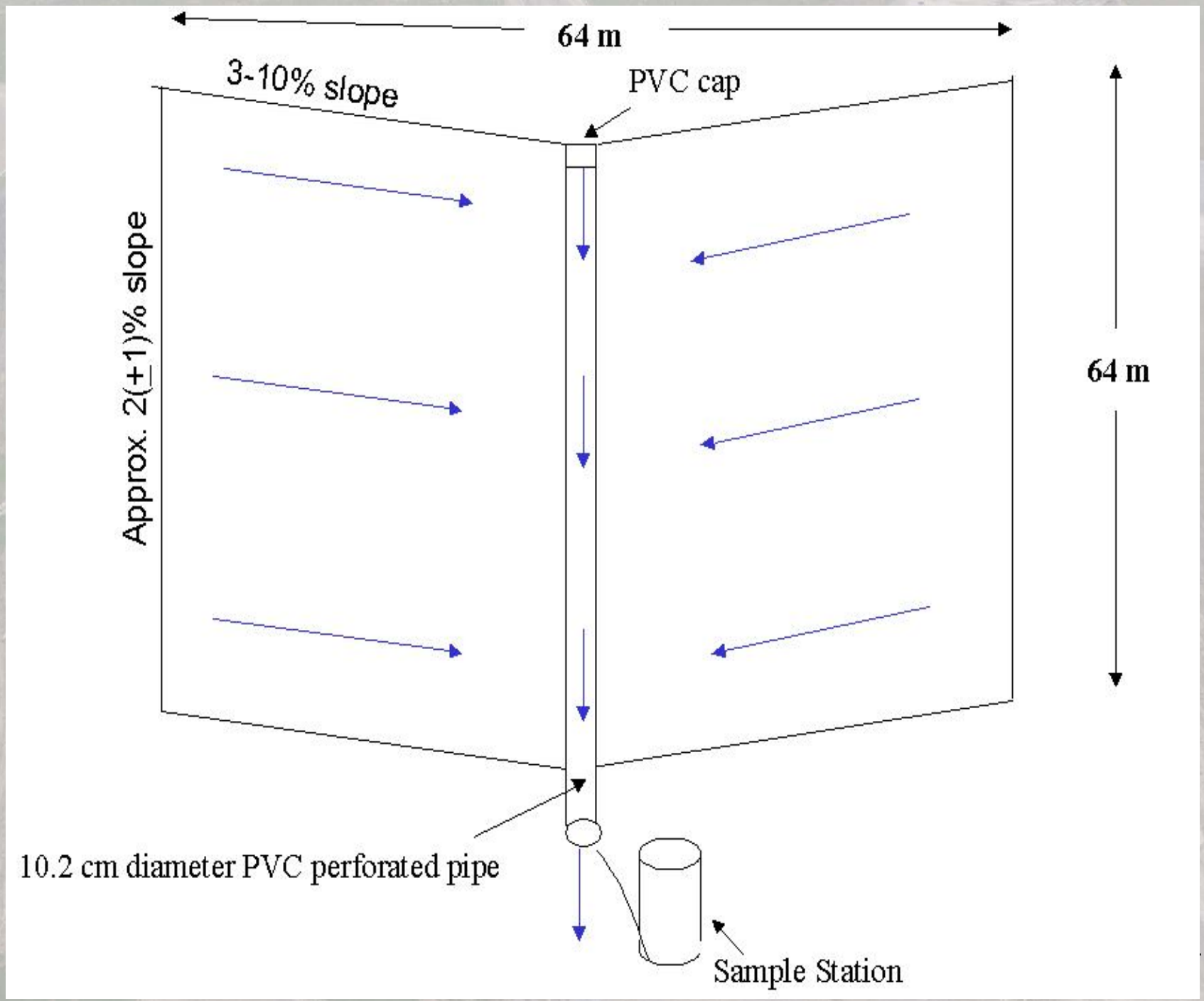
Compacted Spoil Study Site Characteristics

- Drainage area: 7.7 ha
- Slopes: 1.3% upper catchment, 14% lower catchment
- Soils
  - Weathered spoil (sandstone and shale)
  - Compacted
  - Infiltration rate ~ 3-5 mm/hr
- Hydrologic soil group B


x 402.9
402
x 400.2
399
x 397.9
Road
Road
N
x 398.7
396
393
390
387
4
flow line used to calculate time of concentration
0
50m
Channel
Contour Interval = 3m
x 381.1 m
Infiltration Basin
Upper Area
Lower Area

Loose-Dumped Spoil Study Site Characteristics

- Drainage area: 0.4 ha
- Cross slope: 3-10%; longitudinal slope: 2-4%
- Soils
  - Brown weathered sandstone
  - Gray unweathered sandstone
  - Mixture of brown and gray sandstones and shale
- Hydrologic soil group A


64 m
3-10% slope
PVC cap
Approx. 2(±1)% slope
64 m
10.2 cm diameter PVC perforated pipe
Sample Station

Curve Number Methodology

$$Q = \frac{(P - I_s)^2}{(P + I_s)} \qquad P \geq 0.2S \qquad S = \frac{25{,}400}{CN} - 254$$

The variable Q represents the direct storm runoff, P is the storm rainfall, I_s is the initial abstraction (equals 0.2S), and S is the storage. All units are in millimeters.

$$S = 5\left[P + 2Q - \left(4Q^2 + 5PQ\right)^{0.5} \right]$$

When precipitation and runoff volume data are available for a watershed, P and Q pairs are used directly to find a CN.

Forested Curve Numbers: Literature

Location	Area (ha)	CN	Source
Southern Ohio	20	77	Bonta et al. (1997)
Eastern Kentucky	82	85	Hawkins (1993)
Eastern Kentucky	116	93	Hawkins (1993)
Eastern Kentucky	93	91	Hawkins (1993)
Eastern Kentucky	93	86	Springer et al. (1980)
Eastern Kentucky	93	88	Springer et al. (1980)
Eastern Kentucky	93	88	Springer et al. (1980)
Eastern Kentucky	93	92	Springer et al. (1980)
Western North Carolina	46	55	SCS (1972)

Compacted Spoil Curve Numbers: Literature

Location	Area (ha)	CN	Reclamation Method	Source
Western Kentucky	-	82-86	Constructed profile; heavy compaction	Ward (1981)
Southern Ohio	10-17	87-97	Graded spoil; planted to grass and trees	Bonta et. al. (1997)
Pennsylvania	3-32	83-88	Graded spoil; topsoil and revegetation	Ritter and Gardner (1991)
North Dakota	8.8×10^{-4}	96-97 [1]	Unspecified	Schroeder (1987)

Loose-Dumped Spoil: Literature

None

Curve Numbers Measured at Study Sites

- Forested (Little Millseat)
  - Mean: 83 (T. Taylor et al., 2007)
- Compacted spoil (Starfire)
  - Mean: 85 (P. Taylor et al., 1995)
- Loose-dumped spoil (Bent Mountain)
  - Mean: 77 (T. Taylor et al., 2007)

SEDCAD Modeling Inputs

- Area: 100 ac
- Design storm: 10-year 24-hr NRCS Type II, 107 mm
- Forested
  - Time of concentration: 2.7 hr
  - Unit hydrograph shape: slow
- Compacted spoil
  - Time of concentration: 0.37 hr
  - Unit hydrograph shape: fast
- Loose-dumped spoil
  - Time of concentration: 3.5 hr
  - Unit hydrograph shape: slow

SEDCAD Estimated Peak Flows and Runoff Volume

	Peak Flow (m^3/s)			Runoff Volume (m^3)
CN	**Forest**	**Compacted Spoil**	**Loose-dumped Spoil**	**All**
70	0.37	3.34	0.30	15,057
75	0.48	4.20	0.39	18,688
80	0.60	5.10	0.49	22,697
85	0.73	6.01	0.60	27,108


Questions?