



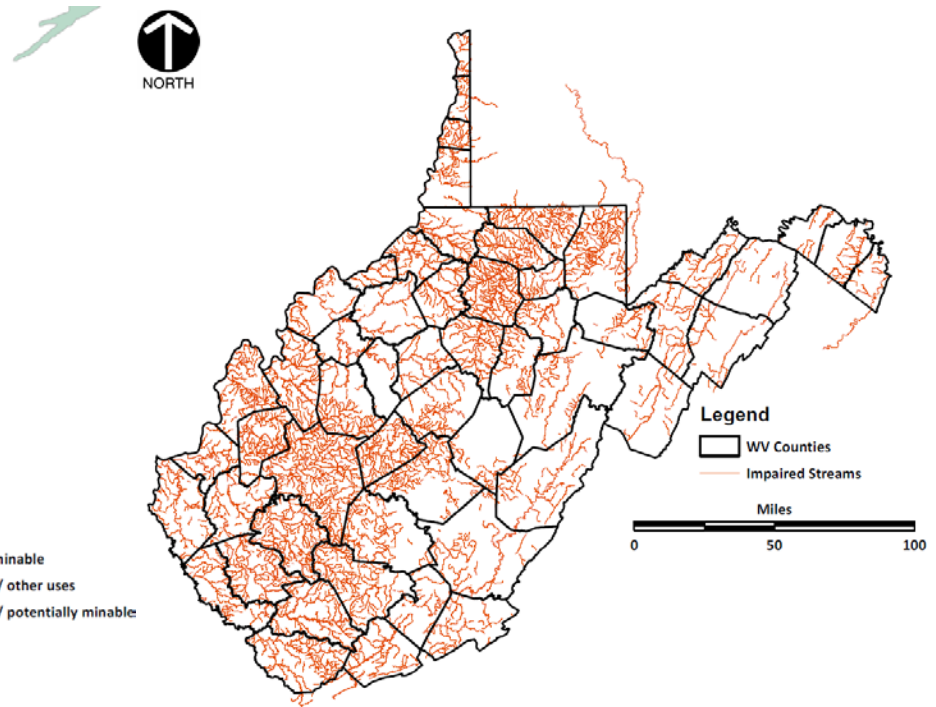
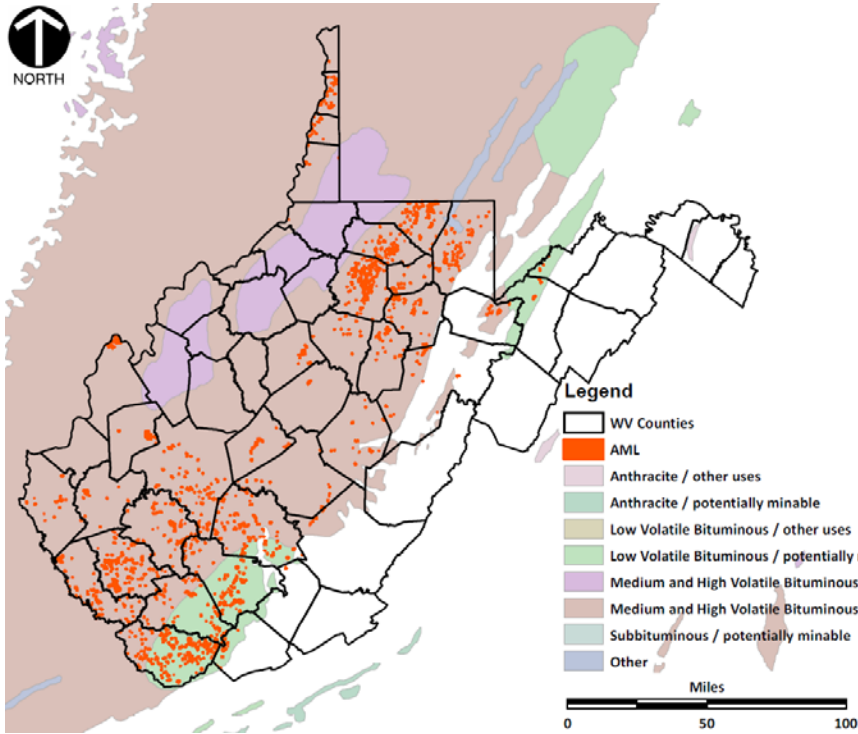
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Stream Restoration on Mining Impacted Properties

West Virginia Mitigation Banking

Timothy A. Denicola

West Virginia Coal Mining



*Data from WVDEP and WV GIS Technical Center



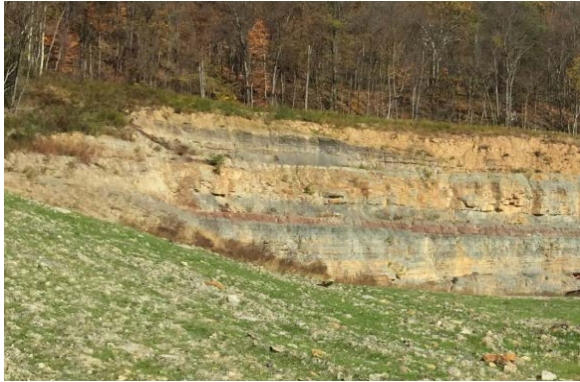
Residual Mining Impacts

Disturbs local and regional geomorphology, hydrology, chemistry, and ecology

- ▶ Excavation of geologic units
- ▶ Disposal of overburden
- ▶ Development of surface seeps and mine pools
- ▶ Impacts to tributary headwaters
- ▶ Generation of acidity and metal (Fe, Al, Mn) precipitates
- ▶ Degradation of aquatic habitats



Residual Mining Impacts



Reclamation Techniques for AML

- ▶ Grading and drainage
- ▶ Material handling plans for “hot” material
 - Disposal of reactive material offsite
 - Encapsulating reactive material onsite
- ▶ Active, semi-active, and passive chemical treatment
 - Fully automated treatment facilities
 - Semi-automated reagent delivery with passive techniques
 - Limestone beds, settling ponds, aerobic wetlands



Example Techniques for AML



*Bingmaps.com



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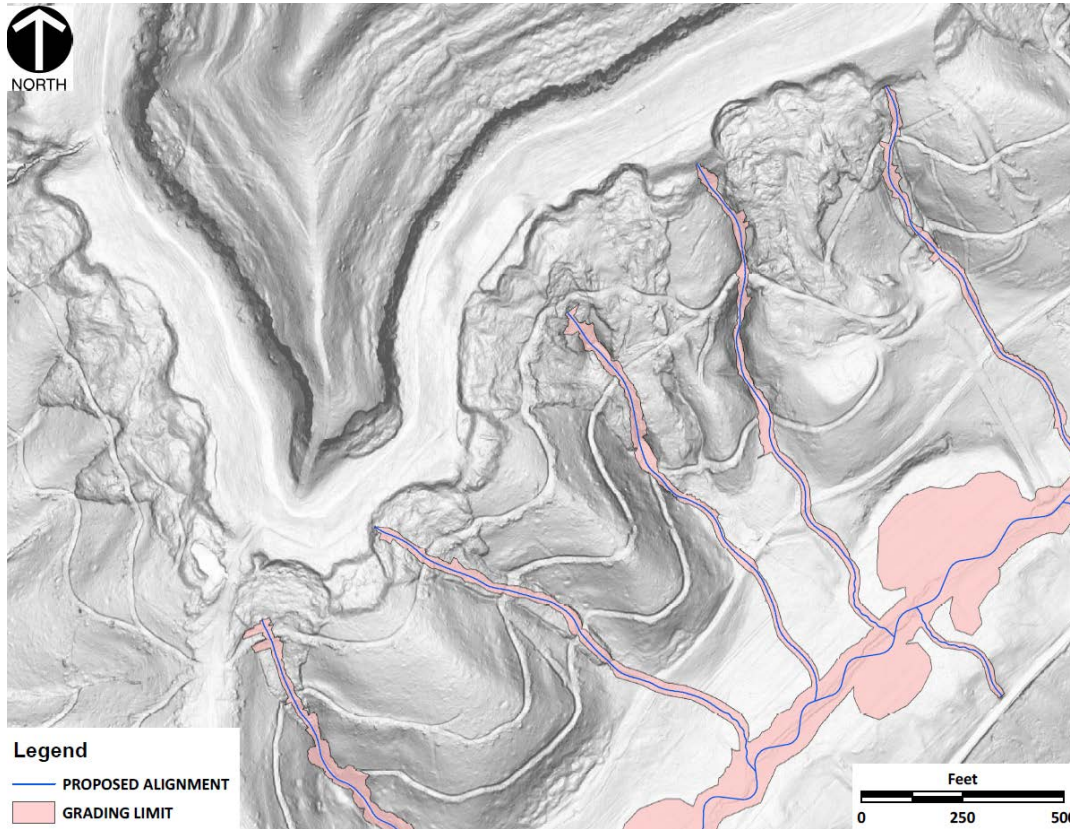


Modifications for Restoration

- ▶ Mine spoil identification
- ▶ Excavation and sequestration
- ▶ Soil amendment
- ▶ Aerobic wetland construction
- ▶ Natural Site Stabilization / Revegetation
- ▶ Impermeable barrier installation



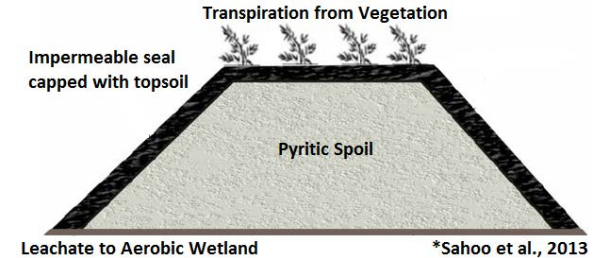
Mine Spoil Identification



- ▶ Identify spoil from high resolution LIDAR imagery
- ▶ Overlay grading limits on digitized spoil area
- ▶ “Hot” material heterogeneously distributed
- ▶ Excavate test pits
- ▶ Conduct analytical soil and water analysis

Mine Spoil Handling

- ▶ Excavate and sequester “hot” material to designated disposal areas
 - Encapsulate with impermeable material
 - Revegetate
 - Construct BMPs for leachate
- ▶ Amend remaining spoil within grading limits
 - Limestone fines and organic compost
 - Alkalinity reduces prevalence of acidophilic, iron-oxidizing bacteria
 - Organic compost depletes oxygen available for mineral oxidation



Aerobic Wetlands



Natural Site Stabilization

▶ Initial Construction

- Introduces oxygenated groundwater
- Increases mineral surface area exposure
- First-flush of recently exposed/oxidized constituents

▶ Post-Construction

- Progressive depletion of groundwater oxygen
- Stabilization of water table
- Depletion of first-flush mineral concentrations

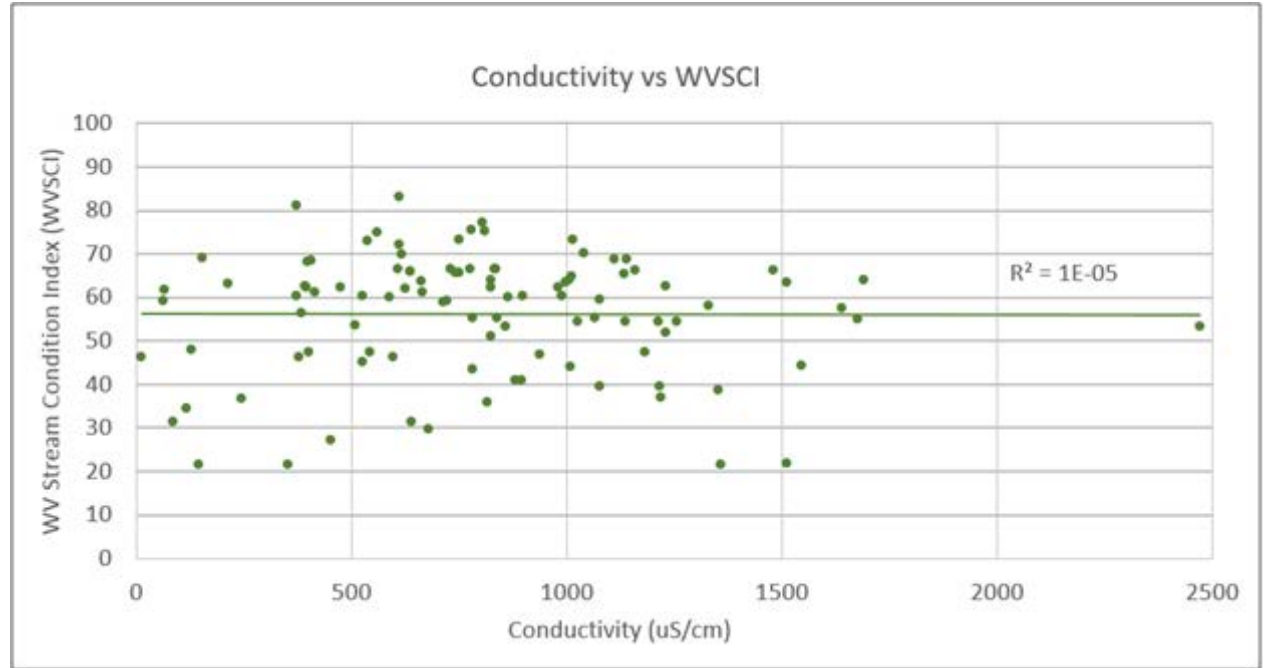
▶ Revegetation

- Aides site stabilization
- Increased transpiration, reduces groundwater/mineral interaction



Total Dissolved Solids

TDS mg/L	Ca %	Alk %	SO4 %	Total %
1121	20%	34%	40%	94%
842	20%	27%	46%	92%
949	19%	23%	50%	92%
1351	19%	31%	45%	94%
379	17%	26%	50%	93%
2316	21%	16%	57%	94%
1432	22%	23%	48%	94%
1928	23%	10%	60%	94%
1087	15%	17%	55%	88%
299	15%	58%	22%	95%
289	27%	27%	41%	95%
645	22%	24%	45%	91%
438	19%	13%	61%	93%
790	20%	6%	68%	94%
615	21%	19%	53%	92%



Impermeable Barriers

- ▶ Onsite clay-rich soil
 - Excavated from nearby pastureland
- ▶ Soil/bentonite slurry
 - Mixed onsite with grout-like application technique
- ▶ Bentomat or Claymax brand geosynthetic liners
 - Keyed in beyond bankfull



AML Reclamation Literature

- ▶ WVDEP (2017) Division of Mining and Reclamation Permit Handbook
- ▶ WVDEP (2005) Division of Mining and Reclamation Geologic Handbook
- ▶ WVDEP (2001) Division of Mining and Reclamation Quarry Handbook
- ▶ WVDEP (1993) Division of Mining and Reclamation Technical Handbook
- ▶ WVDEP (1992) Division of Mining and Reclamation Inspection and Enforcement Handbook
- ▶ Office of Surface Mining (1980) Coal Mine Operators Handbook
- ▶ University of Kentucky (1996) Kentucky Coal Mining Practice Guidelines for Water Quality Management
- ▶ Smart, et al. (2015) Assessment of Acid Neutralization Rates from Site Rock for AMD Control
- ▶ Sahoo et al. (2013) Current Approaches for Mitigating Acid Mine Drainage
- ▶ Gusek (2012) Sulfate-Reducing Bioreactor Design and Operating Issues
- ▶ Wilkin, et al. (2008) Contaminant Attenuation Processes at Mine Sites
- ▶ Johnson, et al. (2005) Acid Mine Drainage Remediation Options
- ▶ Office of Surface Mining (2000) Handbook for Calculation of Reclamation Bond Amounts
- ▶ Rose, et al. (1996) Remediation of Acid Mine Drainage Within Strip Mine Spoil by Sulfate Reduction Using Waste Organic Matter
- ▶ Vile, et al. (1992) Alkalinity Generation by Fe(III) Reduction Versus Sulfate Reductions in Wetlands Constructed for AMD Treatment



Anticipated Outcome

▶ Anticipated Outcome

- Reduced discoloration
- Reduced conductivity
- Increased WV Stream Condition Index (WVSCI) scores
- Increased Stream and Wetland Valuation Metric (SWVM) scores

▶ Prior Successes – Mitigation Banks on AML

- Copperas
- Lower Dempsey
- Marytown



Questions / Comments

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