

EVOLVE CAPP

Evolve Central Appalachia

DE-FE0032055

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ACKNOWLEDGEMENT

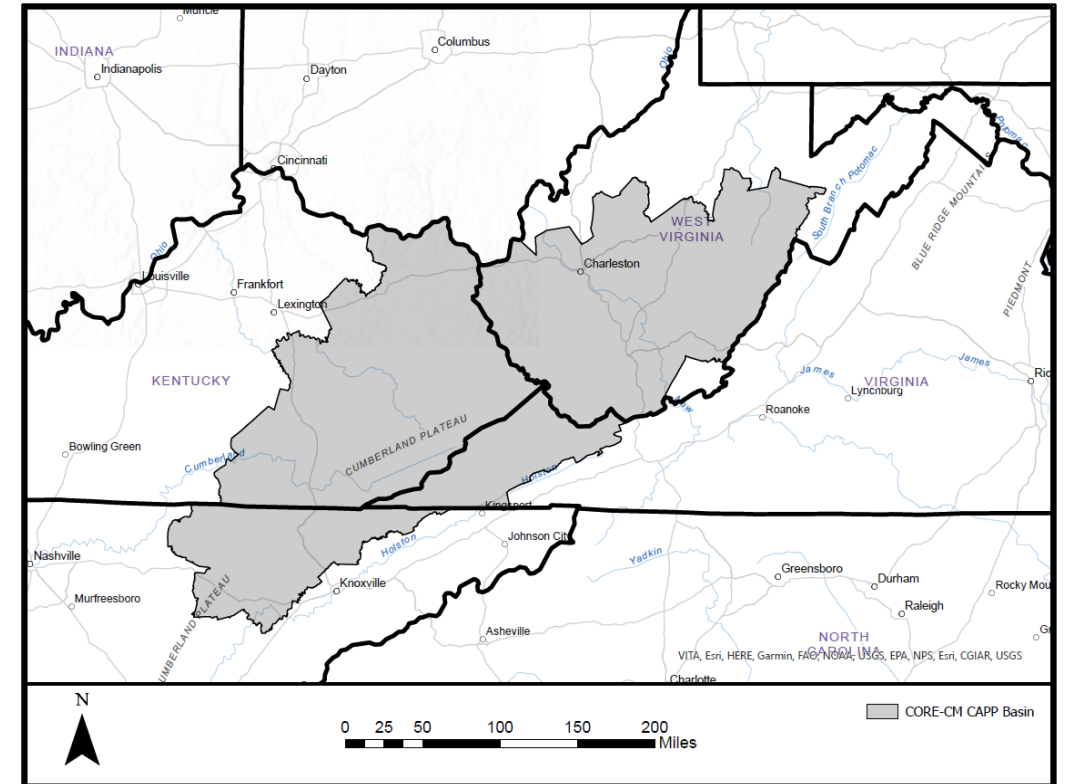
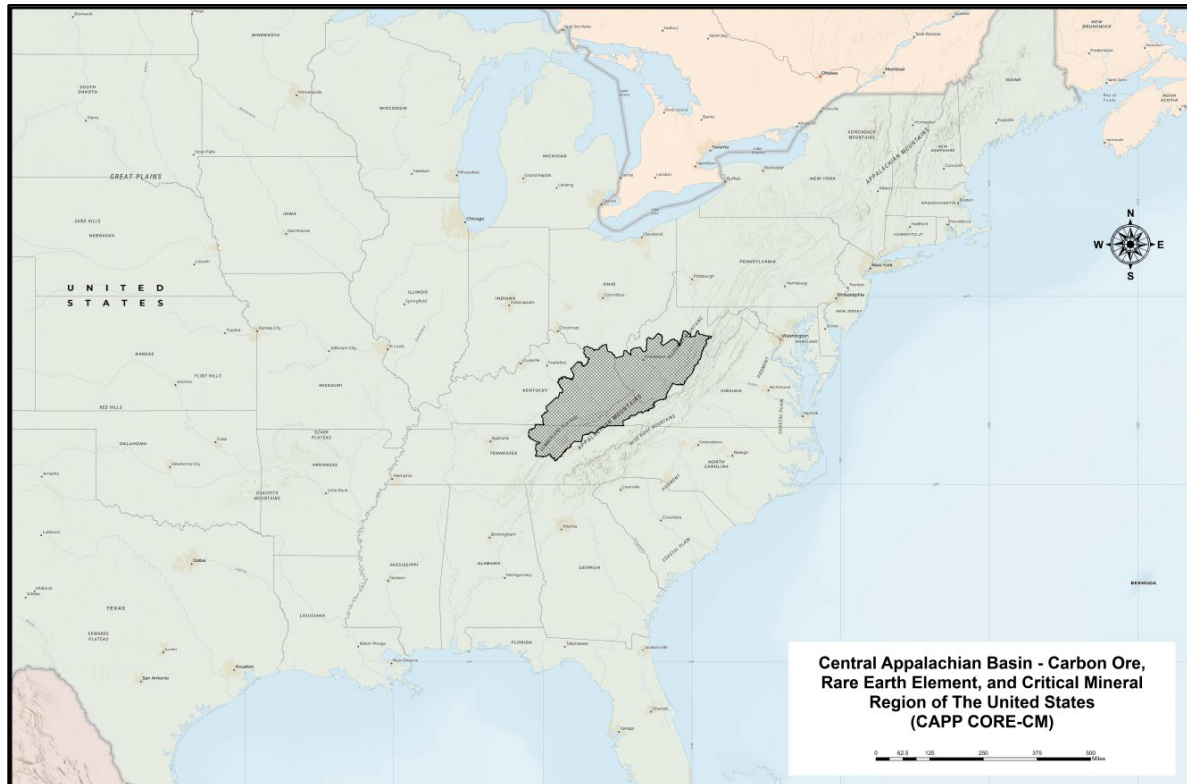
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PROJECT OVERVIEW

- Investigating the Rare Earth & Critical Minerals potential of the Central Appalachian (CAPP) basin
- Project Dates: October 1, 2021 – September 30, 2024; Funding: **\$2,084,999 DOE** + **\$623,868 cost share**



RESEARCH TEAM

**West Virginia University
Mining Engineering**

**Virginia Tech
VCCER & Mining Engineering**

**University of Kentucky
Mining Engineering**

Marshall Miller & Associates

Gray Energy Technologies

Oak Ridge National Laboratory

Advanced Resources Intl.

Chmura Economics

U. S. Geological Survey

Crescent Resource Innovation

Southern States Energy Board

Virginia Dept of Energy

Mountain Empire Community College Coalition

- Mountain Empire Community College (MECC), VA
- Roane State Community College (RSCC), TN
- Southeast Kentucky Community & Tech. College (SKCTC)
- Southern West Virginia Comm. & Tech. College (SWVCTC)

PROJECT SCOPE

The general Evolve CAPP project scope is to:

- 1) Assess existing knowledge*
- 2) Perform a gap analysis*
- 3) Fill identified gaps with future projects*
- 4) Provide educational & public outreach*



ADDRESSING ISSUES, BARRIERS & INCENTIVES

Issues/Barriers (some are lost in the Technology conversation):

- ✓ Technology is not meeting Responsible Sourcing Standards!
- ✓ Asserting Minerals Titles to both Geologic & Waste Stream resources
- ✓ Waste Steams Regulations & Permitting - Authorities & Regulatory jurisdiction in Collection, Processing & Marketing
- ✓ Companies' reluctance to allow access to reclaimed waste sites for sampling & testing purposes. A significantly robust safety net & financial interest may have to be devised for those owners
- ✓ Is CORE-CM the Primary Production or a Byproduct? - What Happens if Mine/Plant closes?
- ✓ Local Community Expectations
- ✓ Production costs & margins
- ✓ Dependence on Global Pricing, “Dumping” & Arbitrage Issues

Incentives:

- ✓ Experience with Tax Credits, Low Interest Loans, Government-Supported FEED Studies
- ✓ New ideas needed (from Long-Term Government Contracts to Robust Community Benefits)



EVOLVE CAPP PRIORITIES & PRINCIPLES

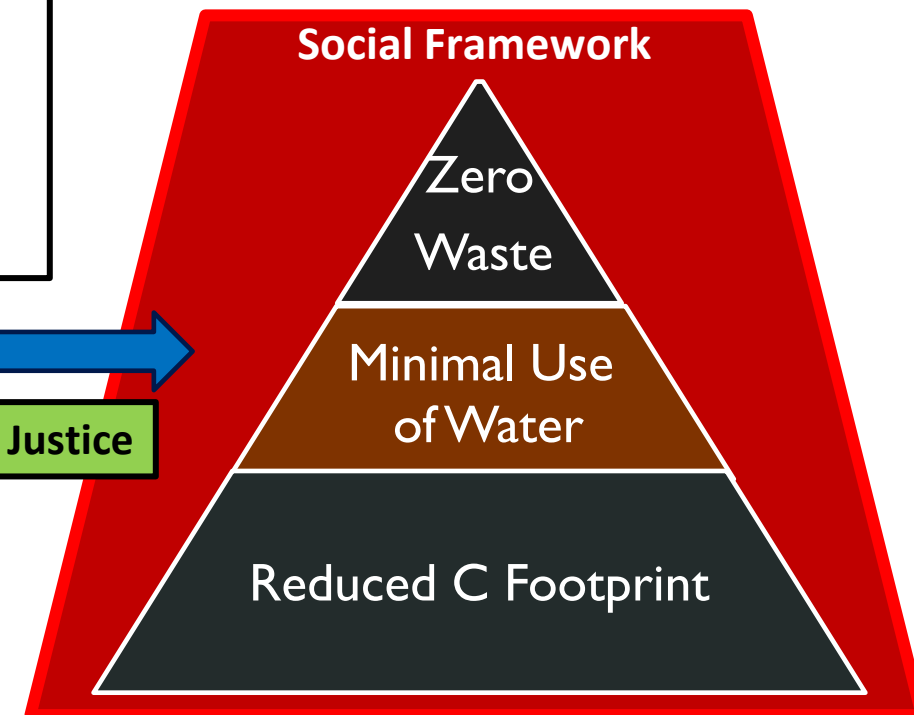
Evolve CAPP Priorities:

- ✓ Establish a CORE-CM Stakeholder **Community**
- ✓ Develop Vibrant CORE-CM Domestic Industries
- ✓ Supply Green & Digital Economy & Contribute to National Security
- ✓ Avoid Mineral Supply Risk, Potential Interruptions
- ✓ Create Downstream Value-Added Industries & Chains
- ✓ Stimulate Economic Growth in CAPP Region
- ✓ Foster New Job Creation & Upskilling of Local Workforce

Evolve CAPP Principles:

- Develop/Adopt Technologies, Processes & Best Practices that aim for “Zero Impacts” & can earn Social Acceptance
- **Sustainable/Responsible Sourcing**

Positive Environmental & Social Outcomes





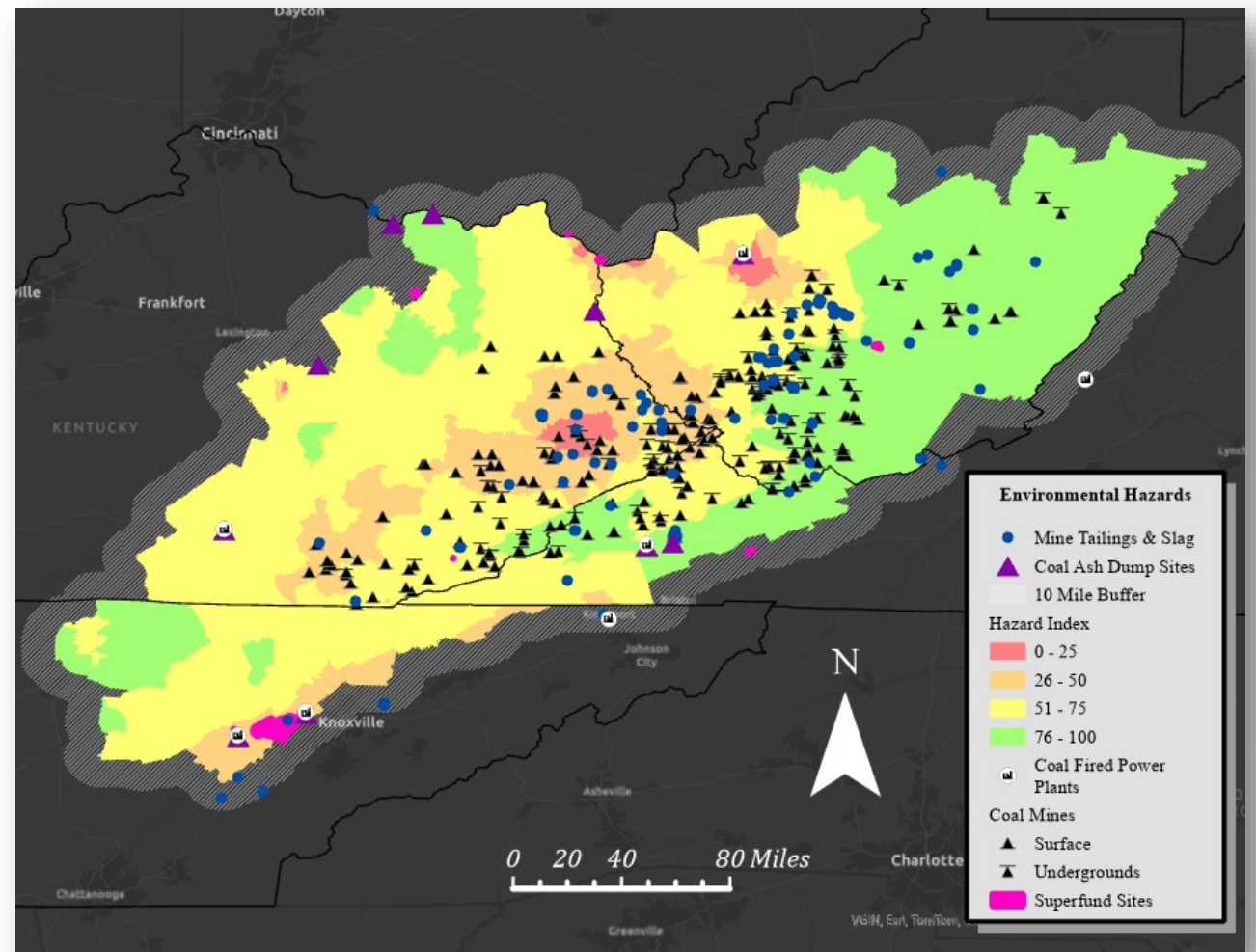
ENVIRONMENTAL JUSTICE

ENVIRONMENTAL HAZARDS IN THE CAPP REGION

Methods of Analysis:

ArcGIS, EJScreen, CORD, CEJST, & other publicly available data

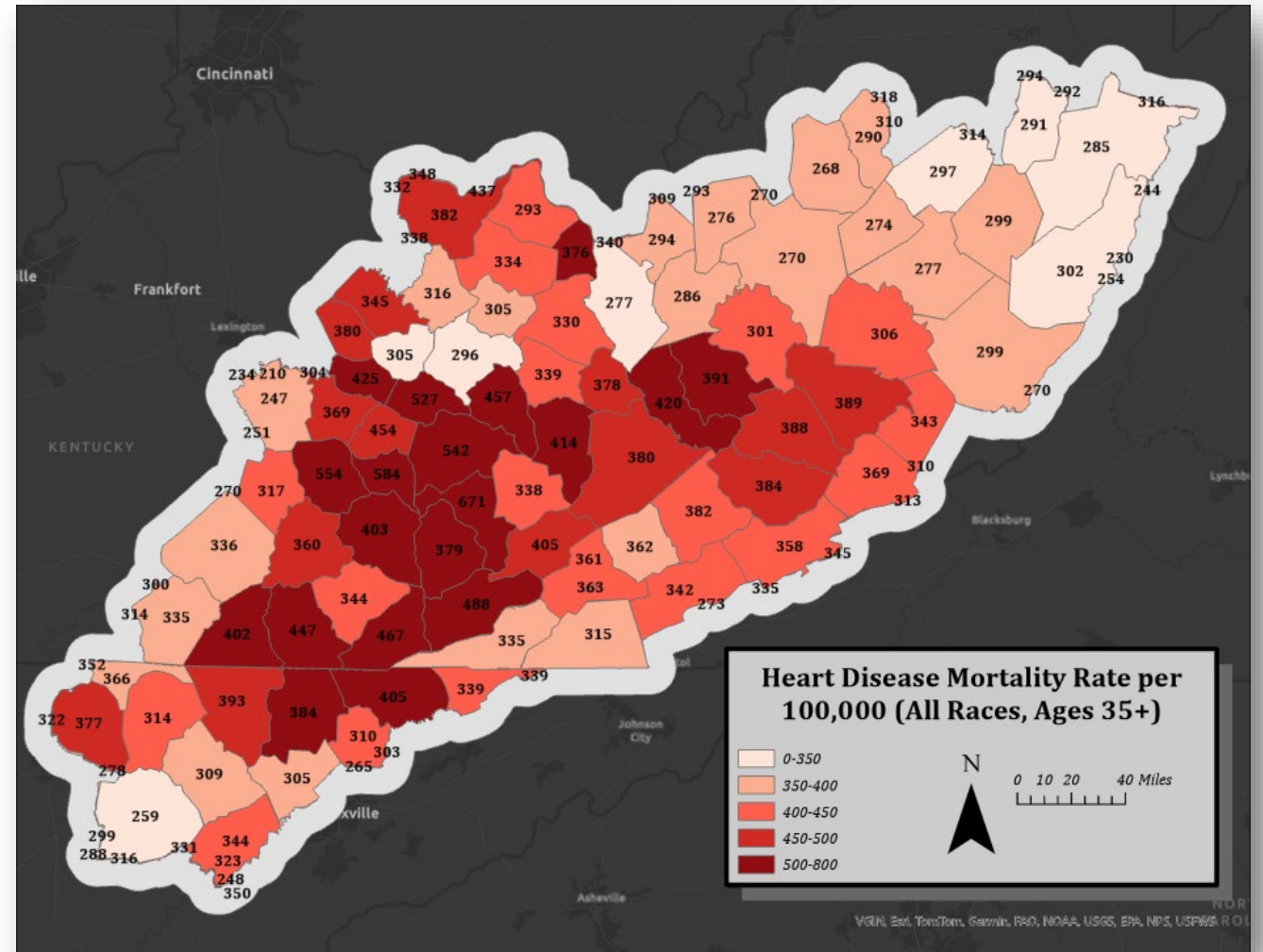
- ❖ 284 Active UG/OP Coal Mines
- ❖ 6 Coal-Fired Power Plants
- ❖ 13 Superfund Sites
- ❖ 80M CY of Coal Waste in SW VA
- ❖ >15% area in RED or ORANGE



Sources: EPA, USGS, EIA, VADOE

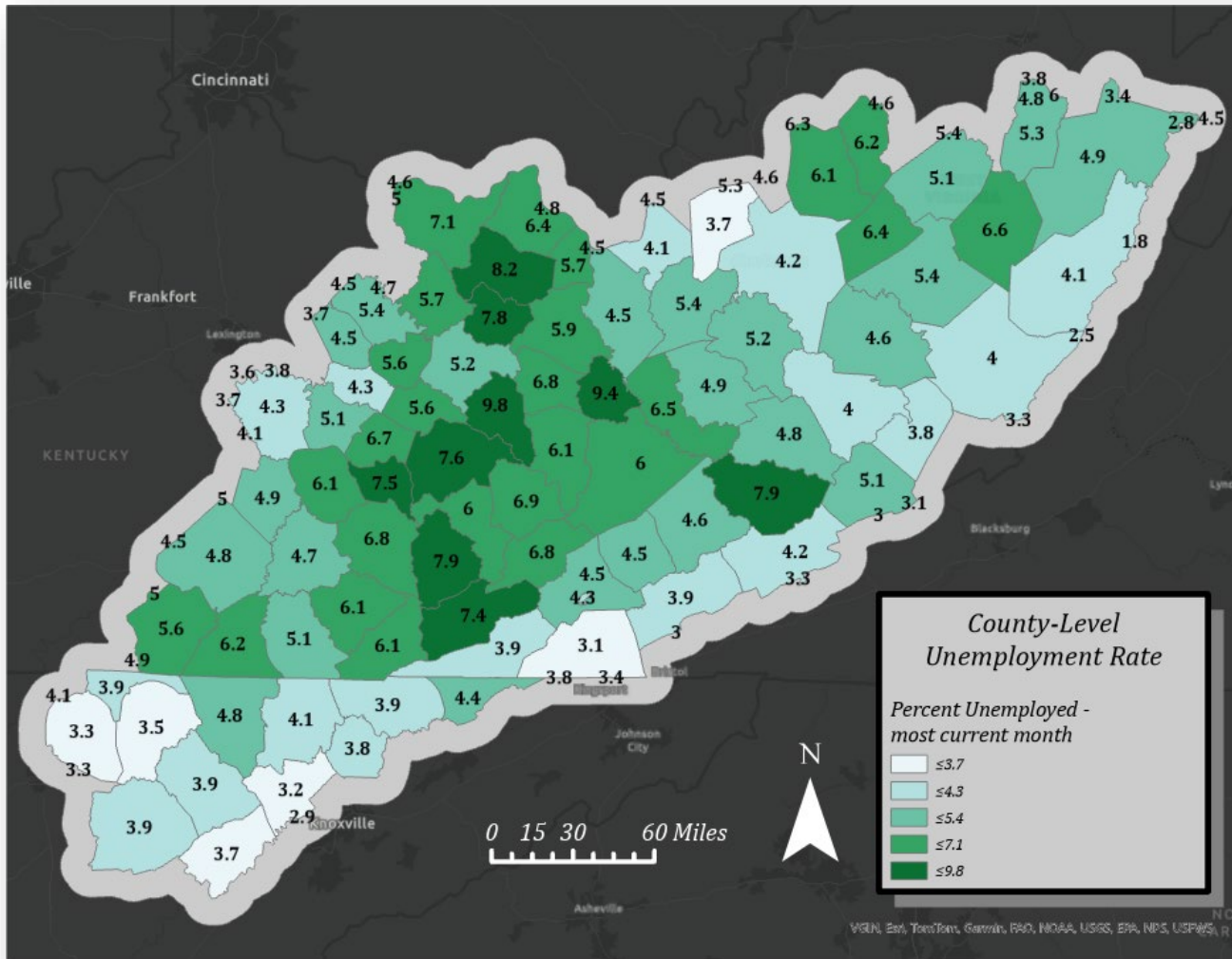
PUBLIC HEALTH CONCERNS IN THE CAPP REGION

- ❖ 429.3 Heart Disease MR (Age 35+)
- ❖ 32% Greater Mortality Rate
- ❖ Extreme High Lung Cancer Incidence
- ❖ Opioid Epidemic



Sources: EIA & NETL

ECONOMIC HARDSHIP IN THE CAPP REGION



- ❖ 5% Average Unemployment Rate
- ❖ Median Income \$41,000 (44% less)
- ❖ Industrial Production Index?

Sources: BLS, Appalachian Regional Commission

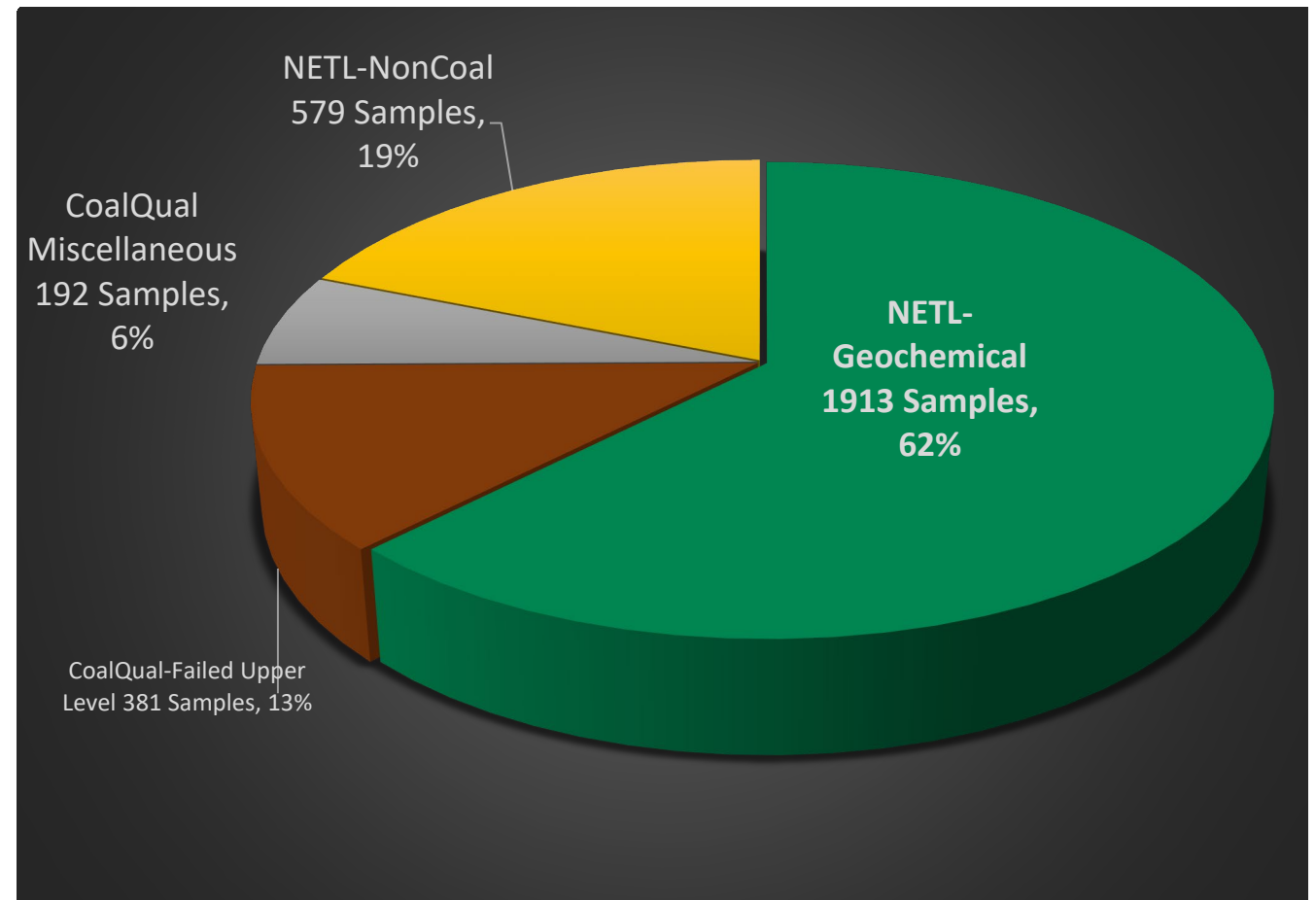
BASINAL ASSESSMENT



INITIAL DATABASE COMPILATION – DATA SOURCES

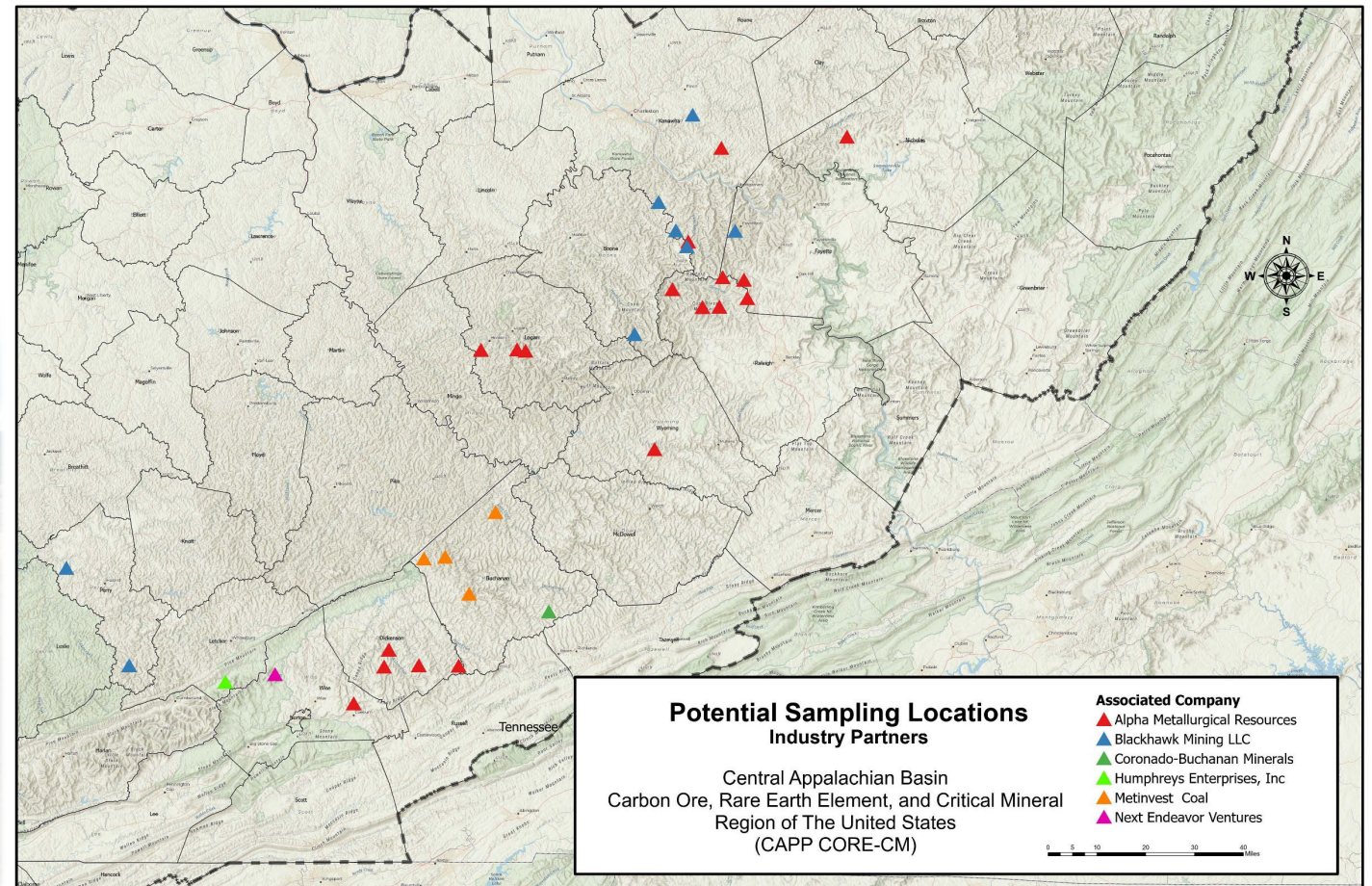
Databases Incorporated:

- NETL-Geochemical (CoalQual)
- NETL-NonCoal
- NETL-Major Chem
- NETL-Other Chem
- NETL-Unknown Chem
- CoalQual – Failed Upper Level
- CoalQual - Miscellaneous

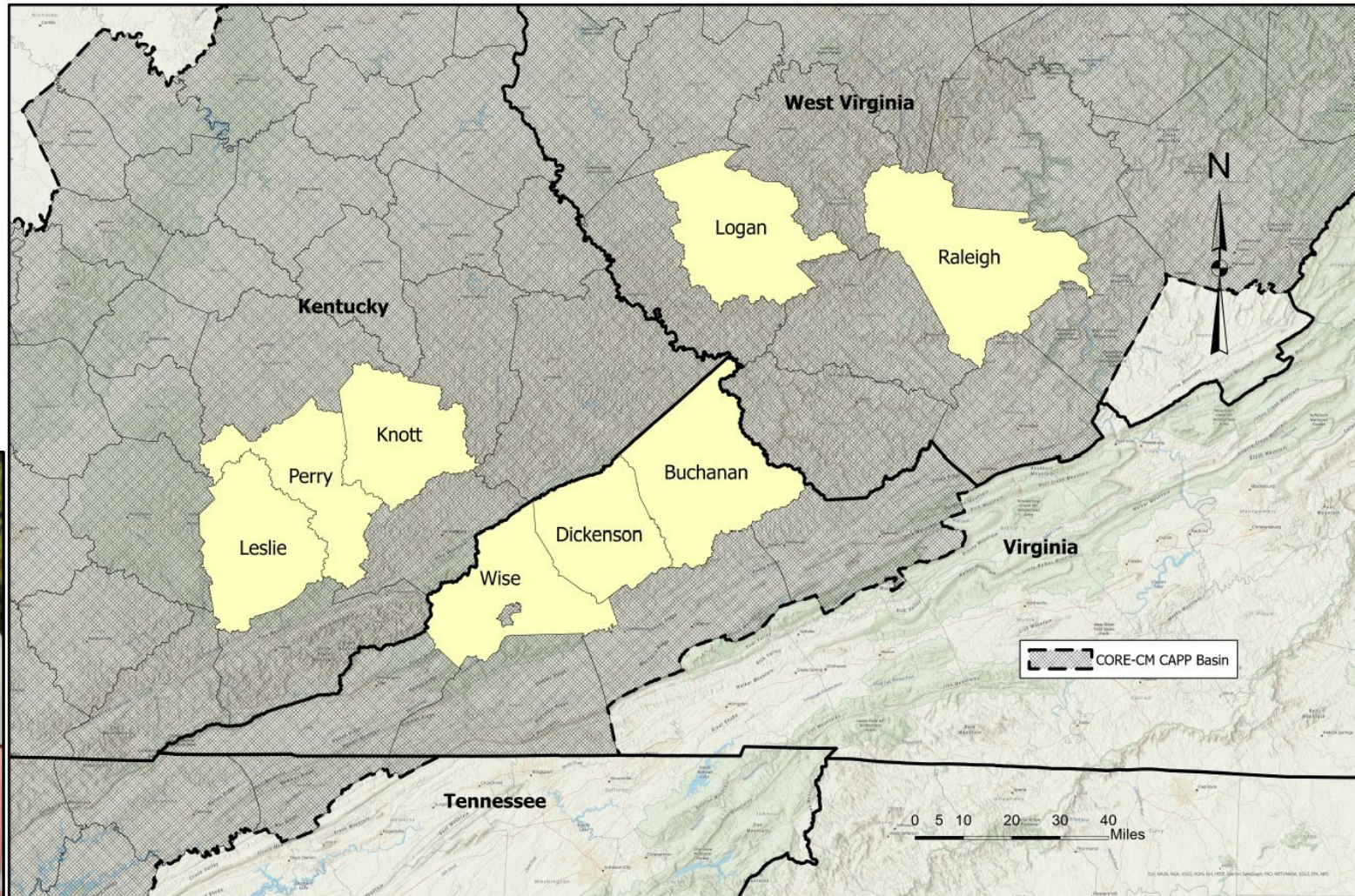


POTENTIAL SAMPLING LOCATIONS WITH INDUSTRY PARTNERS

- Targeting resource gaps
- Confirming historical sampling
- Leveraging industry partnerships



CAPP REGION COUNTIES WHERE SAMPLES WERE COLLECTED



ASSESSMENT OF CORE-CM RESOURCES

- **Sampling:**

- CCR sampling commenced **September 2022 (25 samples)**
- Initial drill core samples **September 2022 (19 samples)**
- Produced water sampling commenced **December 2022 (30 samples)**
- Mine sampling commenced **July 2023 (30 samples)**
- Additional samples collected since **August 2023 (>760 samples)**



BUILDING A DEPOSITIONAL MODEL

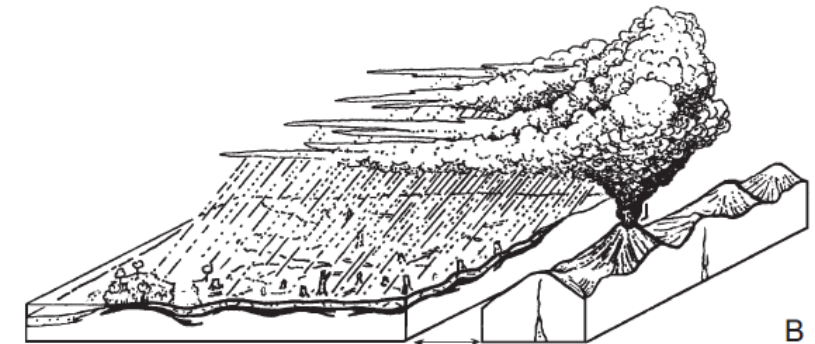
- Basic model for flint clay deposition in sedimentary depositional environment

Eble, CF, Hower, JC, and Andrews, WM, 1999, Compositional Variations in the Fire Clay Coal Bed of Eastern Kentucky: Geochemistry, Petrography, Palynology, and Paleoecology, Report of Investigations 14, Series XI, Kentucky Geological Survey, University of Kentucky, Lexington, KY

A. Peat accumulation in mire subject to clastic influx; will become lower bench of coal seam



B. Volcanic ash deposited; will become flint clay parting



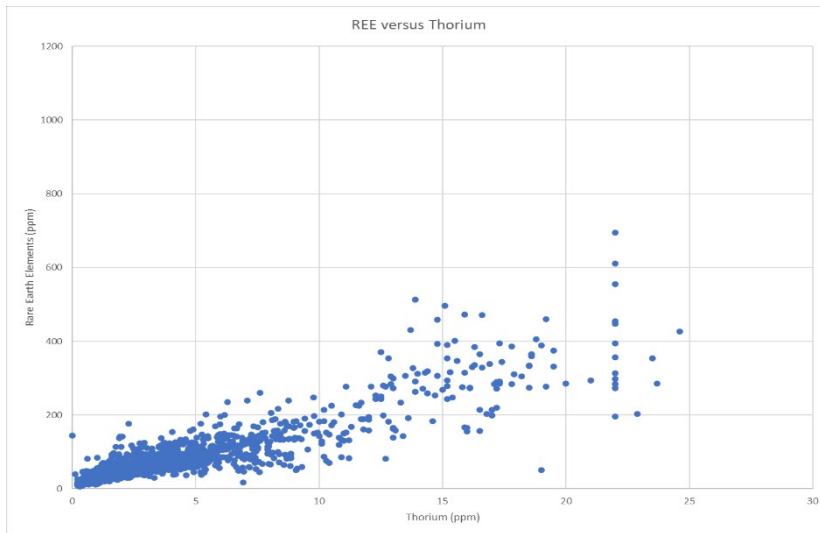
C. Peat accumulates after the ash fall; will become upper bench of coal seam



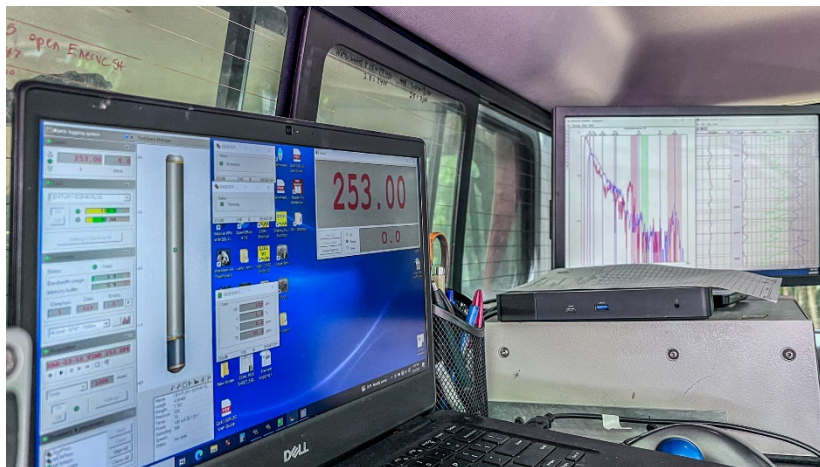
An aerial photograph of a construction site in a dense forest. A large pile of reddish-brown earth is the central focus. Several vehicles are parked around the site, including a red pickup truck, a silver SUV, and a red tractor. A black tarp is spread on the ground near the dirt pile. The text "PRE-SCREENING TOOLS" is overlaid in large white letters across the center of the image.

PRE-SCREENING TOOLS

DOWNHOLE SPECTRAL GAMMA



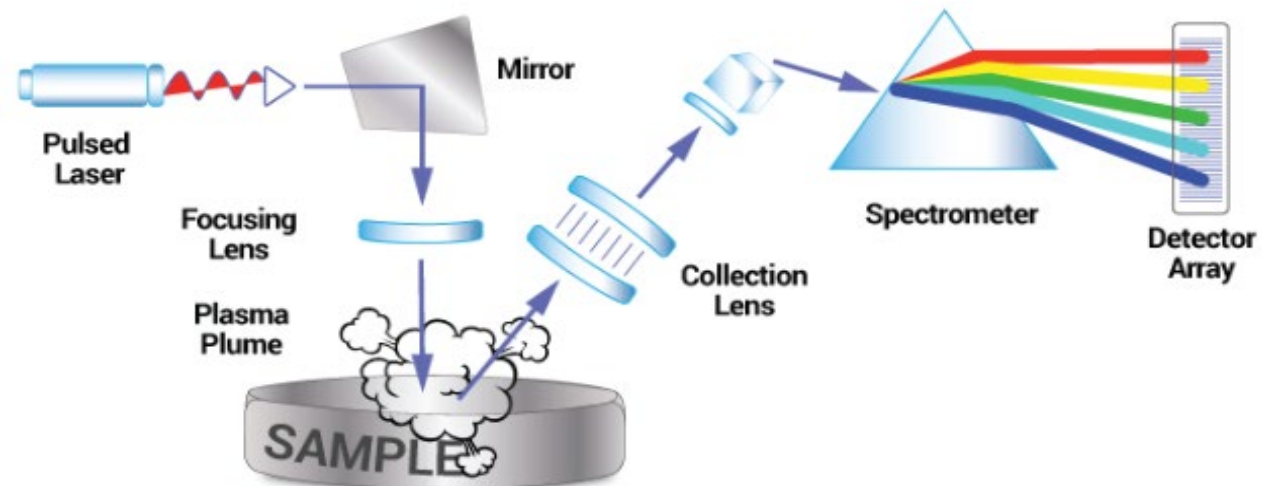
- REEs vs Thorium correlation, detectable w/ Spectral Gamma
- Gamma measured by converting gamma rays to electronic pulses that are measured & counted



LIBS SCREENING



- **L**aser **I**nduced **B**reakdown **S**pectroscopy
- Used >30 years as a lab technique capable of analyzing any element in periodic table, now available handheld
- Pulsed laser fired at sample creates a plasma
- Plasma cools, atoms combine with electrons & emit UV, Optical & IR light compared with known wavelengths



P-XRF SCREENING

Core Hole
CH-1-2014 and CH-1R-2014

- Notes:
1. See Map A1 for location.
 2. Datum: Pocahontas No. 9 Seam

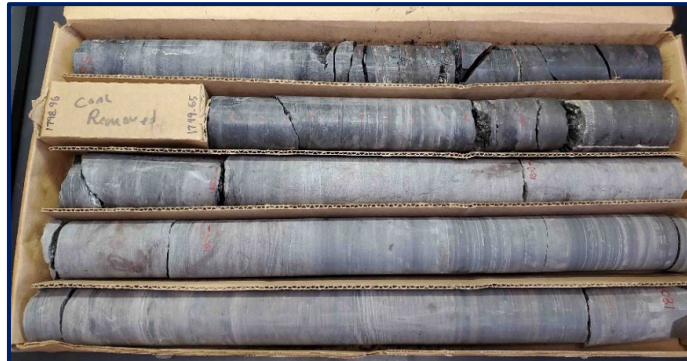
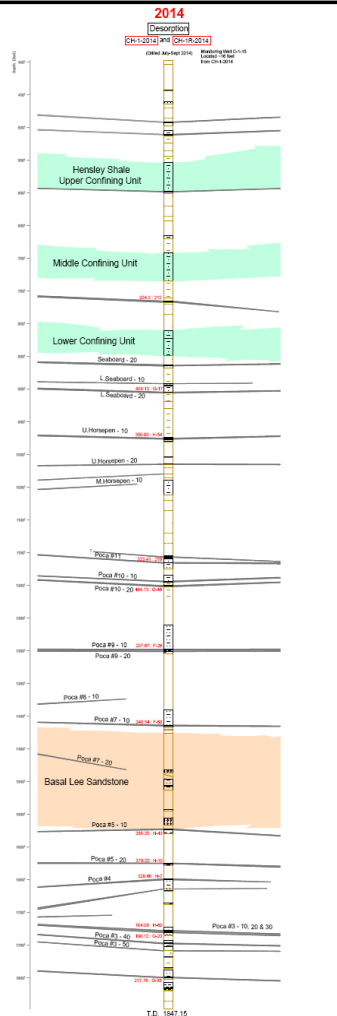
Lithologies

- Bone
- Boney Coal
- Coal
- Coal With Bone
- Fireclay
- Hard Sandstone
- Sandstone
- Sandstone with Coal Spar(s)
- Sandstone with Shale Streak(s)
- Sandy Shale
- Shale
- Shale with Coal Streak(s)
- Unknown Lithology

- 2007 CBM Well Completion Year
- Quartz Arenite
- Shale Confining Unit

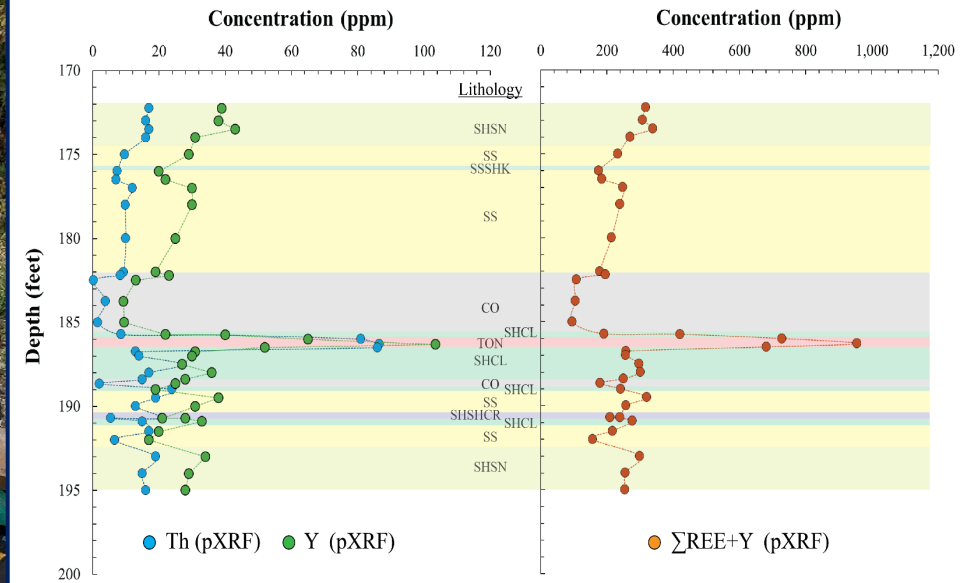
Core Hole

Description	Gas Content Test	
	scft	Canister ID
204.3		212



- Analyzing Core Holes for REE-CMs
- 764 XRF scan results collected
- Comparing to ICP-MS, Spectral Gamma & LIBS

Core Hole KYLE 0427-11
Leslie County, KY: Hazard 4 coal seam



PROJECT EXTENSION - FOCUSED ON SAMPLE COLLECTION

- VCCER planned & implemented a sample collection & analysis plan
- The activities included:
 - Identifying specific sampling opportunities w/ industry partners
 - Field sampling and laboratory analyses including:
 - Rock core collection
 - Channel Sampling – surface & underground mines
 - Fly Ash Sample Collection
 - Acid Mine Drainage (AMD) Sample Collection
 - Oil & Gas Well Produced Water Sample Collection
 - Field screening including:
 - Geologic Logging
 - X-Ray Fluorescence (XRF)
 - Downhole Geophysical Logging – Spectral Gamma



VA-C-1 Box #125: 1797' – 1807'

includes P2 coal (Buchanan County, VA)



pXRF: Y = 32 ppm, Th = 15 ppm
 Σ REE+Y 269 ppm
 Σ LREE 215 ppm
 Σ HREE 23 ppm



KYLE 0427-11, BOX 3: 185.72' – 195.72'

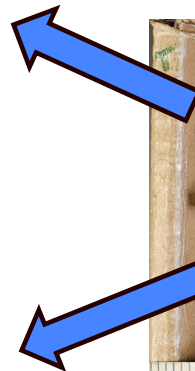
SHCL (ash-mottled claystone):

pXRF: $\sum \text{REE} + \text{Y} = 421 \text{ ppm}$



TON (tonstein):

pXRF: Y = 104 ppm, Th = 87 ppm
 $\sum \text{REE} + \text{Y} = 955 \text{ ppm}$





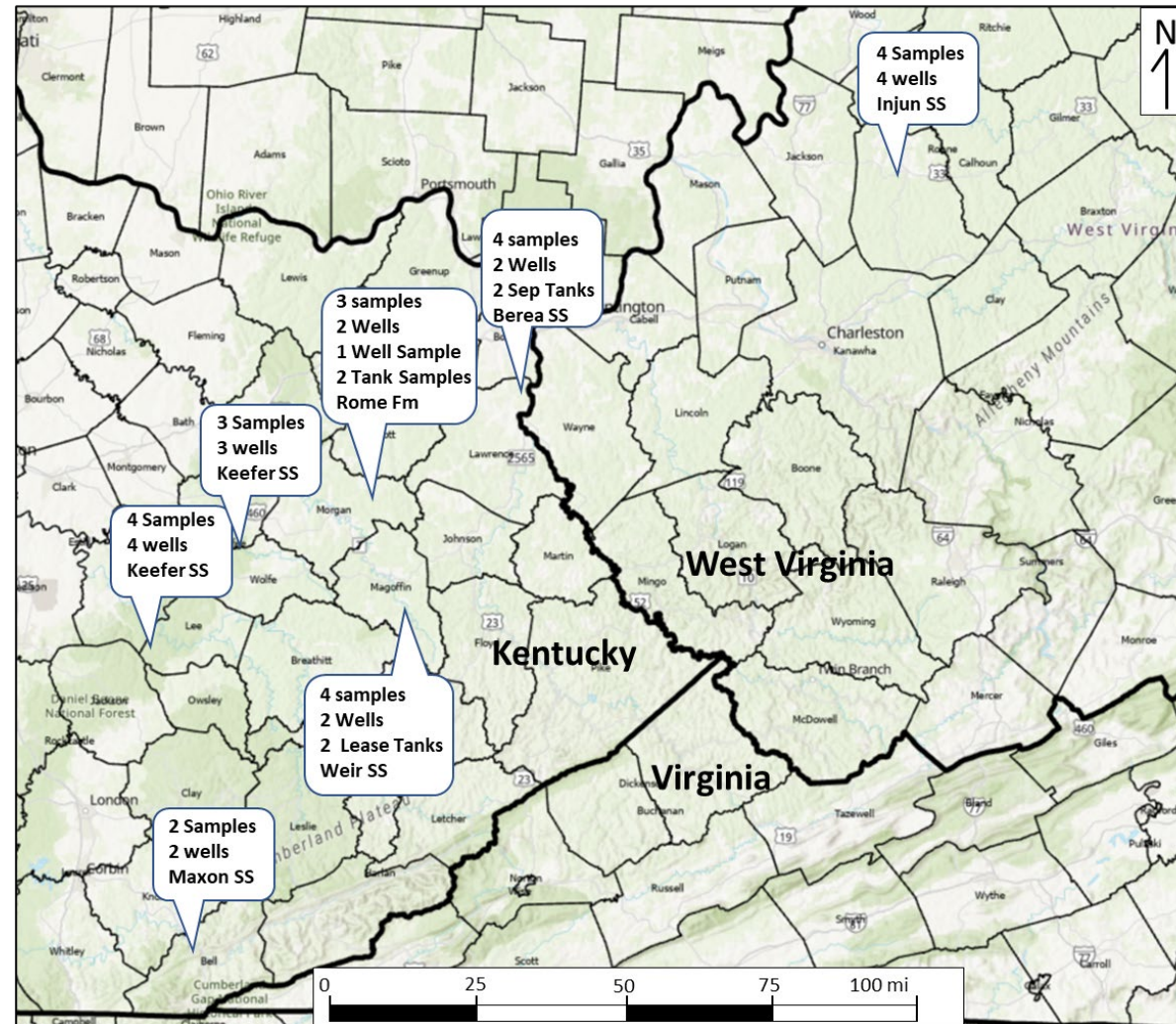
PRODUCED WATER & WASTE STREAMS

PRODUCED WATER SAMPLING

Samples taken from 7 counties across the region:

- Lee County, KY
- Wolfe County, KY
- Morgan County, KY
- Magoffin County, KY
- Lawrence County, KY
- Bell County, KY
- Roane County, WV

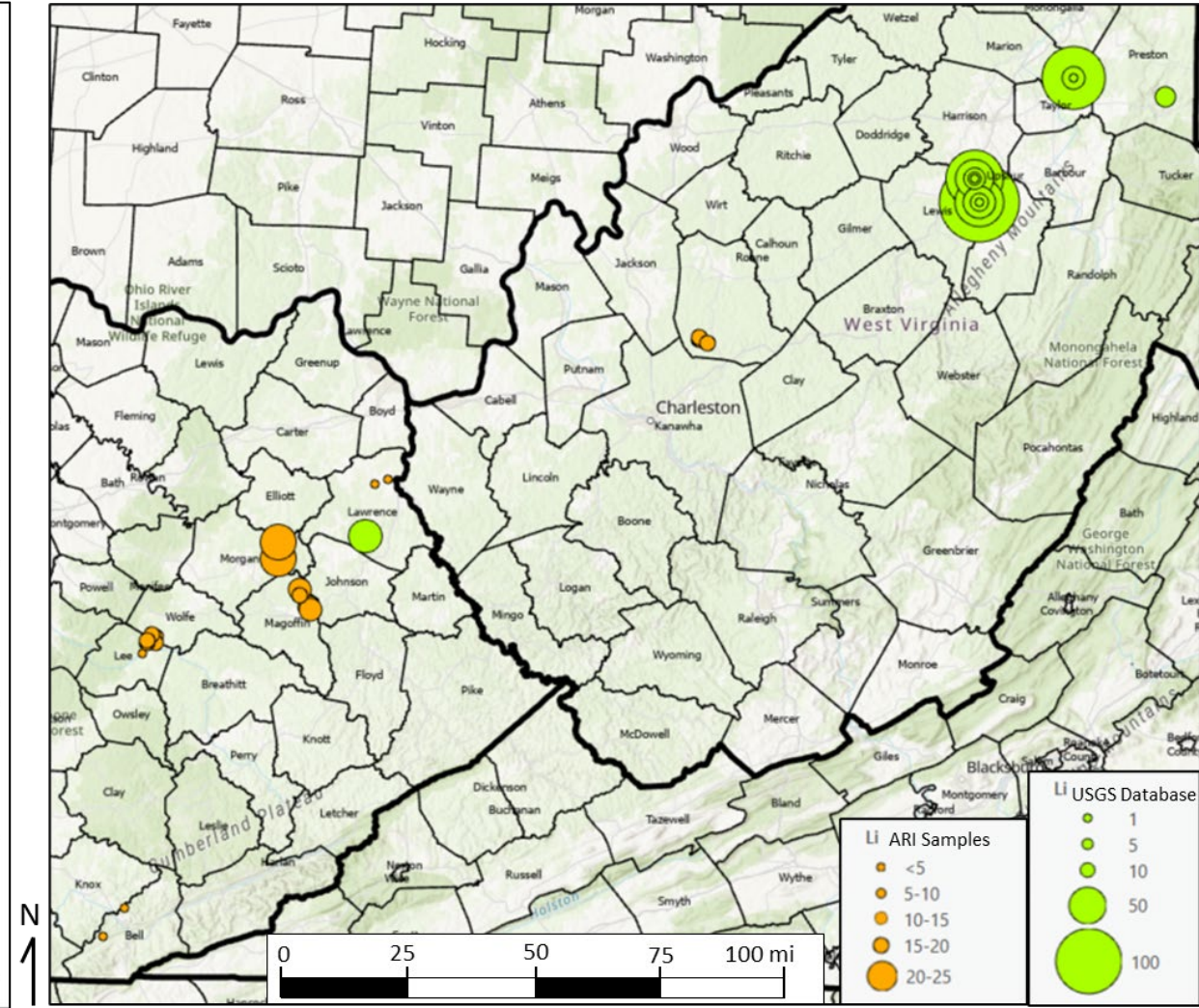
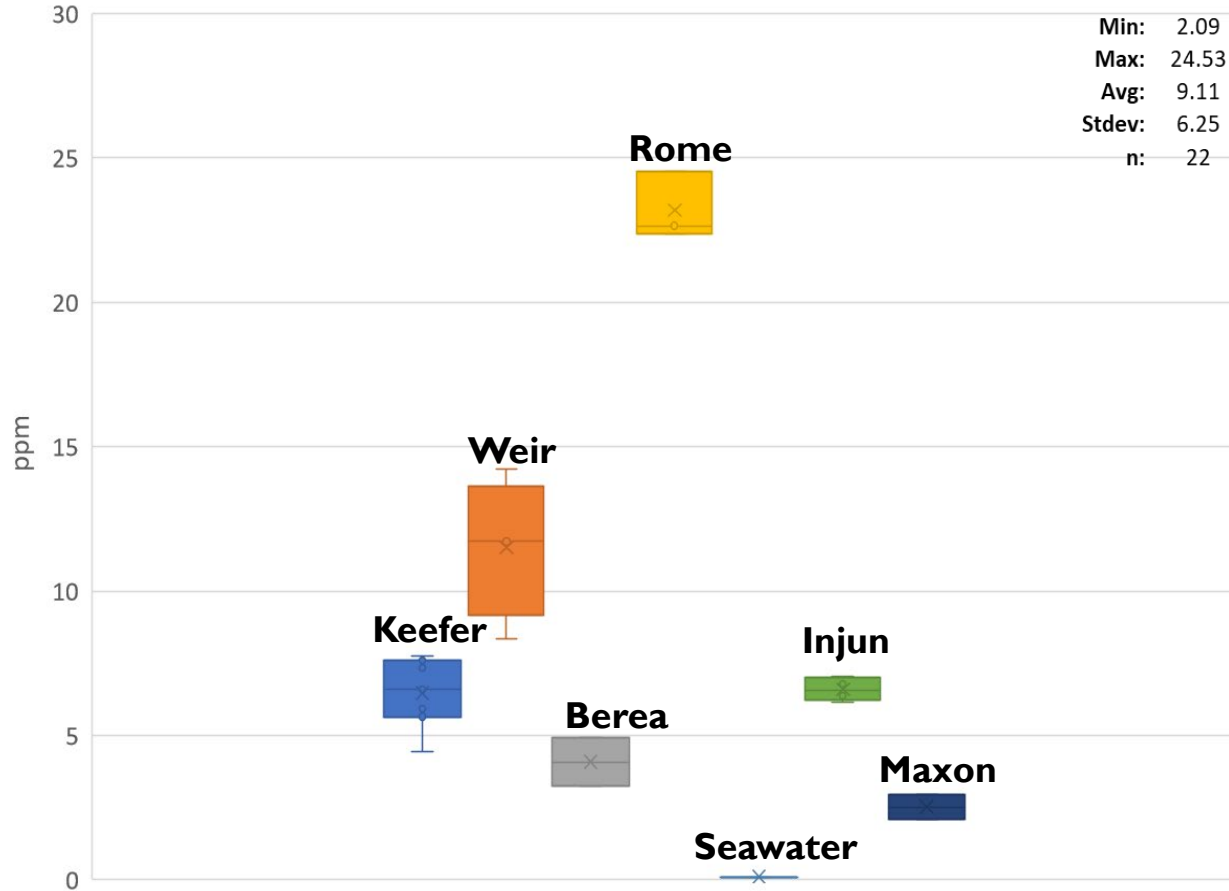
*24 samples were originally taken; however, two Berea samples were too oily to analyze & had to be omitted, bringing total sample count to 22



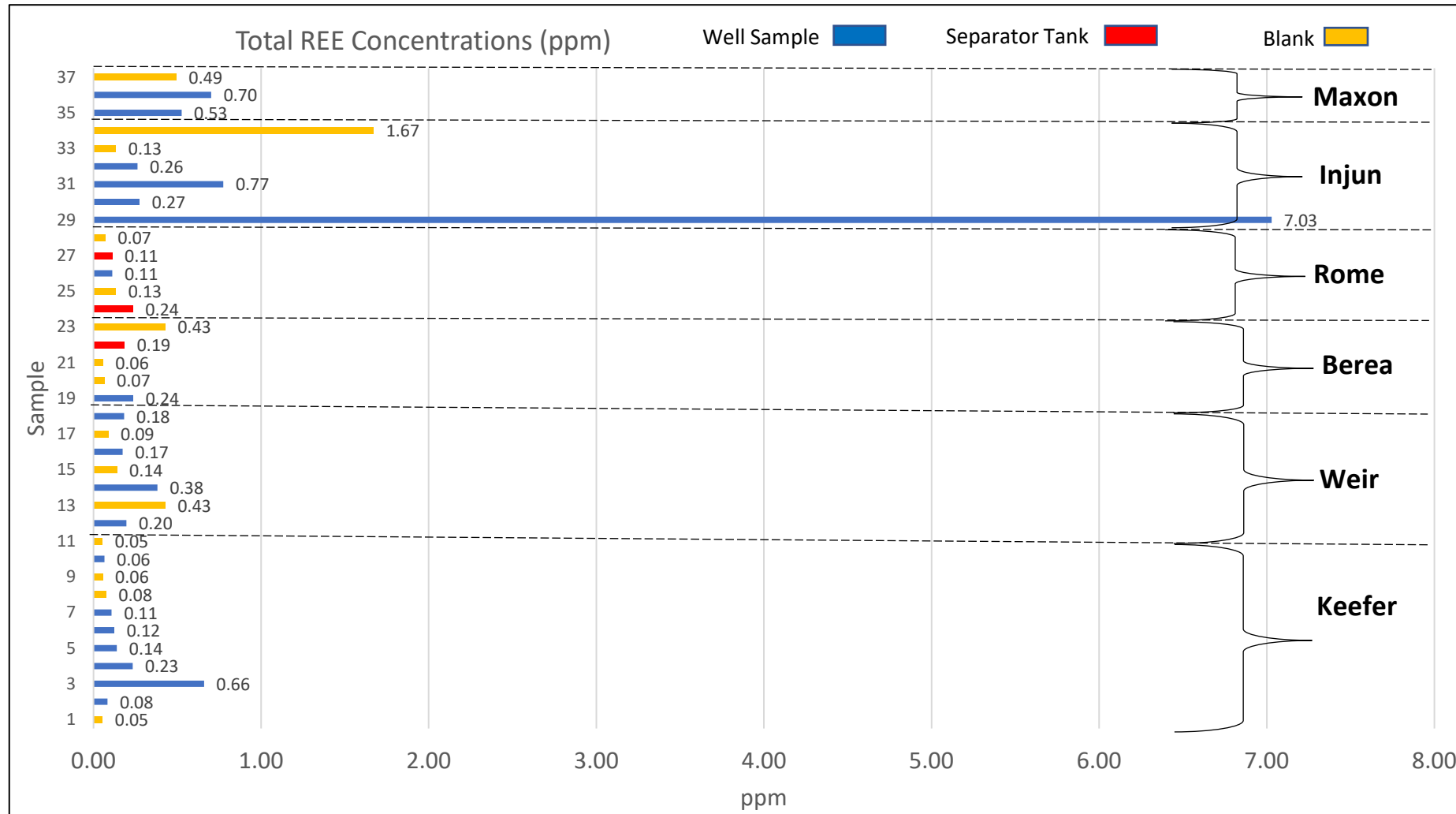
Produced water SAMPLING (Lithium)

Lithium Concentrations by Formation

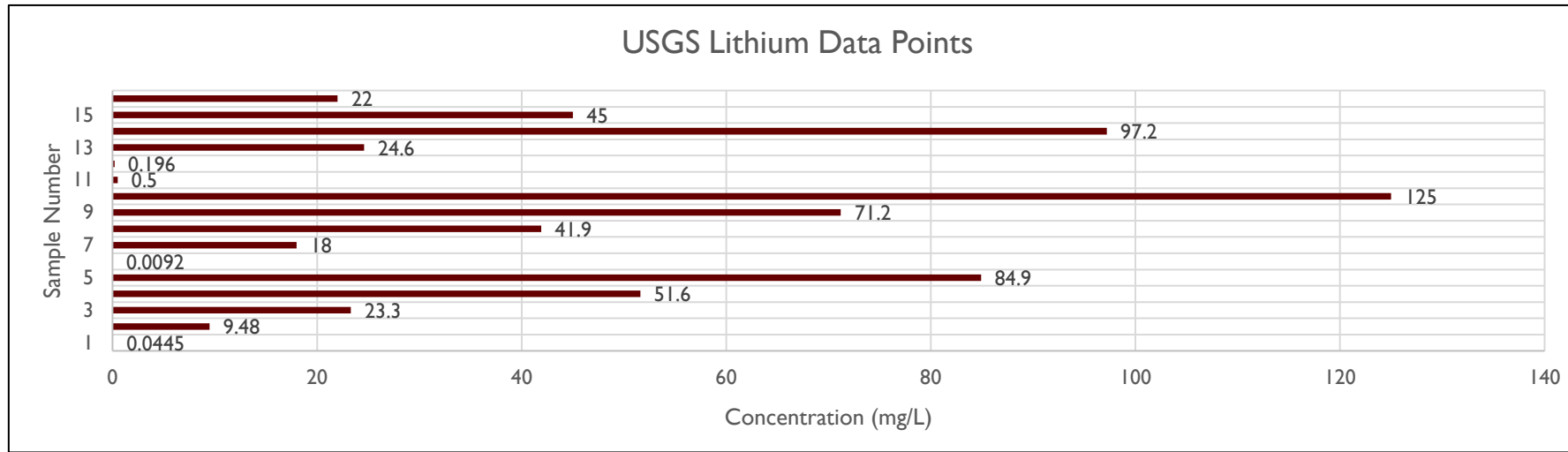
Keifer Weir Berea Rome Seawater Injun Maxon



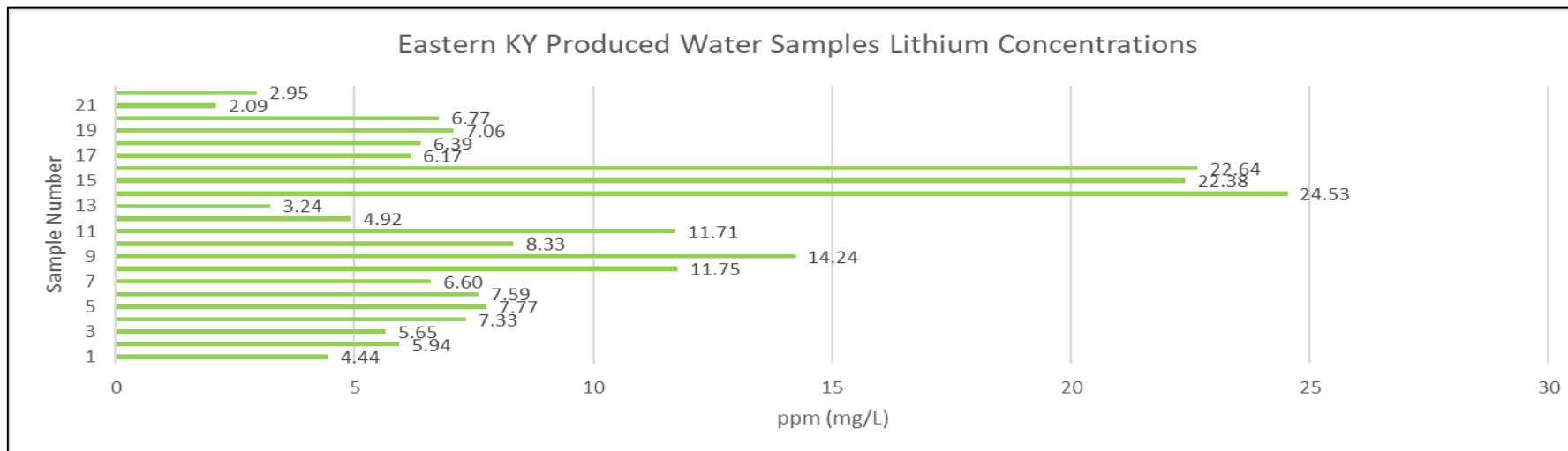
PRODUCED WATER SAMPLING (REE)



LITHIUM COMPARISON WITH USGS DATASET



n: 16
 Min: 0.0092
 Max: 125
 Average: 38.43
 Std Dev: 37.25

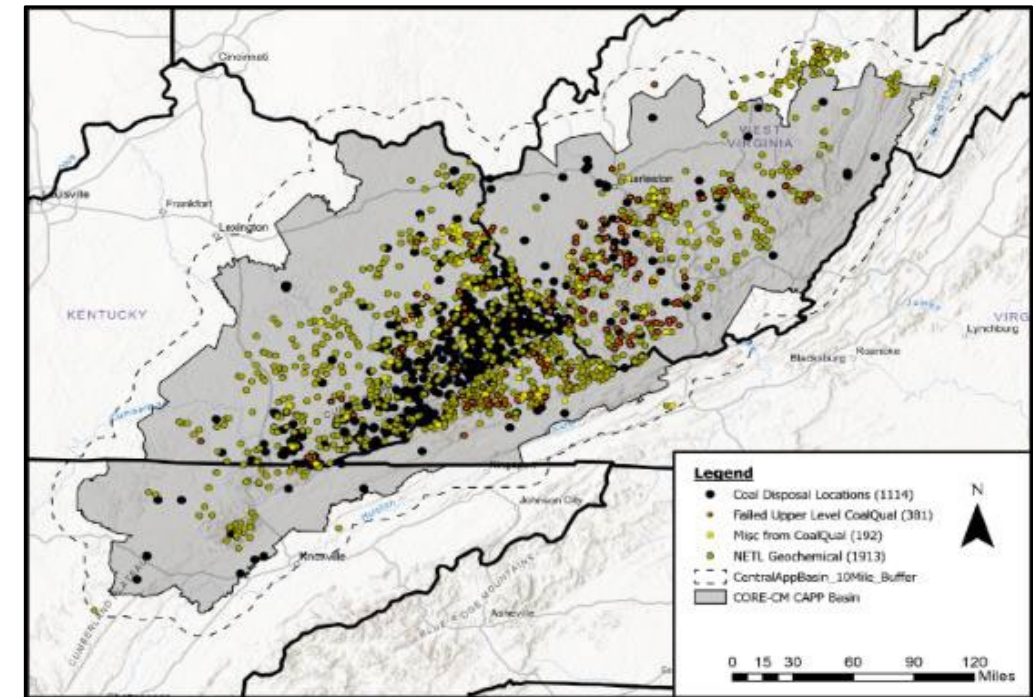


n: 22
 Min: 2.09
 Max: 24.53
 Average: 9.11
 St Dev: 6.25

BASINAL STRATEGIES FOR REUSE OF WASTE STREAMS

Assessment of Mine Refuse & CCR Waste Streams

- Identifying “permitted” sites through State & Federal Regulatory Agencies
- Identifying utility-known CCR landfills & impoundments based on EPA & State Solid Waste Database
- Contacting utilities & industry parties to identify CCR volumes, type of material stored & potential for REE-CMs
- Catalogue operational status in resource database

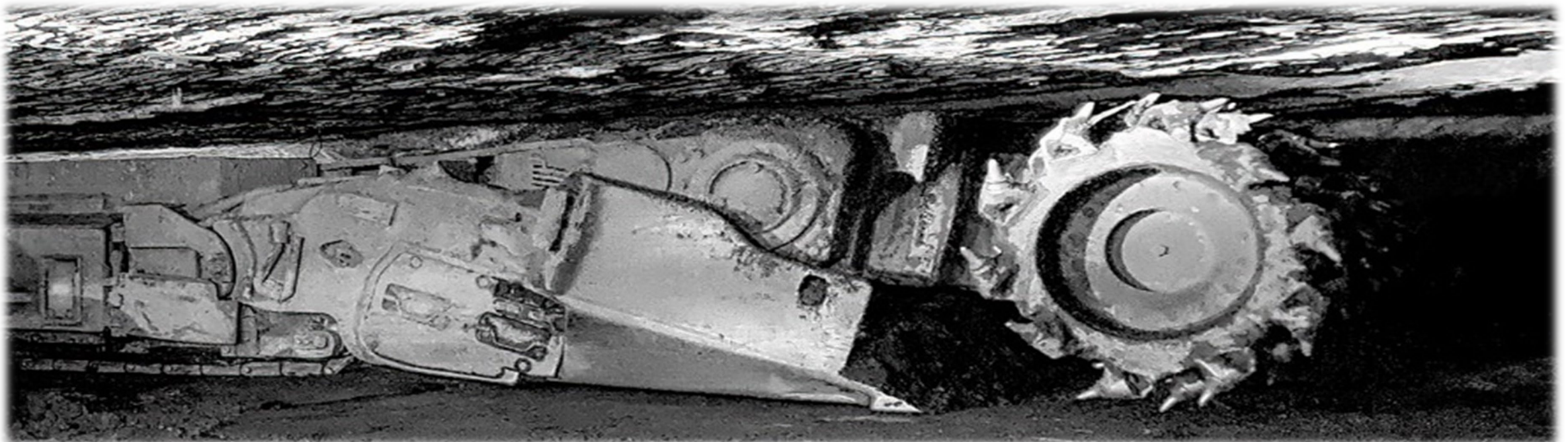


CAPP Basic Infrastructure & Waste Stream Locations



TECHNOLOGY ASSESSMENT, DEVELOPMENT & FIELD TESTING

- Mining (primary, co-products, re-mining)
- Separation Processes
- Carbon Products
- Technology Assessment
- Field-Testing
- Gap Analysis



MINING TECHNOLOGY & OPERATIONS

➤ **Material Handling**

- Movement of ore from working face to processing operation

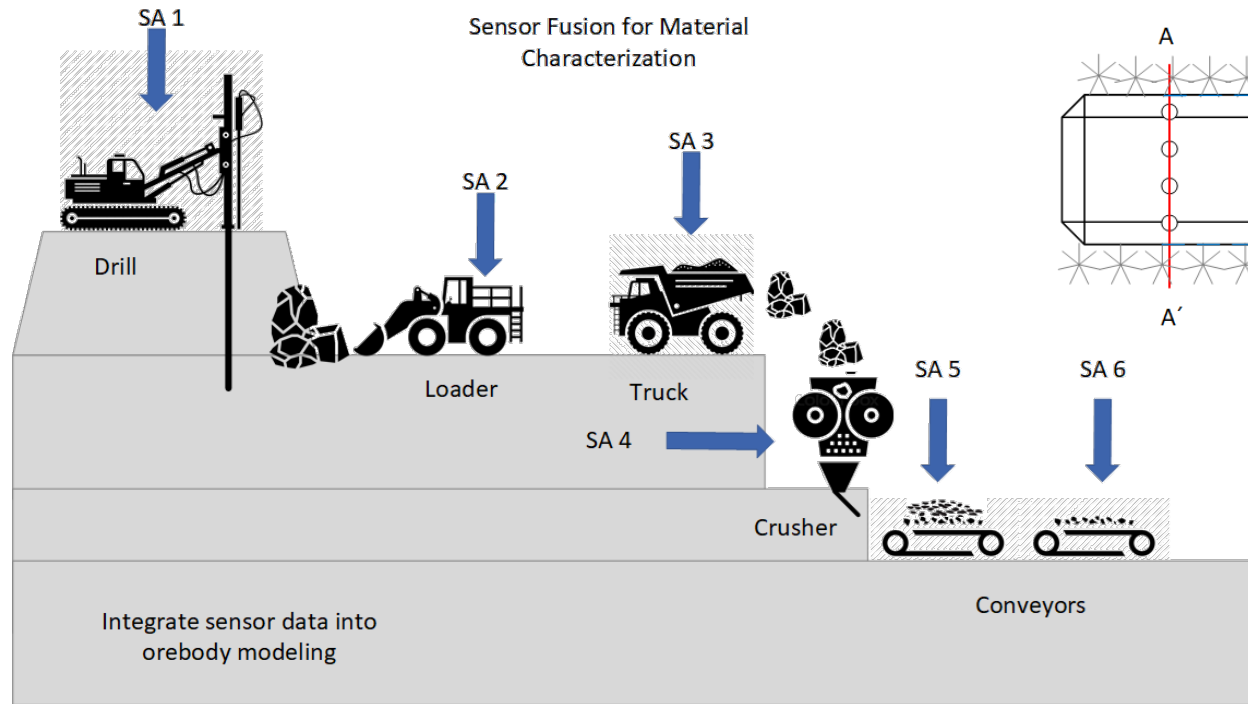
➤ **Surface Operations**

- Out-of-Seam material placed in storage or replaced to get site back to approx. original contour
- Material in storage may be available for re-mining operations to recover REE, but volume of material & mixing of material a challenge
- Selective mining possible for out-of-seam material (flexibility in truck & shovel operations)

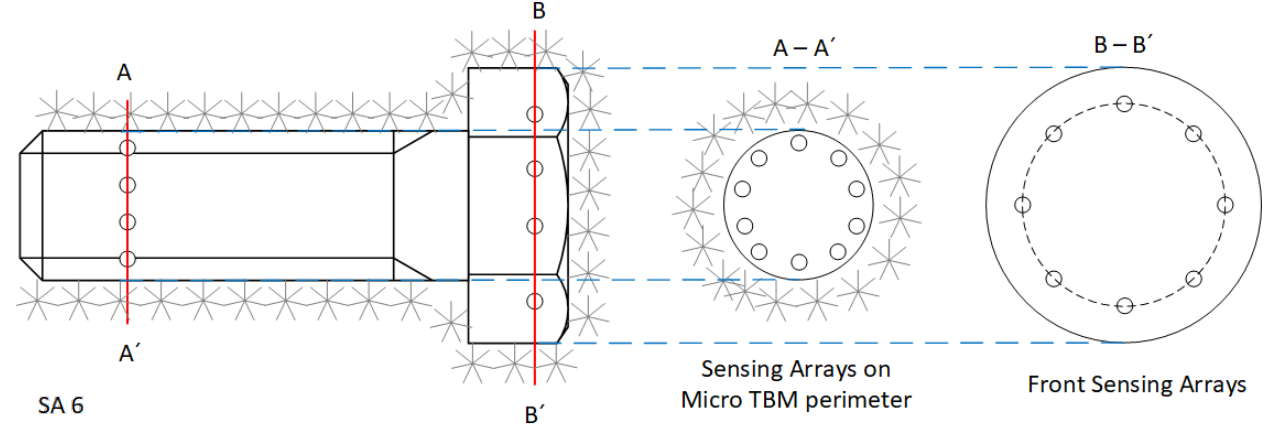
➤ **Underground Operations**

- Selective material handling & selective mining are a challenge
- Out-of-seam material is separated in processing plant & stored separately
- Re-mining options available

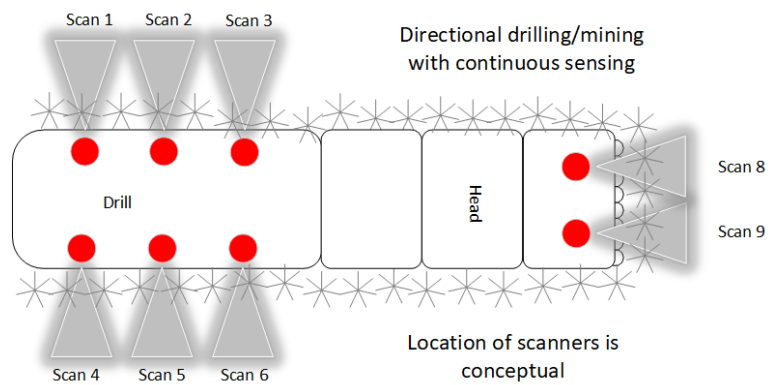
EXAMPLE MINING TECHNIQUES



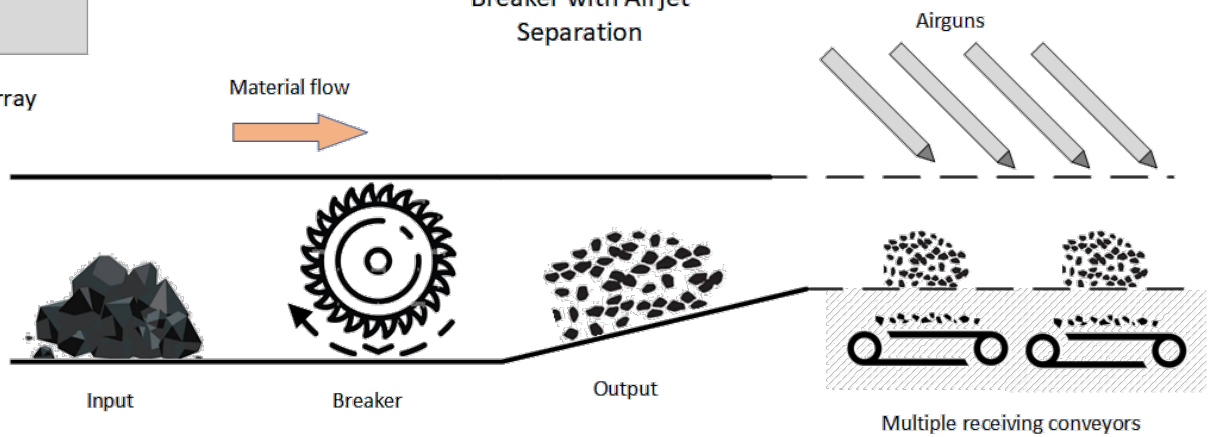
Directional Micro-TBM with Sensing Arrays



SA = Sensor Array



Underground Feeder Breaker with Airjet Separation



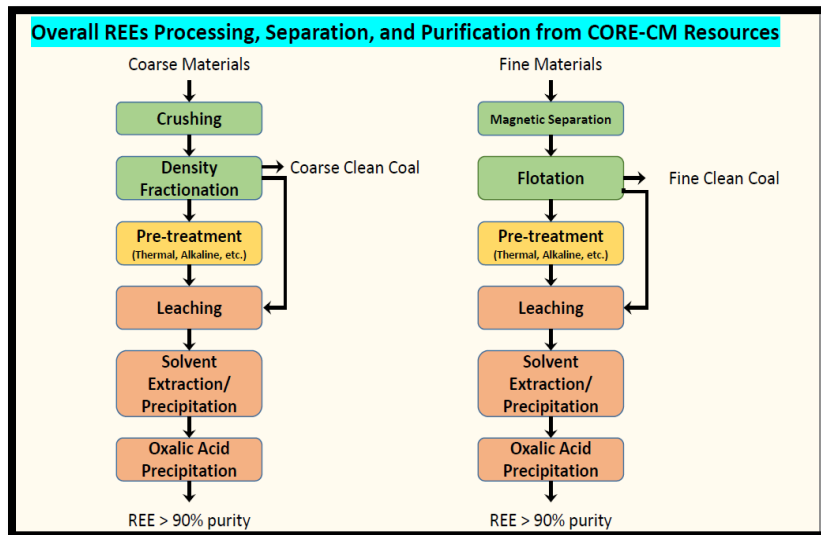
TECHNOLOGY ASSESSMENT – SELECTIVE SORTING



Free et al. (2020)

TECHNOLOGY ASSESSMENT – SEPARATION PROCESSES

- Existing separation technologies being assessed & evaluated for best results under the geologic & waste stream conditions encountered in CAPP basin



Zhang et al. (2020)

Sample	Coal Seam	Pre-Leach Treatment	Leach Conditions	Recovery			Reference
				TREE	LREE	HREE	
Coarse refuse (2.2 SG float, crushed to below 177 μm)	Pocahontas No. 3	None	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	14%	12%	23%	[21]
Coarse refuse (2.2 SG float, crushed to below 177 μm)	Pocahontas No. 3	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	81%	89%	27%	
Middlings (crushed to below 177 μm)	Pocahontas No. 3	None	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	28%	31%	19%	
Middlings (crushed to below 177 μm)	Pocahontas No. 3	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	76%	80%	57%	
Plant feed (2.2 SG sink, crushed to below 177 μm)	West Kentucky No. 13	None	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	24%	21%	36%	[54]
Plant feed (2.2 SG sink, crushed to below 177 μm)	West Kentucky No. 13	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	79%	87%	41%	
Plant feed (2.2 SG sink, crushed to below 177 μm)	Fire Clay	None	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	43%	43%	38%	
Plant feed (2.2 SG sink, crushed to below 177 μm)	Fire Clay	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	62%	68%	33%	
Plant feed (2.2 SG sink, crushed to below 177 μm)	Illinois No. 6	None	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	32%	31%	37%	[53]
Plant feed (1.4 SG float, crushed to below 177 μm)	Illinois No. 6	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	65%	73%	41%	
Plant feed (1.4 SG float, crushed to below 177 μm)	West Kentucky No. 13	None	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	25%	30%	15%	
Plant feed (1.4 SG float, crushed to below 177 μm)	West Kentucky No. 13	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	86%	88%	82%	
Plant feed (1.4 SG float, crushed to below 177 μm)	Fire Clay	None	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	41%	47%	20%	[53]
Plant feed (1.4 SG float, crushed to below 177 μm)	Fire Clay	Calcination at 600 °C for 2 h without adding any additives	1.2 M HCl; 75 °C, 1% (w/v) solid concentration, 5 h	84%	87%	75%	

OUTREACH INTEGRATED WITH PROJECT MANAGEMENT

Project Management
& Planning



Stakeholder Outreach &
Education

Initial Stakeholder Outreach &
Education Plan

EJ
Considerations

Economic
Revitalization
& Job
Creation
Outcomes

EH&S
Analysis

Stakeholder
Advisory
Committee

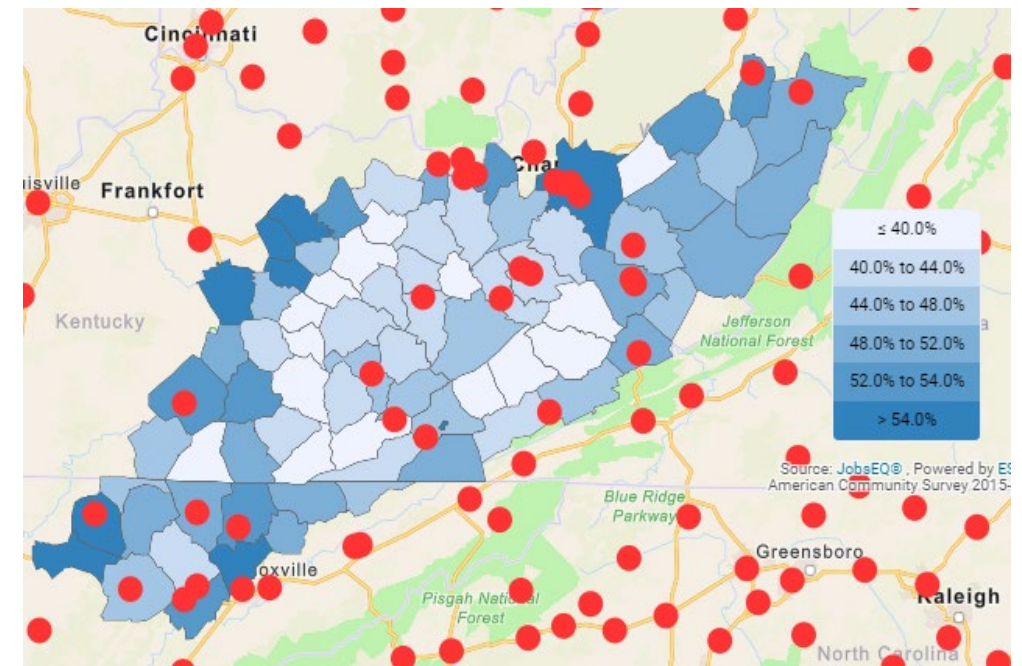
Workforce
Readiness &
Development

Public
Outreach,
Education &
Engagement

WORKFORCE READINESS & DEVELOPMENT

- Workforce Readiness Plan
- Workshops & Forums
 - ✓ Engage stakeholders/entrepreneurs, public, future workforce personnel
 - ✓ Identify & assess skillsets & employment opportunities
- Offer programs, certifications & skills training to match needs of projects in basin

Labor Force Participation Rate with locations of Public 2-year or Less Training Facilities



Workforce Readiness Plan



EDUCATION & TRAINING – CAPP REGION

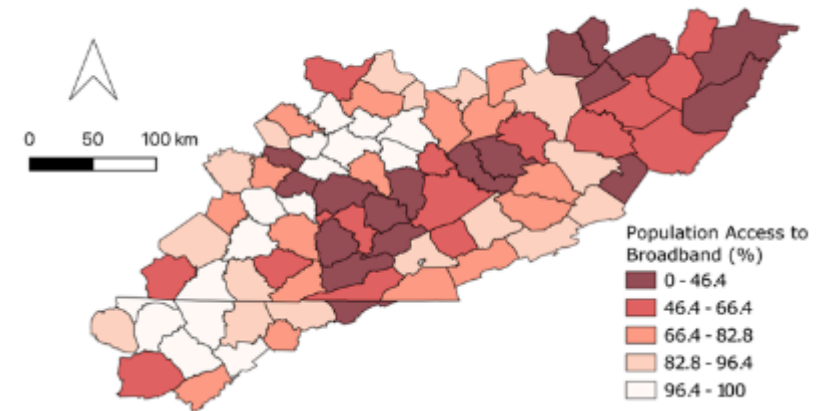
School	Commercial Vehicle	Construction/ Heavy Equip.	Diesel Mech. & Technician	Drafting & Design Tech.	Electrical & Electronic Tech.	Electrical & Electronic Comm.	Electrician	Industrial Mechanics	Information Technologies	Machine Shop Tech.	Welding
Academy of Careers and Technology	x		x	x			x				x
Ashland Community and Technical College	x		x	x			x	x	x	x	
Ben Franklin Career Center		x	x								x
Berea College									x		
Big Sandy Community and Technical College	x		x	x	x		x	x	x	x	x
Bluefield State College						x			x		
BridgeValley Community & Technical College			x	x		x					x
Cabell County Career Technology Center							x			x	x
Carver Career Center							x				
Eastern Kentucky University									x		
Fayette Institute of Technology							x				
Fortis Institute-Cookeville	x										
Fred W Eberle Technical Center	x		x				x				x
Hazard Community and Technical College	x	x	x	x			x		x		x
Marshall University									x		
Mercer County Technical Education Center							x				x
Morehead State University									x		
Mountain Empire Community College						x			x		x
Mountwest Community and Technical College						x				x	x
New River Community and Technical College			x								x
Somerset Community College	x		x		x		x	x	x	x	
Southeast Kentucky Community			x	x	x		x	x		x	x
Southern WV Community and Technical College						x	x				x
Southwest Virginia Community College						x			x		x
TN College of Applied Technology-Crossville	x		x					x			x
TN College of Applied Technology-Harriman			x					x			x
TN College of Applied Technology-Jacksboro							x				x
TN College of Applied Technology-Livingston			x					x			x
TN College of Applied Technology-Oneida-Huntsville											x
University of the Cumberlands									x		
University of Pikeville									x		
West Virginia University Institute of Technology					x				x		

INITIAL INFRASTRUCTURE ASSESSMENT

Screening for various metrics, including:

- Cheapest source of electricity
- Primary & secondary roads
- Power generation
- Railroad networks
- Commercially navigable waterways
- Fly ash pond locations
- Population with access to broadband
- Educational opportunities

CAPP Region Population With Access to Broadband

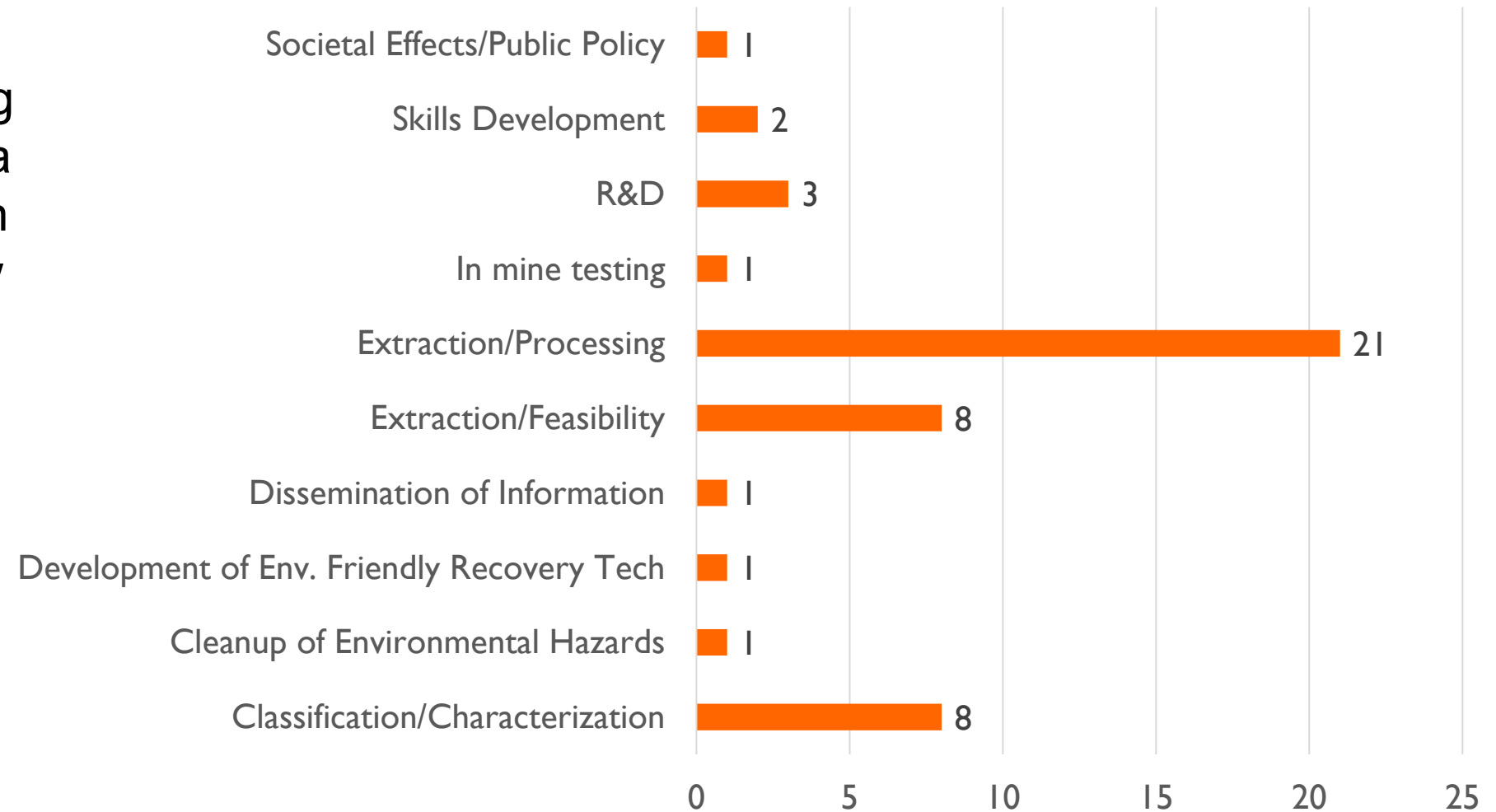


CAPP Region Railroad Network



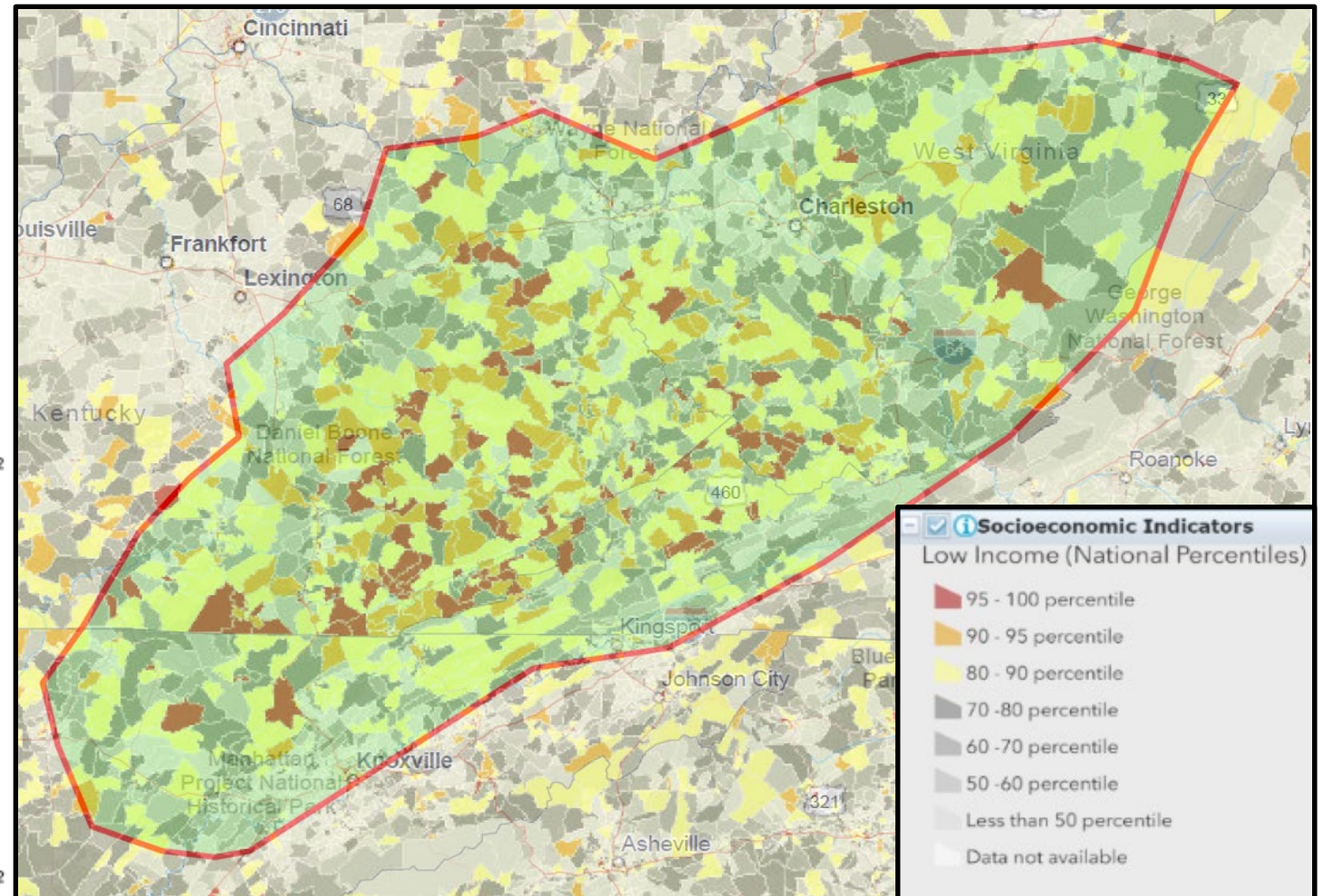
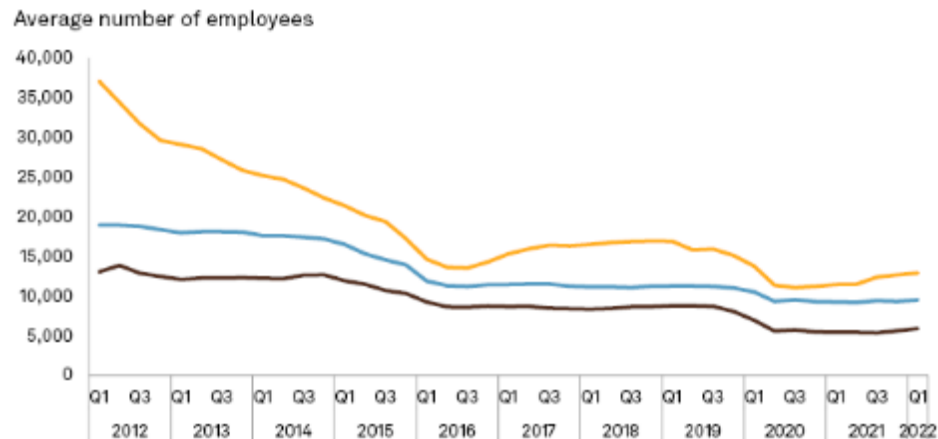
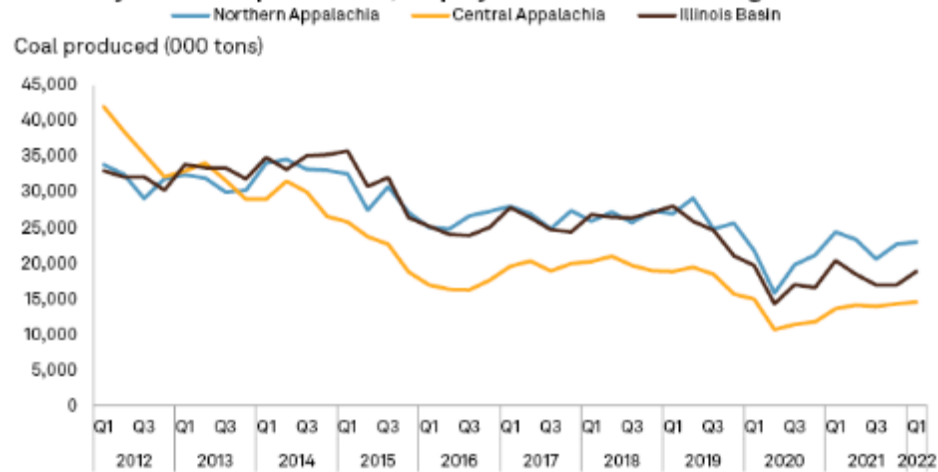
TECHNOLOGY INNOVATION CENTER - QUESTIONNAIRE

Surveyed various stakeholders regarding location & function of a Technology Innovation Center (TIC) for a new CORE-CM industry..



CAPP EMPLOYMENT TRENDS & SOCIOECONOMIC INDICATORS

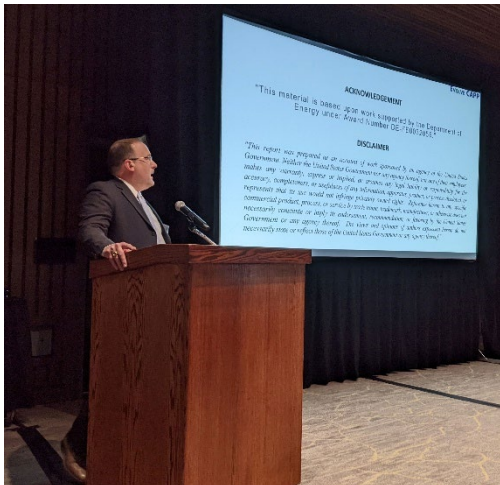
Quarterly coal mine production, employee count for select regions



Source: S&P Global Market Intelligence (May 2022)

STAKEHOLDER OUTREACH & EDUCATION

- Open Public Session + Stakeholder Mtg: Abingdon, VA, **March 2022**
- Stakeholder Meeting: Lexington, KY, **December 2022**
- Open Public Session + Stakeholder Mtg: Julian, WV, **August 2023**
- Public Outreach, Education & Engagement: **>42 presentations to date..**
 - **MCPA, USEA, SSEB, SME, SME-CAS, SME-FL, SPE, etc.**



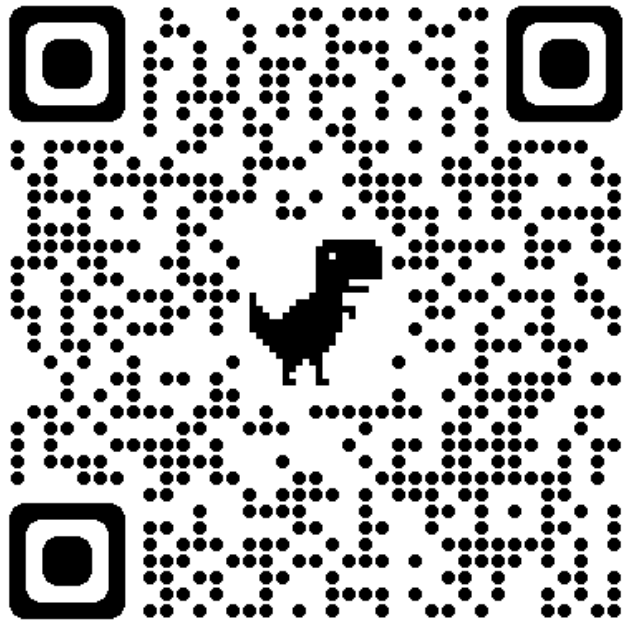
IMPORTANT OPPORTUNITIES IN THE REE INDUSTRY

- Existing conditions in global market & region support establishment / growth of REE industries
- U.S. Government support is essential
- Targeted incentives:
 - Production tax credits
 - Research & development funding
 - Export restrictions or tariffs



EVOLVE CAPP

Evolve Central Appalachia



*Scan QR code
for more info:*

<https://energy.vt.edu/research/evolve-capp.html>

*For more information,
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