

# Summary of Mining and Environmental Planning Aspects of Production of Saleable Rare Earth Products from Coal and Coal Byproducts in the US Using Advanced Separation Technologies



Presented by:  
Marshall Miller & Associates, Inc.  
Contract: DE-FE0029956  
**PRODUCTION OF SALABLE RARE EARTH PRODUCTS  
FROM COAL AND COAL BYPRODUCTS IN THE U.S.  
USING ADVANCED SEPARATION PROCESSES**

2019 Annual Project Review Meeting for Crosscutting,  
Rare Earth Elements, Gasification and Transformative  
Power Generation  
**DOE/NETL**  
Pittsburgh, PA  
April 9 – 11, 2019

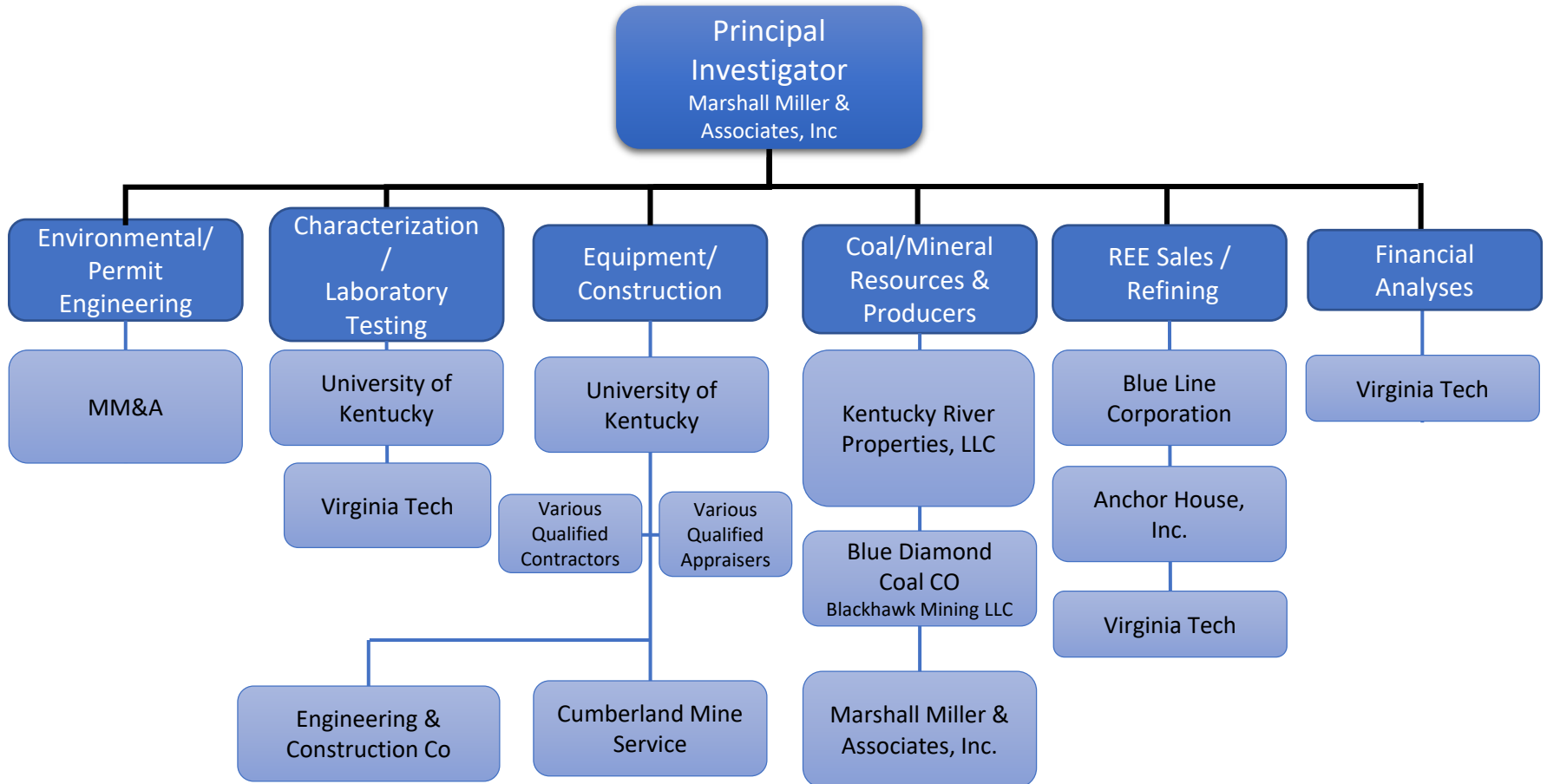


## Scope of Work

- > Past research has shown that REE's are present in coal and coal byproducts, particularly the non-carbon bearing portions of coal deposits which are not economical to sell as a coal product. These are commonly referred to as "partings" or "high ash" material. Such material is included in run-of-mine (ROM) coal and is removed in processing plants and discarded in refuse embankments or impoundments.
- > High-ash partings (and subsequently relatively high REE bearing material) is discarded in large volumes on a daily basis. Additionally, refuse impoundments contain significant volumes of material which contain REE's.
- > **This project aims to assess the feasibility of recovering REE's from high ash, discarded material.**

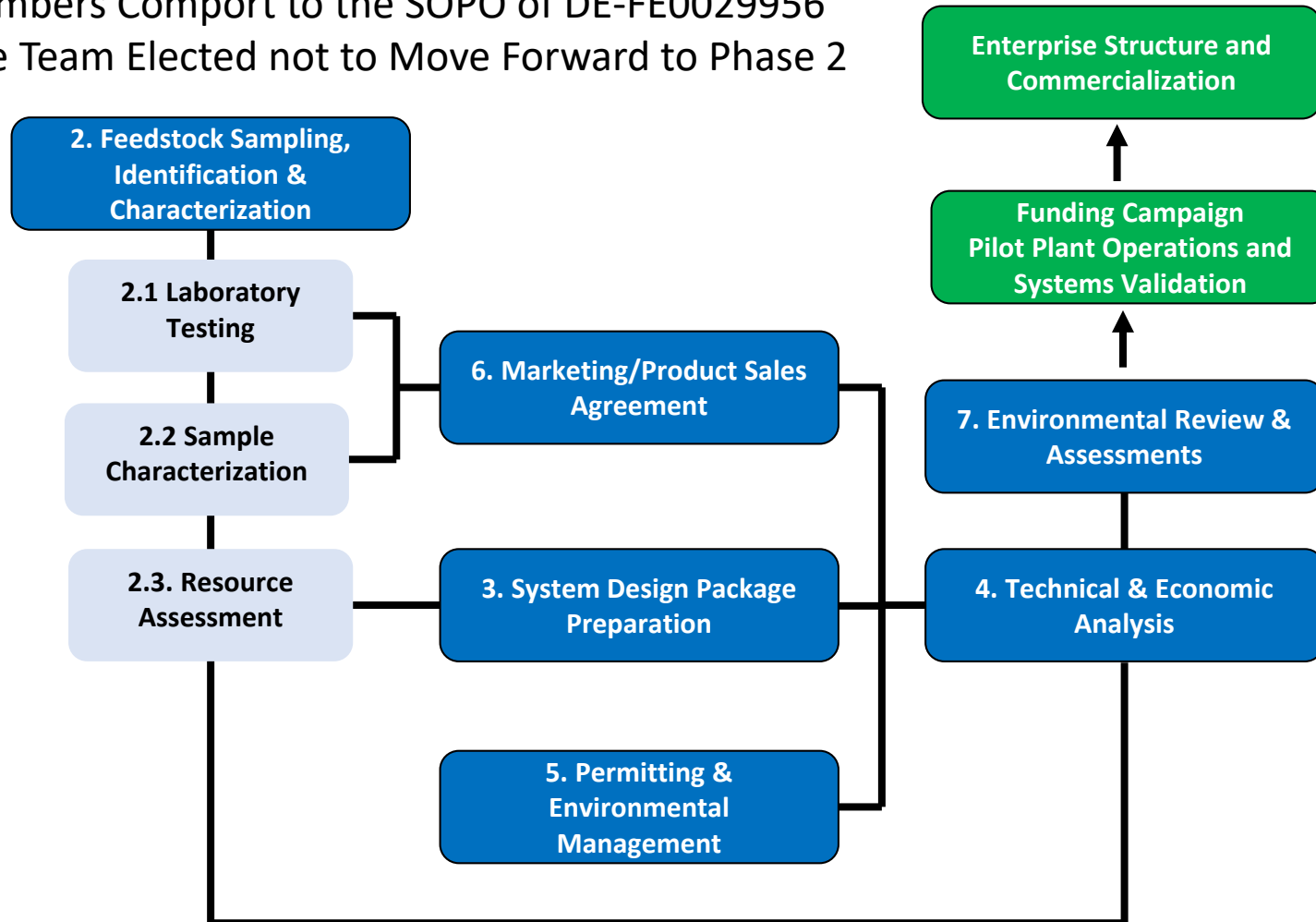


# Overview of Project Team



# Project Flow Chart

Numbers Comport to the SOPO of DE-FE0029956  
The Team Elected not to Move Forward to Phase 2







## Fire Clay Coal Seam Preparation Plant Refuse – The Root Source of REE for this Project

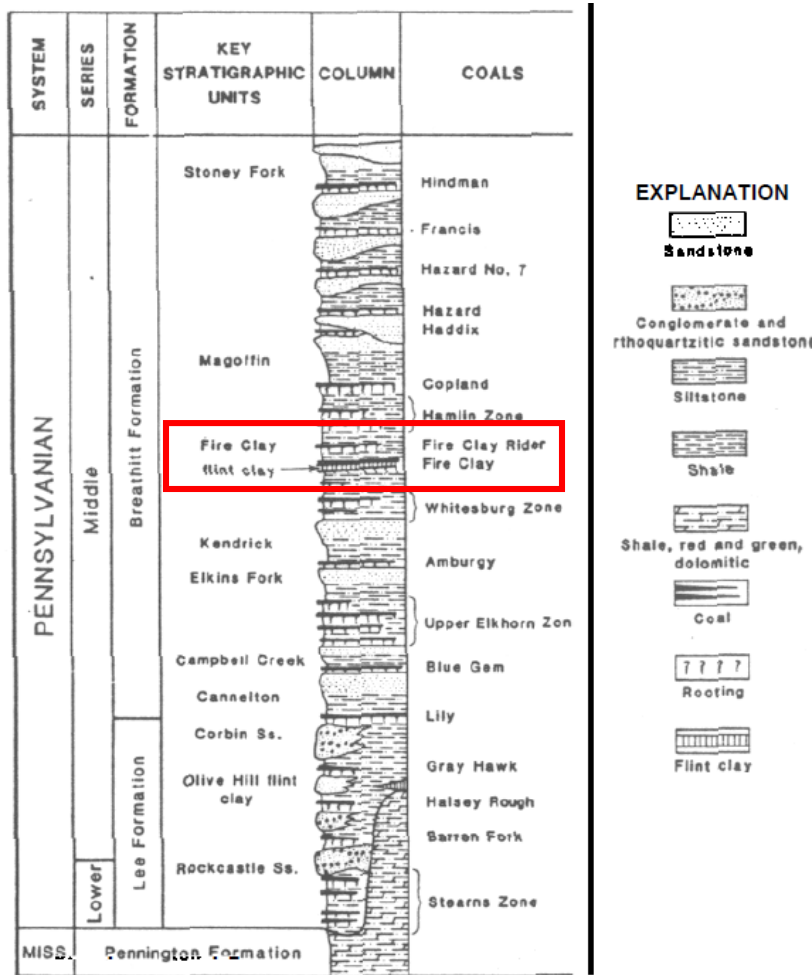
This Fire Clay seam “refuse” is now determined to be a viable feedstock for REE concentration purposes.

The tests conducted on the thickener-underflow revealed limited potential for coal and REE recovery, the team focused on the coarse refuse process stream of the Blue Diamond (Leatherwood) preparation plant.

### Coal Seams Examined in the Course of this Project

Coal Seam Refuse Source	Sponsor/Contributor/Location
Pocahontas No. 3 Coal Seam	Arch Coal Inc, Beckley Coal Preparation Plant, Beckley, WV
Blue Gem Coal Seam	Alden Resources, FerroGlobe Preparation Plant, Whitley and Knox Counties, Eastern KY
Jellico Coal Seam	Alden Resources, FerroGlobe Preparation Plant, Whitley and Knox Counties, Eastern KY
Coal-to-Oil Process Refuse	Vitol Company, Arq Group, Eastern Kentucky
Fire Clay Coal Seam	Blue Diamond Mining, Inc., No. 76 Plant (Leatherwood) Eastern, KY

# Pennsylvania Rocks of Eastern Kentucky – Home of the Fire Clay Seam



SOURCE OF THE VOLCANIC ASH DEPOSIT (FLINT CLAY)  
 IN THE FIRE CLAY COAL OF THE APPALACHIAN BASIN  
 DONALD R. CHESNUT  
 Kentucky Geological Survey, University of Kentucky, U.S.A.

Fig.1 Generalized lithologic column for part of the Pennsylvanian rocks of eastern Kentucky.

# Fire Clay Coal Bed, Flint Clay and Volcanic Ash Deposition

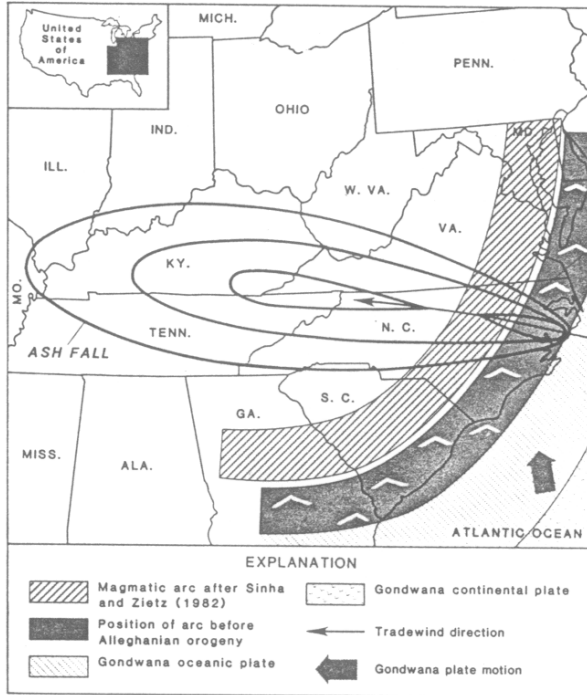


Fig. 11. Probable original ash-fall distribution for the flintclay parting, based on wind patterns, the present position of a Carboniferous volcanic arc (after SINHA & ZIETZ, 1982), and a reconstructed position of this arc. The collision of the African continent (Gondwanan continent) with the North American continent (Laurussian continent) created the Alleghanian orogeny, which shoved the magmatic arc, the Inner Piedmont, and the Blue Ridge deformed rocks inland by at least 120 km (COOK, 1983).

Flint clay is a claystone composed of microcrystalline to cryptocrystalline kaolinite or halloysite; it is smooth, hard, flint-like in appearance, and breaks with a conchoidal fracture.

A flint clay parting in the Fire Clay coal of the Breathitt Formation (Middle Pennsylvanian, Westphalian B) occurs throughout most of eastern Kentucky and in parts of Tennessee, Virginia, and West Virginia.

Examination of Westphalian continental reconstructions, trade wind patterns, and a present-day, ash-fall distribution indicate that the location of the volcanic source for this flint clay was along a line from Kentucky to North Carolina (approximately due east). The intersection of this line with a palinspastically replaced, known Hercynian magmatic arc occurs in extreme eastern North Carolina. This is the approximate location of the volcanic source for the ash.

Because of the extensive distribution of the parting, the Fire Clay coal bed is the only coal bed in eastern Kentucky that can be positively identified over a large area.

[SOURCE OF THE VOLCANIC ASH DEPOSIT \(FLINT CLAY\) IN THE FIRE CLAY COAL OF THE APPALACHIAN BASIN DONALD R. CHESNUT](#) Kentucky Geological Survey, University of Kentucky, U.S.A.



# Summary of Geochemical Processes

The Fire Clay coal bed in the Central Appalachian basin region contains a laterally-persistent tonstein that is found in the coal throughout most of its areal extent.

Tonstein is a hard, compact sedimentary rock that is composed mainly of kaolinite or, less commonly, other clay minerals such as montmorillonite and illite. The clays often are cemented by iron oxide minerals, carbonaceous matter, or chlorite. [Tonsteins form from volcanic ash deposited in swamps.](#) (Wikipedia)

The tonstein contains an array of minerals, including sanidine, b-quartz, anatase and euhedral zircon, that constitutes strong evidence for a [volcanic origin of the parting](#).

The Fire Clay tonstein significantly influenced the geochemistry of the Fire Clay coal bed in eastern Kentucky.

[Lanthanide elements](#) show a similar [enrichment in the coal directly underlying the tonstein](#), ranging from 1965 to 4198 ppm ash basis. for Y + $\Sigma$ REE compared to 511 to 565 ppm in the tonstein samples.

We suggest that [the mechanism for the enrichment of Y + \$\Sigma\$ REE is leaching of volcanic ash by ground water](#), and the incorporation of those elements into monazite and Y-bearing Ca-phosphates (crandallite?).

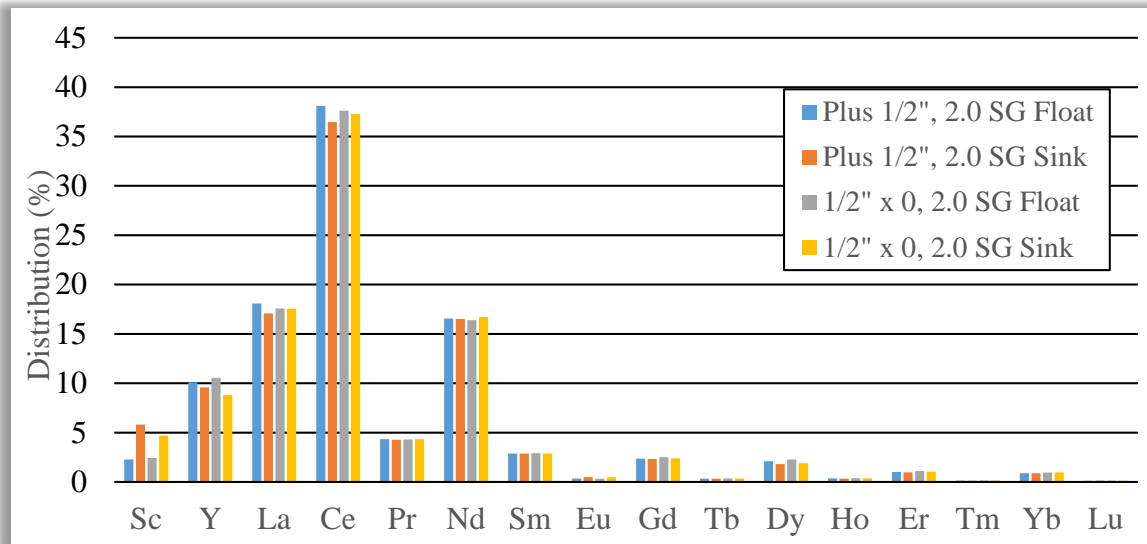
The trace element distribution of the Fire Clay coal bed suggests that the geochemical influence of the ash fall extended throughout the coal.

Source: [Lanthanide, yttrium, and zirconium anomalies in the Fire Clay coal bed, Eastern Kentucky](#), James C. Hower, Leslie F. Ruppert, Cortland F. Eble, *International Journal of Coal Geology* 39 1999. 141–153

## Focus Has Shifted to REE Content in the Refuse Generated by Processing (“cleaning”) the Fire Clay Coal Bed

Particle Size Fraction	Specific Gravity Fraction	Weight (%)	Ash (%)	Total REE (ppm, ash basis)	Total REE (ppm, whole basis)
Plus 2-in	2.0 Float	19.51	51.16	724	371
	2.0 Sink	37.28	89.63	389	349
Minus 2-in	2.0 Float	2.15	38.30	933	357
	2.0 Sink	41.06	89.88	397	357
<b>Total</b>		<b>100.00</b>	<b>81.12</b>	<b>439</b>	<b>357</b>

Total rare earth element distribution as a function of particle size and specific gravity in the Fire Clay coarse refuse of the Leatherwood processing plant (No. 76 Plant).



Rare earth element distribution by particle size and specific gravity in the Fire Clay coarse refuse collected from the Leatherwood preparation plant.



## Principal Fire Clay Coal and Fire Clay Refuse Resource Supplier

**Kentucky River Properties LLC**  
**360 East Vine Street, Suite 310**  
**Lexington, KY 40507-1522**



Kentucky River Properties (KRP) Holdings in the Central Appalachian Coal Basin are located primarily in the southeastern Kentucky counties of Perry, Knott, Letcher, Leslie, Breathitt, Clay and Harlan Counties. KRP’s properties currently consist of more than 282,000 acres of mineral or fee properties, containing a resource base of nearly 500 million tons of potentially recoverable coal. KRP’s reserves can be mined by both the surface and underground mining methods. Typical coal seams in the basin include multiple seams of high quality Central App coal with average Btu content of 12,500.

KRP leases out its mineral holdings to coal production companies on a royalty basis. Blackhawk Mining LLC is a key lessee of KRP’s Fire Clay Seam Deposits in Perry and Leslie Counties, Kentucky. The lands were formerly operated and permitted as Blue Diamond Mining Company.

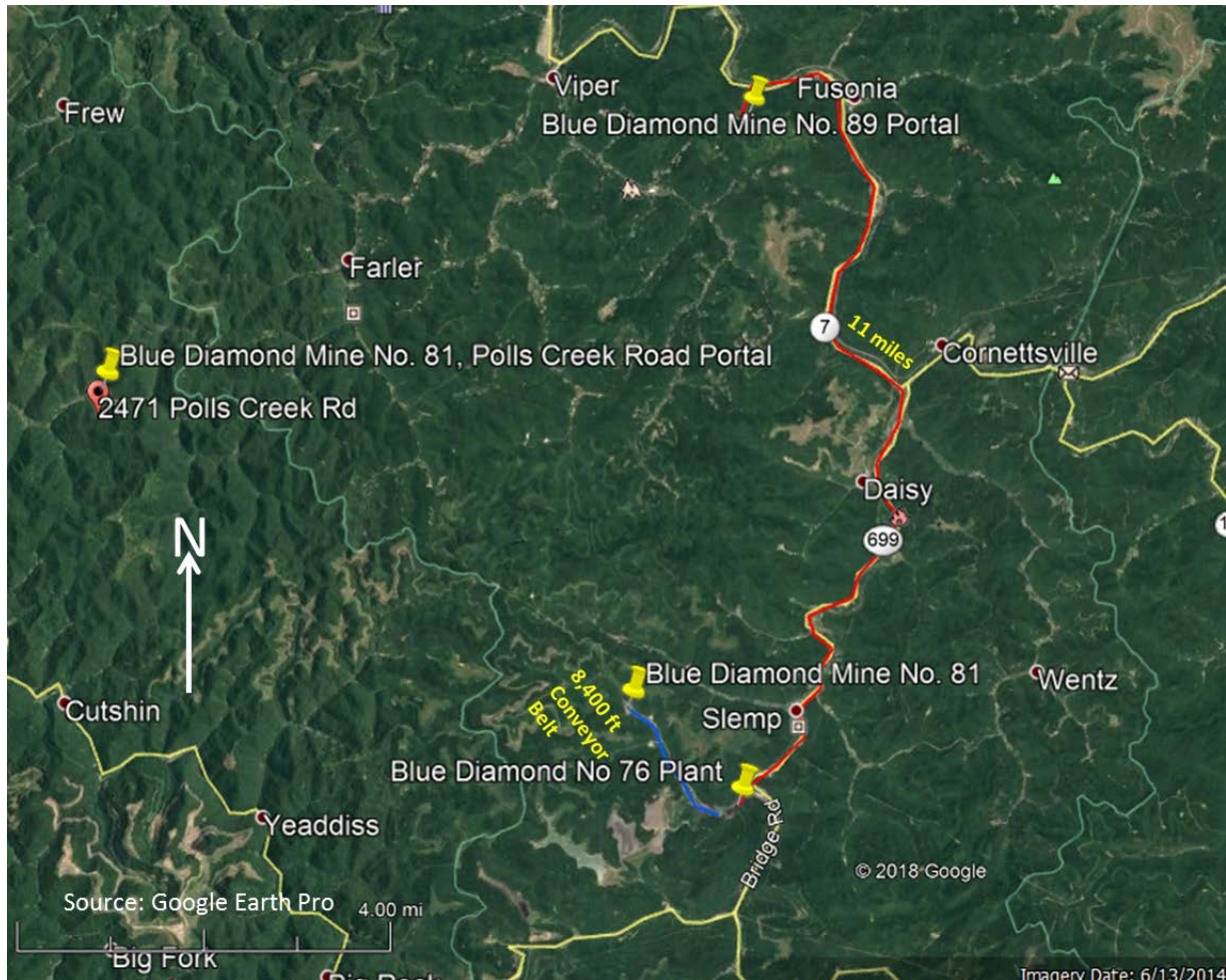
**Blackhawk Mining, LLC**

3228 Summit Square Place,  
Suite 180, Lexington, KY 40509

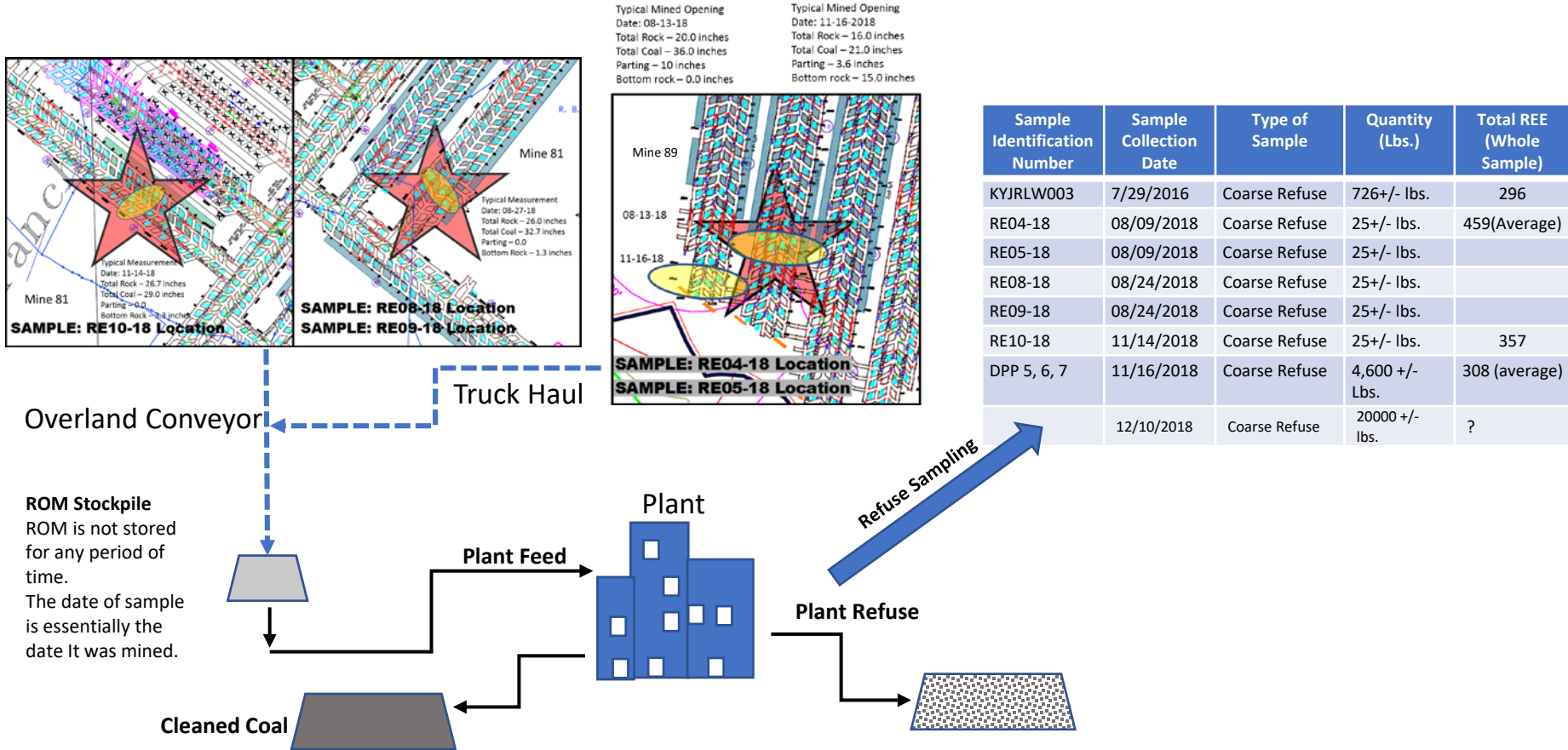




# Fire Clay Coal Resource Area – Principal Facilities of Former Blue Diamond Mining Company (now Blackhawk)



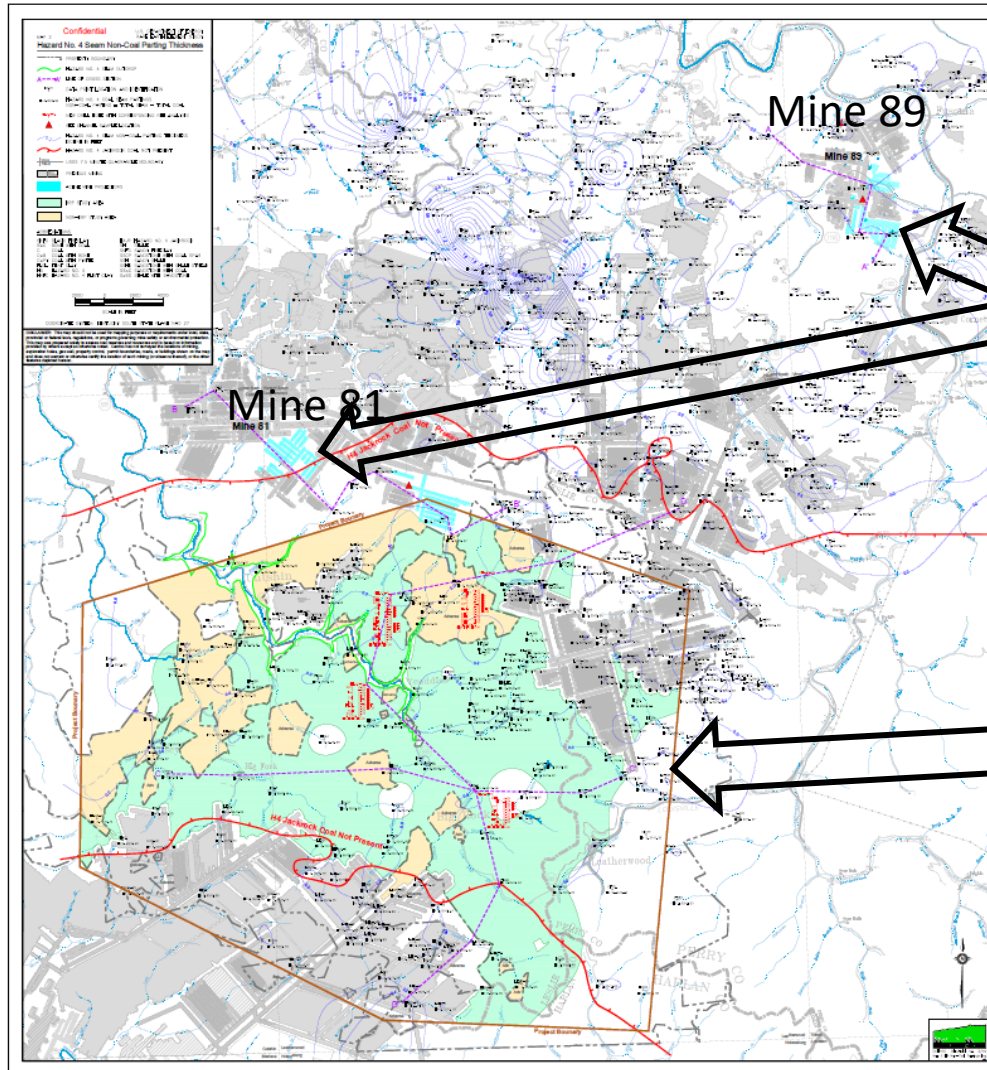
# Preparation Plant Refuse Source, Materials Handling and Collection Dates



Source: Personal Communications and Documentation Exchanges with Kentucky River Properties LLC



# Coal and Coal Refuse Rejects Resource Area

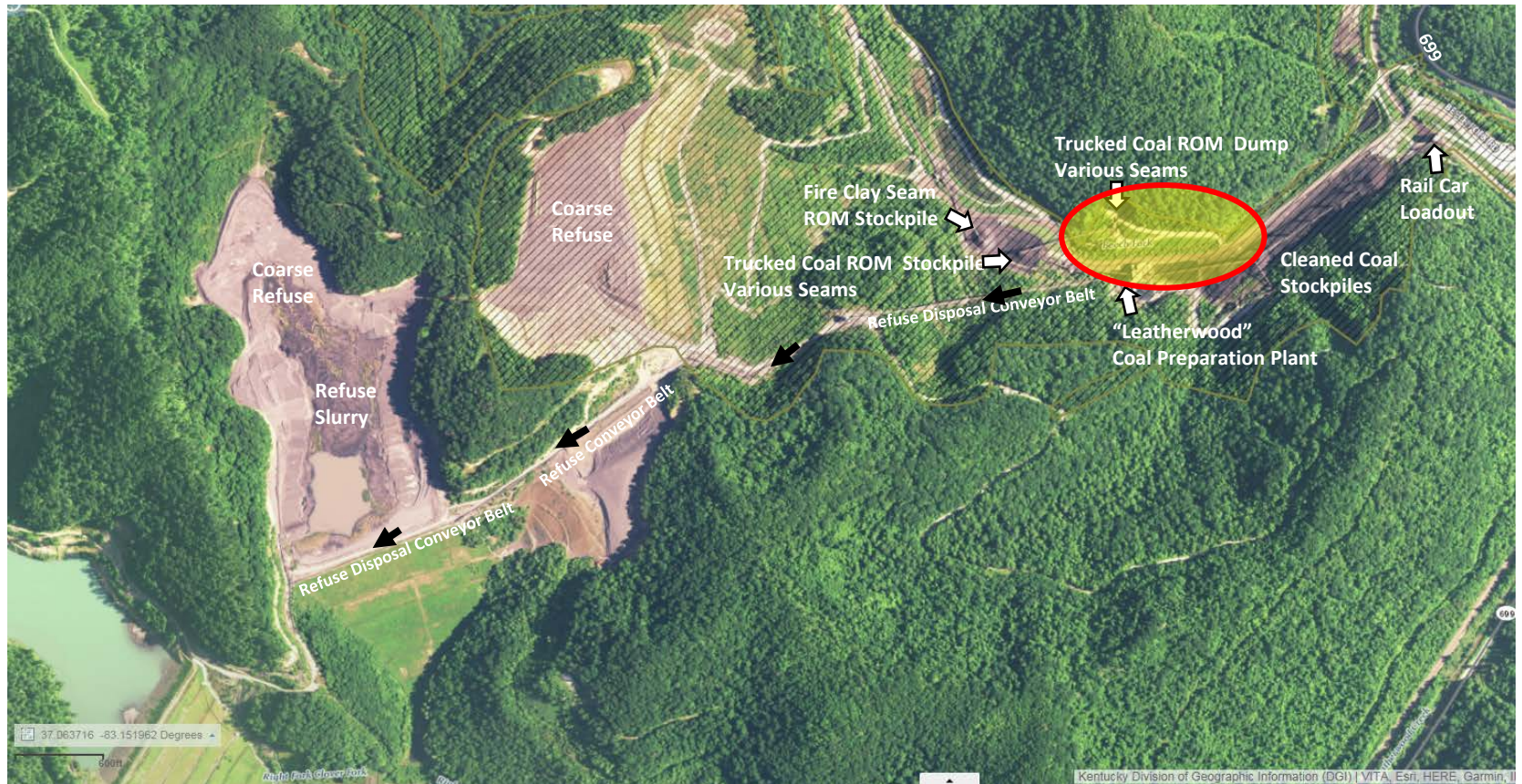


Current Fire Clay Seam refuse Sources

Fire Clay Seam refuse Source  
“Commercialization” Area” recommended by KRP



## No. 76 Plant, KDSMRE Permit 897-8062, Materials Handling Systems Conceptual Location of Commercialized REE Concentrate/Products Plant



<https://epcgis.ky.gov/smis/>



## Inventory of Blue Diamond Operations, KY (Circa 2018)

MSHA ID	Operator	Facility Name	Type	Status
15-12753	Blue Diamond Coal Company	Calvary Mine No. 81	Underground	Active
15-05151	Blue Diamond Coal Company	Jeff Tipple	Facility	Temporarily Idled
15-16353	Blue Diamond Coal Company	No. 64 Plant	Facility	Non-producing
15-09636	Blue Diamond Coal Company	Mine No. 77	Underground	Active
15-16520	Blue Diamond Coal Company	No. 76 Plant	Facility	Active
15-17478	Blue Diamond Coal Company	Mine No. 75	Underground	Non-producing
15-17497	Blue Diamond Coal Company	Mine No. 68	Underground	Non-producing
15-19400	Blue Diamond Coal Company	Mine No. 88	Underground	Temporarily Idled
15-19405	Blue Diamond Coal Company	Orchard Branch Mine No. 89	Underground	Active



## Blue Diamond Coal Company No. 76 Plant MSHA Mine Information and POV Report

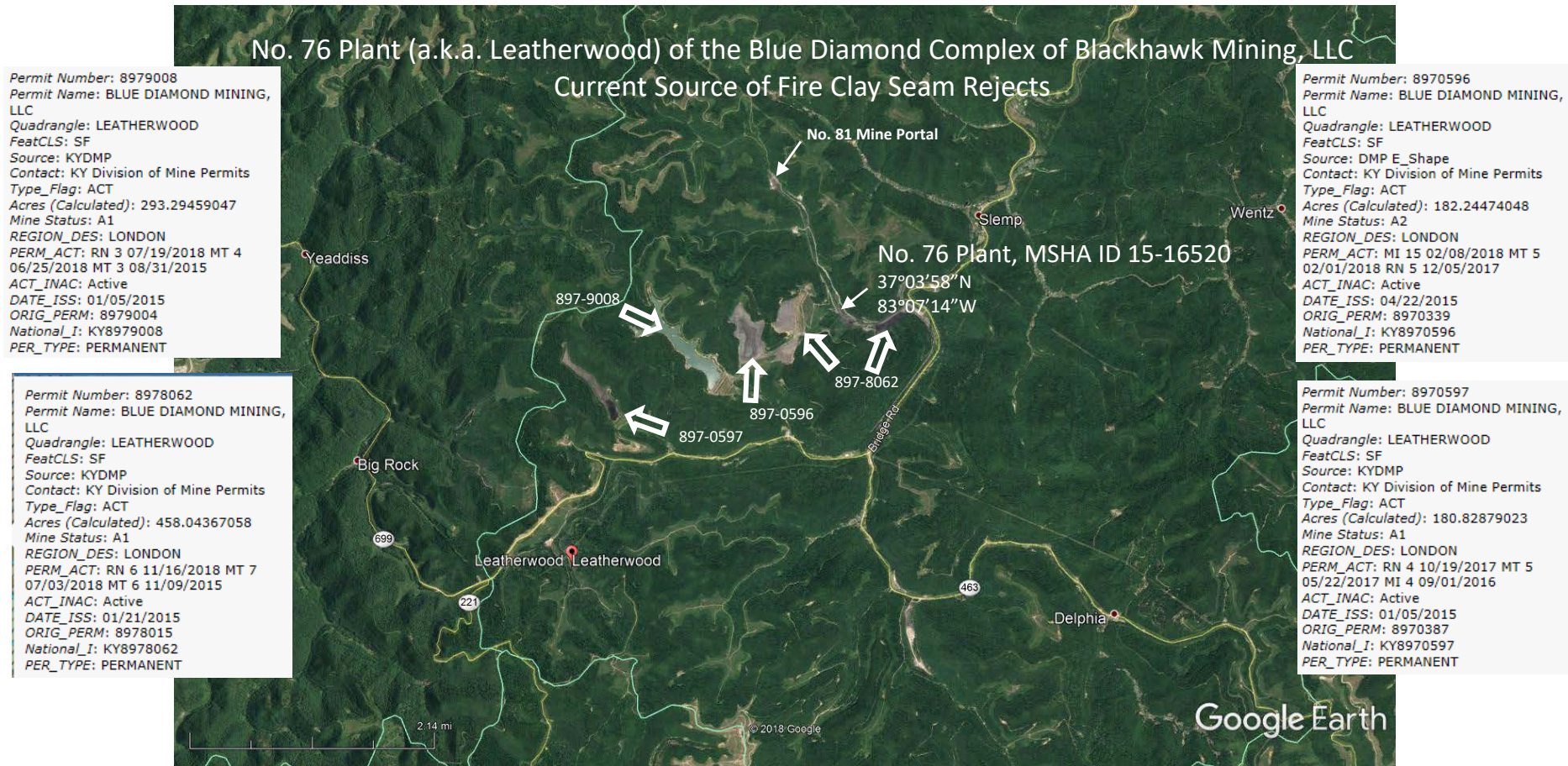
Current Mine Information - MSHA - Blue Diamond Coal Company No. 76 Plant				
Item	Description	Operator History for Mine ID: 15-16520		
		Operator Name	Begin Date	End Date
Mine ID:	15-16520	Blue Diamond Coal Company	9/4/2014	
Operator:	Blue Diamond Coal Company	Blue Diamond Coal Company	11/17/2008	9/3/2014
Opr. Begin Date:	9/4/2014	Leatherwood Processing Company	5/18/1998	11/16/2008
Mine Name:	No. 76 Plant	Blue Diamond Coal Company	11/1/1988	5/17/1998
Current Controller:	Blackhawk Mining LLC			
Controller Start Date:	9/4/2014			
Mine Status:	Active			
Status Date:	8/31/1990			
Mined Material:	Coal (Bituminous)			
Type of Mine:	Facility			
Location:	Perry County, KY			
Address of Record:	1021 Tori Drive, Hazard, KY 41701			

Pattern of Violations (POV) Report, MSHA Single Source Page - No. 76 Plant		
Overall Results		
Does the mine meet either Criteria 1 or 2 (30 CFR 104.2)?	NO	
	Data Last Refreshed	
	15-Jan-2019	
Mine ID: 15-16520	Four QTR Part 50 Data Range	
Mine Status: Active (As of Last Data Refresh Date)	1st QTR:	01-Oct-2017
Mine Name: No. 76 Plant	4th QTR:	30-Sep-2018
Mine Type: Facility	12 Month Enforcement Range	
Controller: Blackhawk Mining LLC	Start Date:	01-Jan-2018
Operator: Blue Diamond Coal Company	End Date:	31-Dec-2018

Physical Address:  
48 Beech Fork Road  
Slemp, Perry County, KY 41763



# No. 76 Plant Site of the Blue Diamond Complex of Blackhawk Mining, LLC Current Source of Fire Clay Seam Rejects





# Blue Diamond Coal Co. Calvary Mine No. 81 MSHA Mine Information, Production History, Pattern of Violation Status and KY DMS Safety Performance Statistics

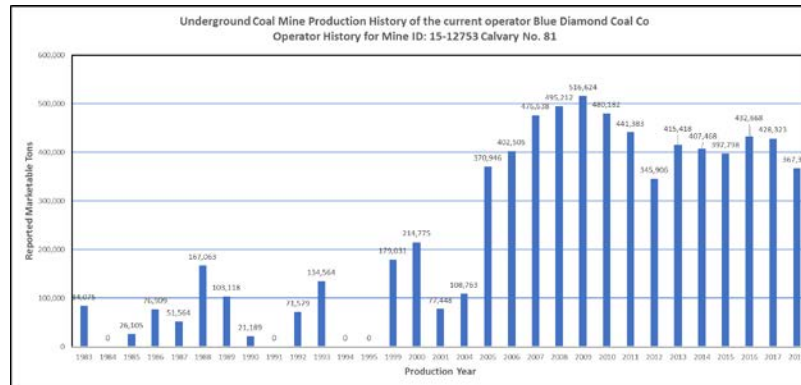
Current Mine Information - Calvary No. 81				
Mine ID:	Operator History for Mine ID: 15-12753			
	Operator Name	Begin Date	End Date	
Operator:	Blue Diamond Coal Co	9/4/2014		
Opr. Begin Date:	Blue Diamond Coal Co	2/5/2004	9/3/2014	
Mine Name:	Calvary Coal Co. Inc	1/28/1999	2/4/2004	
Current Controller:	Blue Diamond Coal Company	4/17/1995	1/27/1999	
Controller Start Date:	Sovereign Mining Company	4/29/1992	4/16/1995	
Mine Status:	Kentucky Prince Mining Company	11/20/1986	4/28/1992	
Status Date:	Kentucky Prince Coal Corp	5/28/1985	11/19/1986	
Mined Material:	River Processing Inc	12/21/1983	5/27/1985	
Type of Mine:	River Processing Inc	3/1/1981	12/20/1983	
Location:	Leslie County, KY			
Address of Record:	1021 Tori Drive, Hazard, KY 41701			

Pattern of Violations (POV) Report, MSHA Single Source Page		
Calvary Mine No. 81 Overall Results		
Does the mine meet either Criteria 1 or 2 (30 CFR 104.2)?	NO	
	Data Last Refreshed	
	15-Jan-2019	
Mine ID: 1512753	Four QTR Part 50 Data Range	
Mine Status: Active (As of Last Data Refresh Date)	1st QTR:	01-Oct-2017
Mine Name: Calvary Mine No. 81	4th QTR:	30-Sep-2018
Mine Type: Underground	12 Month Enforcement Range	
Controller: Blackhawk Mining LLC	Start Date:	01-Jan-2018
Operator: Blue Diamond Coal Company	End Date:	31-Dec-2018

<https://www.msha.gov/>

Mine type: Underground  
Main Portal:  
Location: Leslie County, KY  
Physical Address: 2471 Polls Creek Road, Smilax, Kentucky 41764

Conveyor Portal:  
Location: Perry County KY  
Physical Address: 45 Beech Fork Road, Slemp, Kentucky 41763  
<http://www.jamesrivercoal.com/d/jrcc/bluediamondcc.pdf>



<https://www.msha.gov/>

<https://www.msha.gov/>

Five-Year Safety Statistics for Calvary Mine No. 81 (Kentucky Division of Mine Safety Annual Reports)

Year	Company	Mine	Operator	SFN	Location	Tonnage	Men Employed	Days Wrkd	Seam Name	Seam Hgt	Accidents			
											Reportable	Serious	Fatal	Total
2013	Blue Diamond Coal Co.	81	Joseph G. Evans	08385-31	Smilax	351,961	102	234	Hazard No. 4	48	7	0	0	7
2014	Blue Diamond Mining, LLC	81	Christopher P Woods	08385-31	Smilax	270,396	102	144	Hazard No. 4	48	2	0	0	2
			Jeffrey T Sands		Polls Creek	137,574	102	71			1	0	0	1
			<b>Total</b>			<b>407,970</b>	<b>204</b>							
2015	Blue Diamond Mining, LLC	81	Kevin T Varney	08385-31	Smilax	397,798	102	229	Hazard No. 4	48	5	0	0	5
2016	Blue Diamond Mining, LLC	81	Kevin T Varney	08385-31	Smilax	432,747	109	267	Hazard No. 4	48	4	0	0	4
2017	Blue Diamond Mining, LLC	81	Kevin T Varney	08385-31	Smilax	428,323	104	271	Hazard No. 4	48	6	1	0	7

[http://minesafety.ky.gov/Department Annual Reports](http://minesafety.ky.gov/DepartmentAnnualReports)



# Blue Diamond Coal Co. Orchard Branch Mine No. 89 MSHA Mine Information, Production History, Pattern of Violation Status and KY DMS Safety Performance Statistics

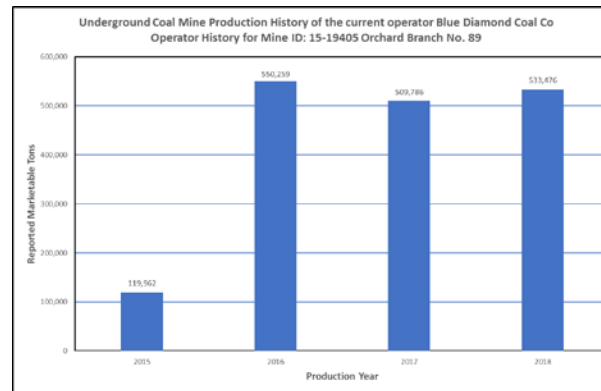
Current Mine Information - Orchard Branch Mine No. 89				
Mine ID:	1519405	Operator History for Mine ID: 15-19405		
		Operator Name	Begin Date	End Date
Operator:	Blue Diamond Coal Company	Blue Diamond Coal Company	9/4/2014	
Opr. Begin Date:	9/4/2014	Blue Diamond Coal Company	6/16/2009	9/3/2014
Mine Name:	Orchard Branch Mine No. 89			
Current Controller:	Blackhawk Mining LLC			
Controller Start Date:	9/4/2014			
Mine Status:	Active			
Status Date:	6/23/2015			
Mined Material:	Coal (Bituminous)			
Type of Mine:	Underground			
Location:	Perry County, KY			
Address of Record:	1021 Tori Drive, Hazard, KY 41701			

<https://www.msha.gov/>

Mine No. 89 (Orchard Branch)  
Physical Address: S. KY HWY 7 Orchard Branch Road, Viper, Kentucky 41774  
[http://www.jamesrivercoal.com/dd/jrc\\_c\\_bluediamondcc.pdf](http://www.jamesrivercoal.com/dd/jrc_c_bluediamondcc.pdf)

Pattern of Violations (POV) Report, MSHA Single Source Page		
Orchard Br. Mine No. 89 Overall Results		
Does the mine meet either Criteria 1 or 2 (30 CFR 104.2)?	NO	
	Data Last Refreshed	
	15-Jan-2019	
Mine ID: 1519405	Four QTR Part 50 Data Range	
Mine Status: Active (As of Last Data Refresh Date)	1st QTR:	01-Oct-2017
Mine Name: Orchard Branch Mine No. 89	4th QTR:	30-Sep-2018
Mine Type: Underground	12 Month Enforcement Range	
Controller: Blackhawk Mining LLC	Start Date:	01-Jan-2018
Operator: Blue Diamond Coal Company	End Date:	31-Dec-2018

<https://www.msha.gov/>



<https://www.msha.gov/>

Five-Year Safety Statistics for Orchard Branch No. 89 (Kentucky Division of Mine Safety Annual Reports)														
Year	Company	Mine	Operator	SFN	Location	Tonnage	Men Employed	Days Wrkd	Seam Name	Seam Hgt	Accidents			
											Reportable	Serious	Fatal	Total
2013	Blue Diamond Coal Co	89	Joseph G. Evans	18642-2	Viper	2376	38	3	Hazard No. 4	48	0	0	0	0
2014	Blue Diamond Mining, LLC	89	Jeffrey T. Sands	18642-2	Viper	0	0	0	Hazard No. 4	48	0	0	0	0
2015	Blue Diamond Mining, LLC	89	Kevin T Varney	18642-2	Viper	119,962	39	128	Hazard No. 4	48	2	0	0	2
2016	Blue Diamond Mining, LLC	89	Kevin T Varney	18642-2	Viper	551,740	71	267	Hazard No. 4	48	14	0	0	14
2017	Blue Diamond Mining, LLC	89	Kevin T Varney	18642-2	Viper	509,697	80	259	Hazard No. 4	48	0	0	0	0

[http://minesafety.ky.gov/Department Annual Reports](http://minesafety.ky.gov/Department%20Annual%20Reports)



# Status of Exploration Sample Testing Results

Status of Laboratory Tests (Total Roof, Coal, Floor Samples)							
Testing Entity	RELW-18-01 (Core)	RELW-18-02 (Core)	RELW-18-03 (Core)	RELW-19-01 (Core)	RECH-1 Mine 81 (Channel)	RECH-A (Mine 89) (Channel)	RECH-2 Mine 89 (Channel)
Mineral Labs Inc.	✓	✓	Pending	Pending	cancelled	N/A	cancelled
SGS Lakefield	Pending	Pending	Pending	Pending	cancelled	N/A	cancelled
KGS	✓	✓	✓	✓	✓	✓	Pending

Status of Laboratory Tests of Additional Segments of Floor Material				
Testing Entity	RELW-18-01 (Core)	RELW-18-02 (Core)	RELW-18-03 (Core)	RELW-19-01 (Core)
Mineral Labs Inc.	cancelled	cancelled	cancelled	cancelled
SGS Lakefield	cancelled	cancelled	cancelled	cancelled
KGS	✓	✓	✓	✓

Source: KRP, KGS

Summary of REE Content (PPM) Analyses by the Kentucky Geologic Survey (Whole Sample Basis)							
Lithology	Sampling Point Identification Number per KRP						
	RELW-18-01 (Core)	RELW-18-01 (Core)	RELW-18-01 (Core)	RELW-19-01 (Channel)	RECH-1 (Mine 81) (Channel)	RECH-A (Mine 89) (Channel)	RECH-2 (Mine 89) (Channel)
Roof Rock	--	--	251.73	--	--	490.45	Pending
Roof Rock	306.38	283.32	272.34	145.05	369.35	336.05	"
Seat Rock	303.52	416.91	--	--	--	--	"
Flint Clay	145.29	492.47	555.99	797.71	395.19	124.46	"
Seat Rock	693.90	696.15	540.93	443.26	325.44	--	"
Seat Rock	389.49	355.61	--	288.85	--	--	"
Seat Rock	338.21	347.79	291.30	274.32	--	--	"
Seat Rock	--	324.02	238.18	275.96	--	--	"
Seat Rock	--	327.05	289.93	296.88	--	--	"
Seat Rock	--	--	--	295.44	--	--	"

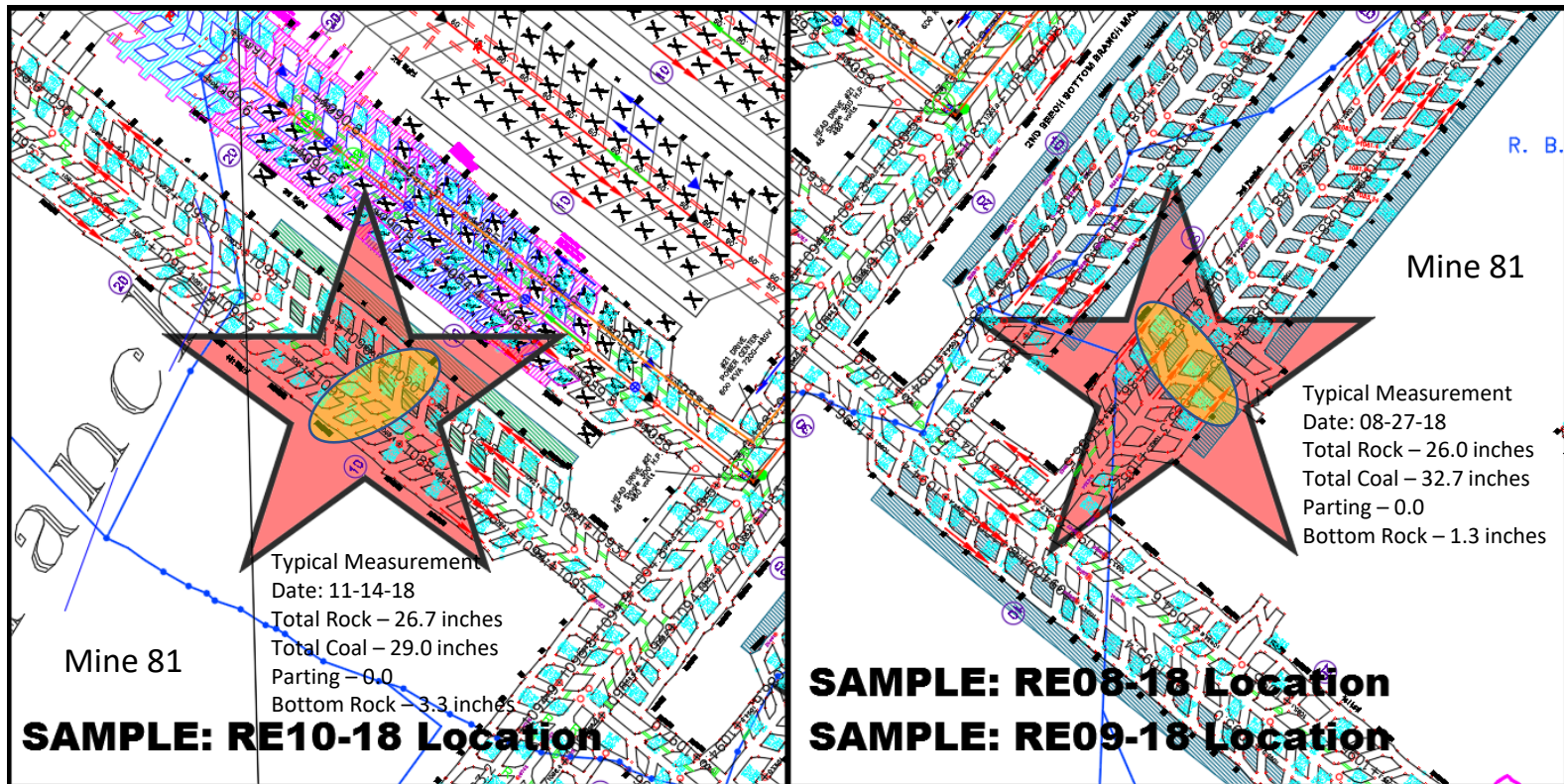




## Status of Plant Refuse Sample Testing Results

Sample Identification Number	Sample Collection Date	Type of Sample	Quantity (lbs.)	Total REE of Refuse (Whole Sample) by KGS
KYJRLW003	7/29/2014	Coarse Refuse	726	296
Black Hawk Mine 89	1/13/2017 (?)	Channel Sample	?	459 (Average)
RE04-18	8/9/2018	Coarse Refuse	25+/- lbs.	?
RE05-18	8/9/2018	Coarse Refuse	25+/- lbs.	?
RE08-18	8/24/2018	Coarse Refuse	25+/- lbs.	?
RE09-18	8/24/2018	Coarse Refuse	25+/- lbs.	?
RE10-18	11/14/2018	Coarse Refuse	25+/- lbs.	357
DPP 5, 6, 7	11/16/2018	Coarse Refuse	46,000 +/- lbs.	308 (average)
?	12/10/2018	Coarse Refuse	20000 +/- lbs.	?

# Mine No. 81: Historical Root-Source of Preparation Plant Coarse Refuse Samples

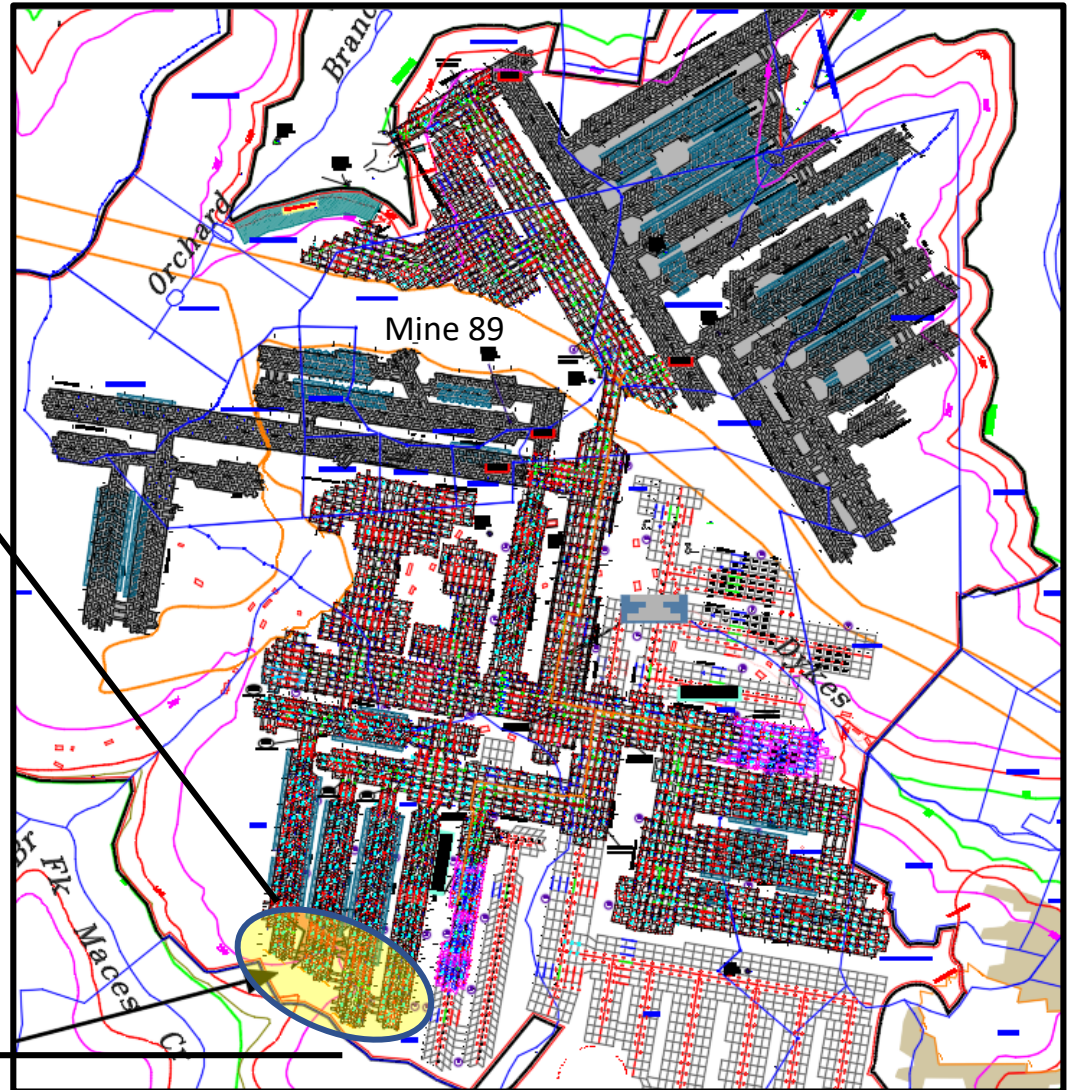
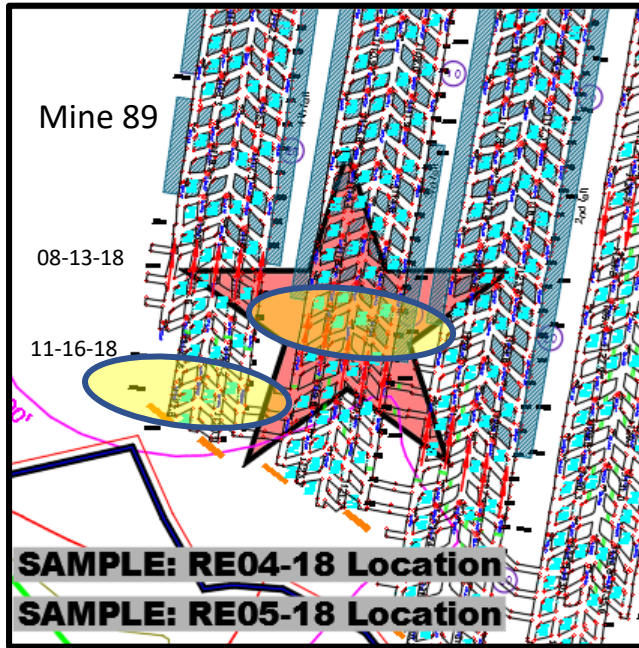




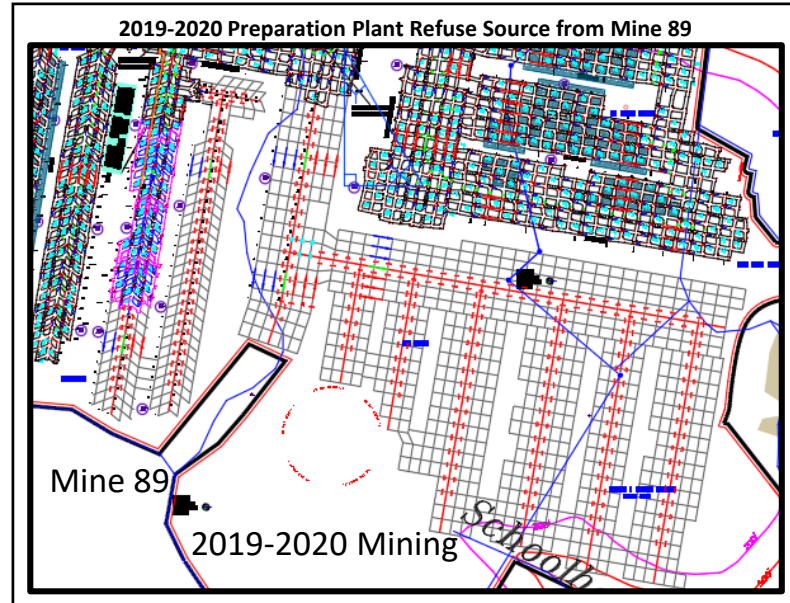
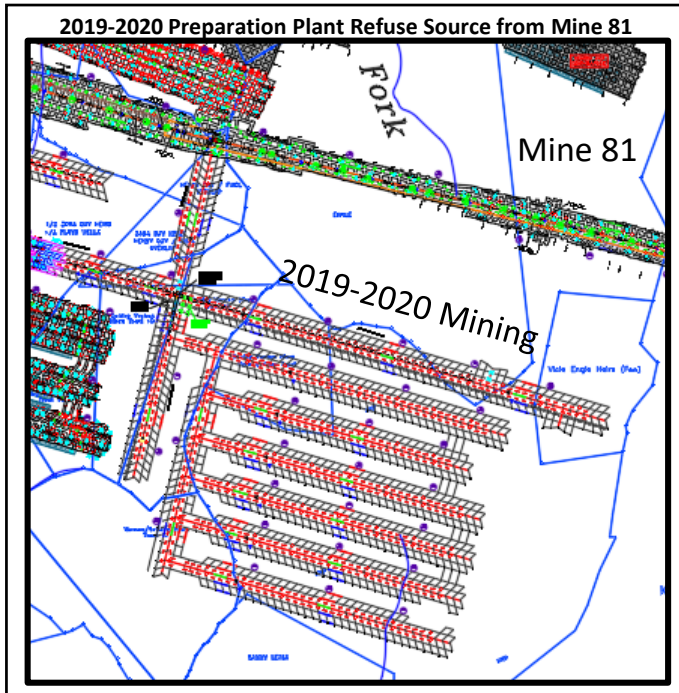
# Mine No. 89: Historical Root-Source of Preparation Plant Coarse Refuse Samples

Typical Mined Opening  
Date: 08-13-18  
Total Rock – 20.0 inches  
Total Coal – 36.0 inches  
Parting – 10 inches  
Bottom rock – 0.0 inches

Typical Mined Opening  
Date: 11-16-2018  
Total Rock – 16.0 inches  
Total Coal – 21.0 inches  
Parting – 3.6 inches  
Bottom rock – 15.0 inches

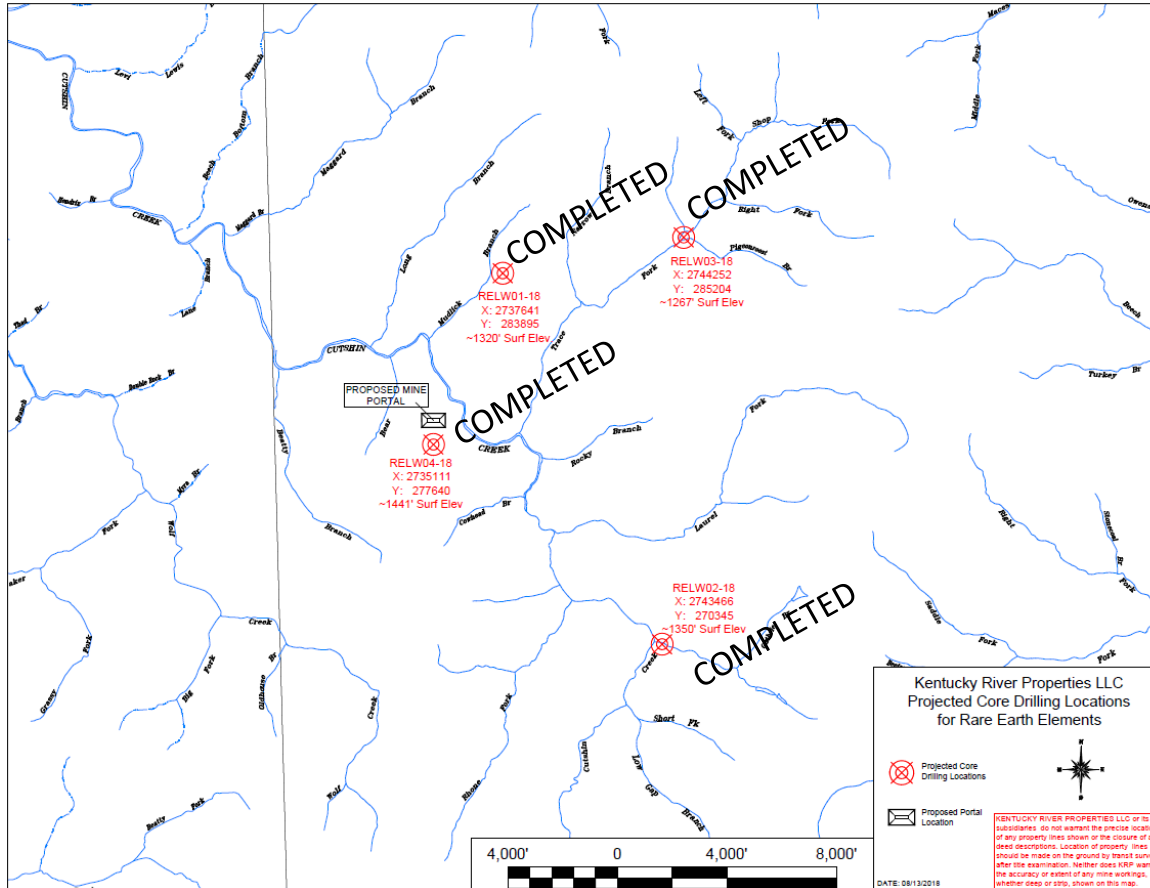


# Immediate Future Coal Preparation Plant Refuse Source Areas

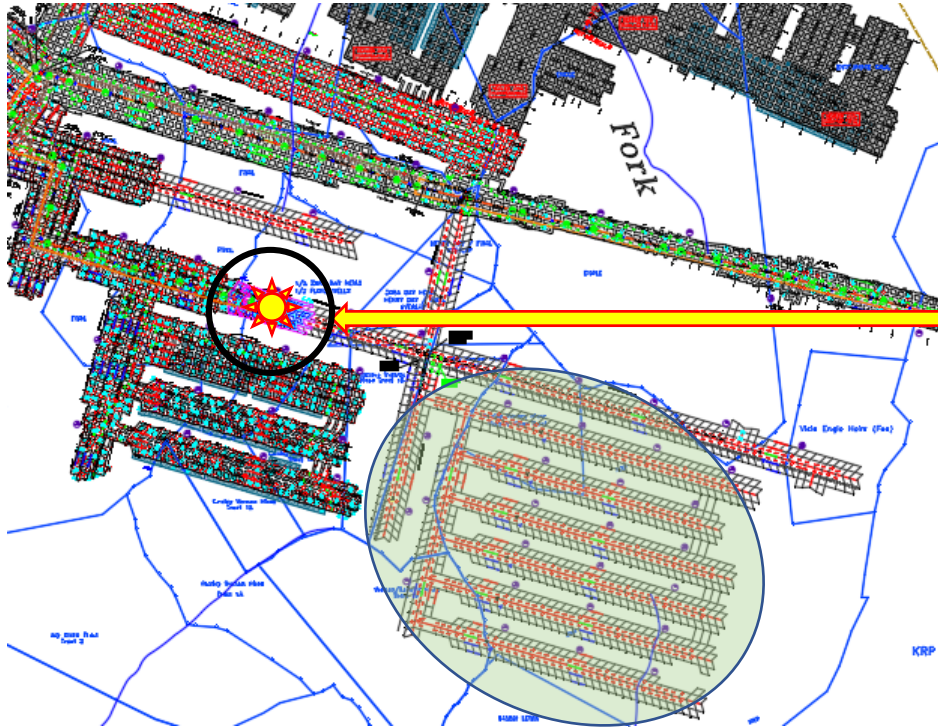




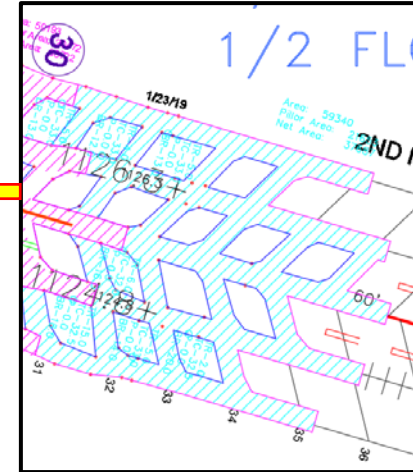
# Completed Core Hole Exploration Sites within Proposed Future Mining Area of Fire Clay Coal Seam



# Blue Diamond (a.k.a. Blackhawk): Mine No. 81, sampled February 6, 2019



**Sample Location**

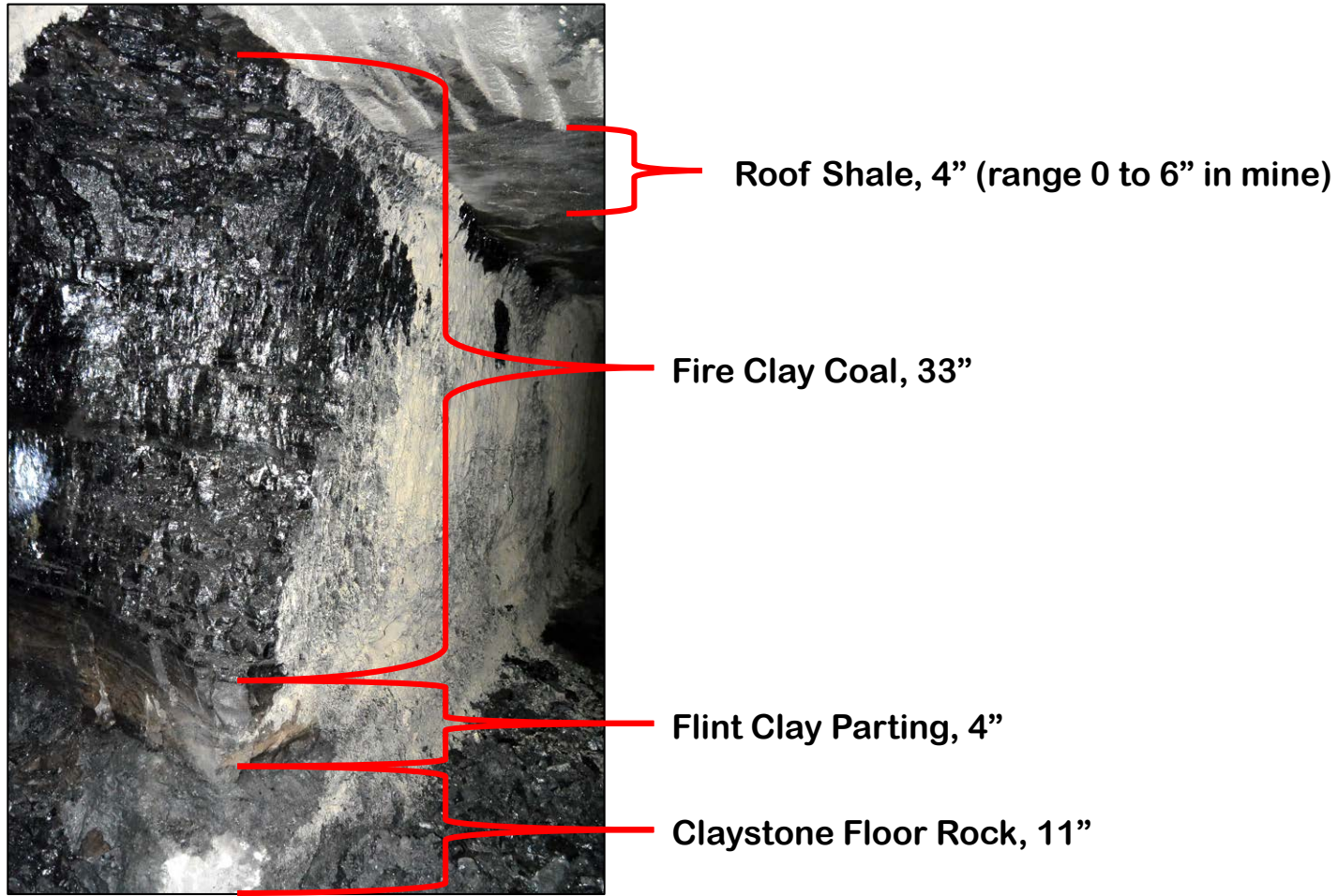


### Samples Collected

Roof – silty shale – 3.5 in.  
Coal – 33.0 in.  
Flint Clay Parting – 4.0 in.  
Floor – 11.0 in.

**Source of Future ROM for Refuse Belt Samples of Phase 2**

## Blue Diamond (a.k.a. Blackhawk): Mine No. 81, Image of Sampling Site, February 6, 2019



Source: KGS

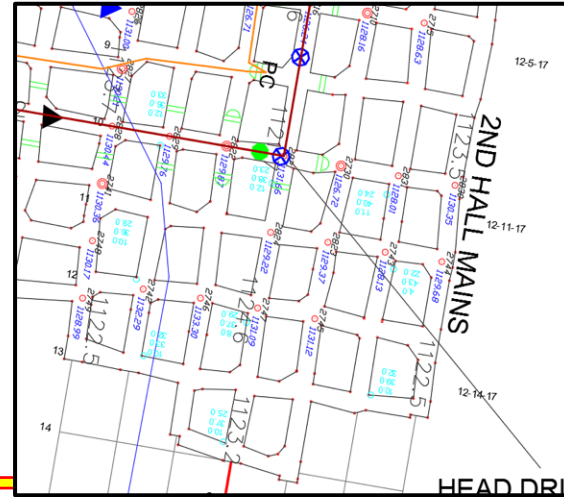


# Blue Diamond (a.k.a. Blackhawk): Mine No. 89, Sampled February 6, 2019



**Sample Location**

Source of Future ROM for Refuse Belt Samples of Phase 2



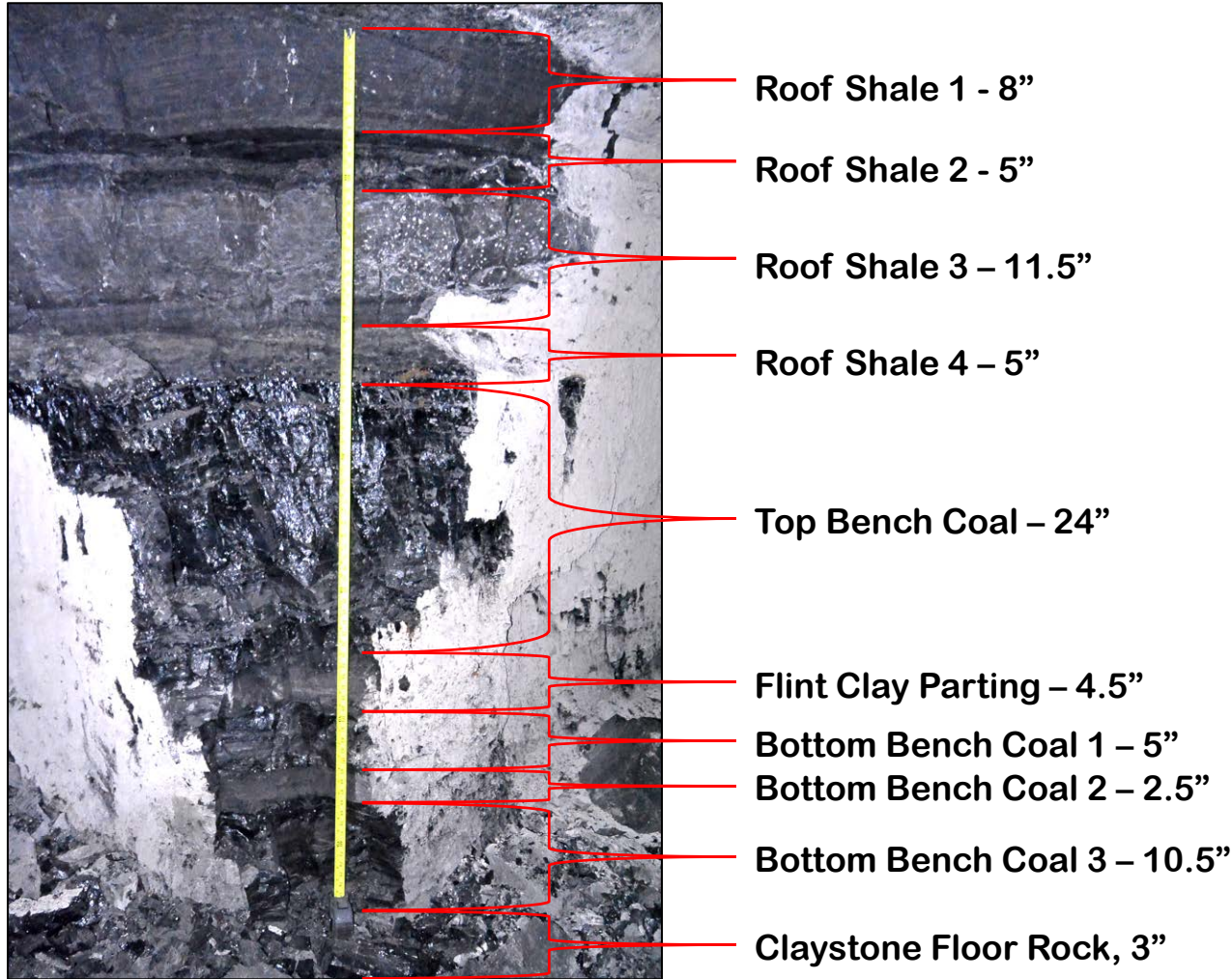
**Samples Collected**

- Roof shale (4) – 29.5 in.**
- Top Bench Coal – 24.0 in.**
- Flint Clay Parting – 4.5 in.**
- Bottom Bench Coal (3) – 18.0 in.**

Approximate Location of Source for ROM of Refuse Belt Samples (Circa 2018) RE04-18 and RE05-18

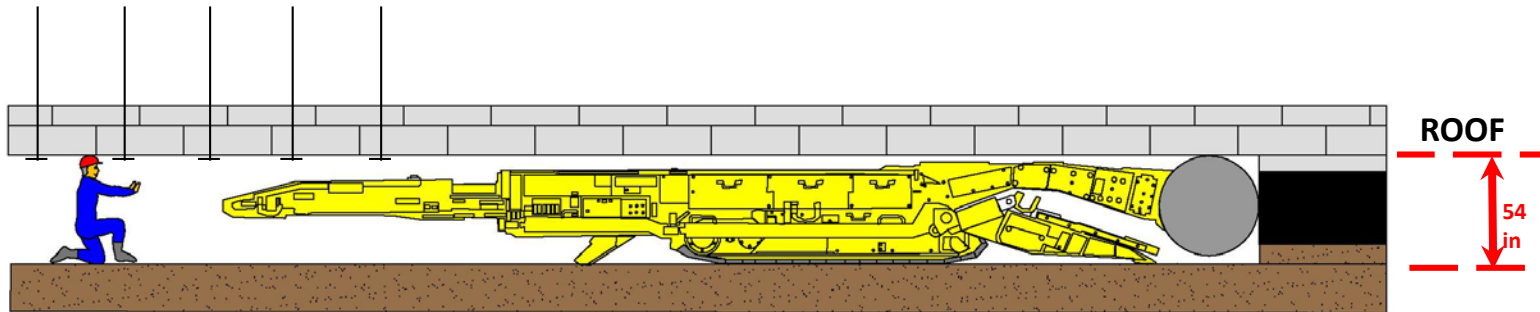


## Blue Diamond (a.k.a. Blackhawk): Mine No. 89, Image of Sampling Site, February 6, 2019

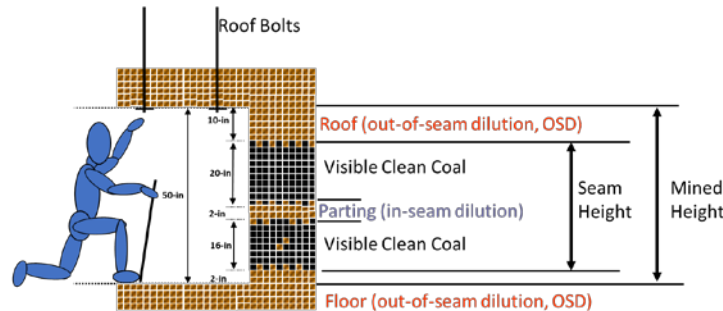


Source: KGS

# Likely Mining Method: Continuous Mining Machine Clearance Requirements



## Definition of Mining Terms



### Explanatory Note(s):

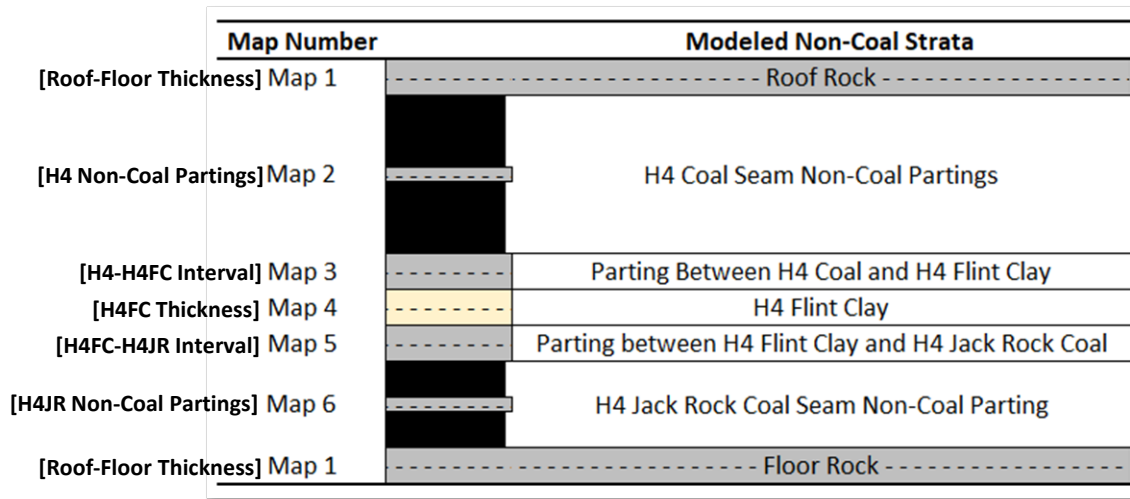
1. In-seam dilution results in "rejects" and is largely unavoidable.
2. Out-of-seam dilution (OSD) results in "rejects" and is created by the mined height.
3. Mined height is often the result of equipment configuration (clearance Requirements)
4. Other causes for mined height causing OSD may include mine ventilation requirements, pre-emptive removal of draw rock (a weak roof layer), breakup of soft floor, and operator preference.



# Potential REE Resource Material from a Mining Bench in the Fire Clay Seam

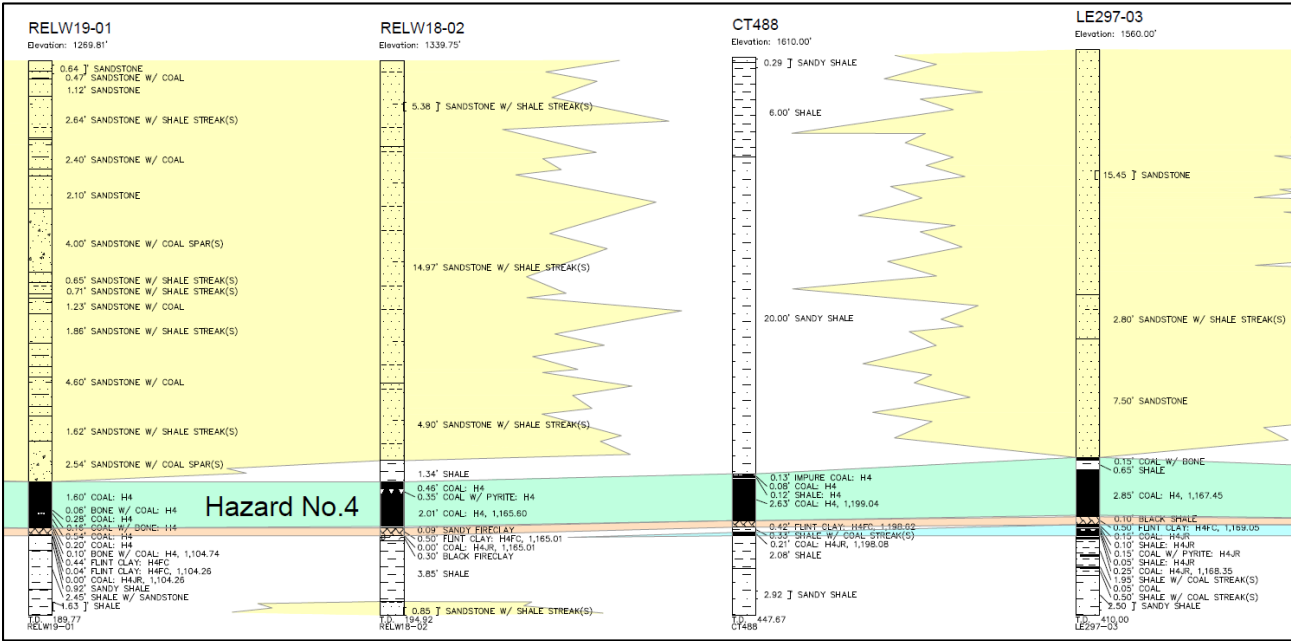
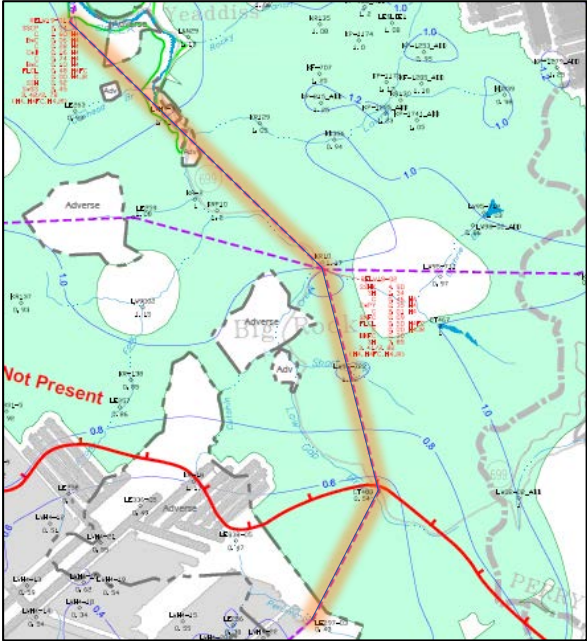
It is assumed that material classified as “coal” will not release REE-bearing material into the coarse-refuse fraction. The remaining material from the mining face includes:

- 1) Roof material;
- 2) Non-coal partings from the Hazard No. 4 coal seam;
- 3) Interval partings between the Hazard No. 4 coal and the Hazard No. 4 Flint Clay;
- 3) Hazard No. 4 Flint Clay;
- 4) Interval partings between the Hazard No. 4 Flint Clay and the Hazard No. 4 Jack Rock coal;
- 5) Non-coal partings from the Hazard No. 4 Jack Rock coal seam; and
- 6) Floor material (same thickness grid as roof material)





# Portion of Section D-D. Commercialization Area



- LITHOLOGIES**
- HAZARD NO.4 RIDER
  - HAZARD NO.4
  - HAZARD NO.4 FLINT CLAY
  - HAZARD NO.4 JACK ROCK CLAY
  - SANDSTONE



# Summary of Non-Coal Tonnages (Refuse) from the Hazard No. 4 Coal Seam Commercialization Area and Active Mines Nos. 81 and 89 Sites

Map Number	Modeled Non-Coal Strata	Study Area: KRP Resources			Study Area: Non-KRP Resources			Mine 81 Projections through 2020			Mine 89 Projections through 2020		
		Tons (IP)	Thk (ft)	Acres	Tons (IP)	Thk (ft)	Acres	Tons (ROM)	Thk (ft)	Acres	Tons (ROM)	Thk (ft)	Acres
Map 1	Roof Rock	37,105,000	0.94	11,196	12,388,000	1.05	3,397	839,000	0.91	261	165,000	0.31	152
Map 2	H4 Coal Seam Non-Coal Partings	1,785,000	0.05	8,742	341,000	0.04	1,914	1,000	0.00	69	5,000	0.01	54
Map 3	Parting Between H4 Coal and H4 Flint Clay	1,323,000	0.03	7,804	415,000	0.03	2,430	16,000	0.02	261	300	0.00	46
Map 4	H4 Flint Clay	12,545,000	0.32	11,036	3,374,000	0.27	3,371	367,000	0.40	261	147,000	0.27	152
Map 5	Parting between H4 Flint Clay and H4 Jack Rock Coal	2,297,000	0.06	4,988	52,000	0.00	528	-	-	-	-	-	-
Map 6	H4 Jack Rock Coal Seam Non-Coal Parting	522,000	0.01	1,811	3,000	0.00	249	2,000	0.00	124	31,000	0.06	140
Map 1	Floor Rock	37,105,000	0.94	11,196	12,388,000	1.05	3,397	839,000	0.91	261	165,000	0.31	152
<b>Total</b>		<b>92,682,000</b>	<b>2.34</b>	<b>56,772</b>	<b>28,961,000</b>	<b>2.45</b>	<b>15,287</b>	<b>2,064,000</b>	<b>2.24</b>	<b>1,236</b>	<b>513,300</b>	<b>0.96</b>	<b>695</b>

### Assumptions

- \* Assumed density of approximately 3528 tons/acre-ft (162 lbs./ft<sup>3</sup>); common density of shale, flint clay, fire clay, etc.
- \* Tonnages can get moved around from roof to floor or vice versa if decided that mining will extract more of one than another
- \* Apparent thickness on diagram is not representative of the actual geology
- \* Tonnages have been rounded to the nearest thousand or hundreds if less than 1,000
- \* Thickness values listed as "0.00" have small amounts and are factored into the resource tonnages
- \* 100% mine recovery in-place tons





## Condensed Summary of Non-Coal Sources (Refuse) from the Hazard No. 4 Coal Seam Commercialization Area and Active Mines Nos. 81 and 89 Sites

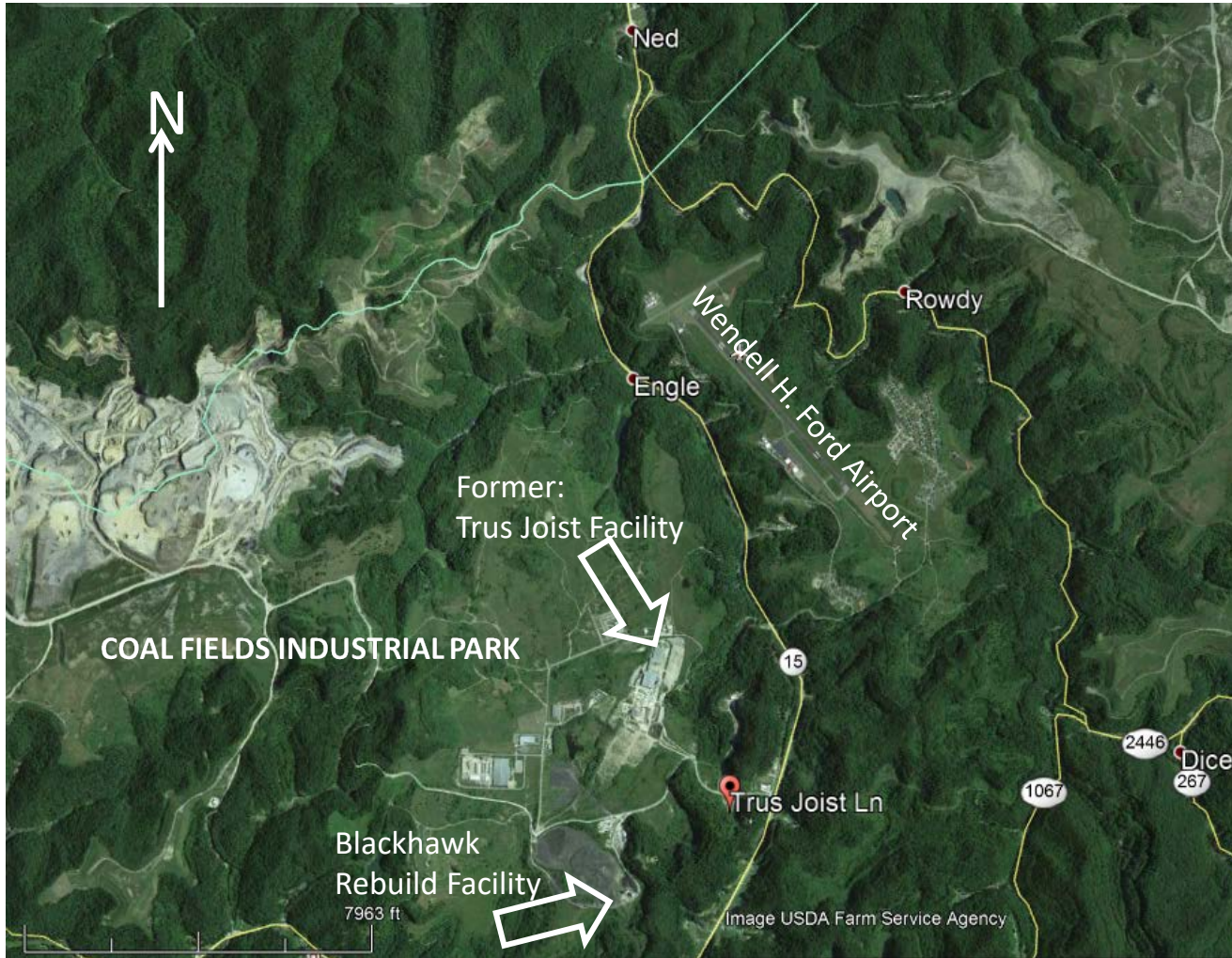
		Total Assignment Area	Total Mines 81 and 89
Map Number	Modeled Non-Coal Strata	Tons In Place	Tons ROM
Map 1	----- Roof Rock ----- -----	49,493,000	1,004,000
Map 2	----- H4 Coal Seam Non-Coal Partings	2,126,000	6,000
Map 3	----- Parting Between H4 Coal and H4 Flint Clay	1,738,000	16,300
Map 4	----- H4 Flint Clay	15,919,000	514,000
Map 5	----- Parting between H4 Flint Clay and H4 Jack Rock Coal	2,349,000	None Present
Map 6	----- H4 Jack Rock Coal Seam Non-Coal Parting	525,000	33,000
Map 1	----- Floor Rock ----- -----	49,493,000	1,004,000
<b>Total:</b>		<b>121,643,000</b>	<b>2,577,300</b>
<b>Grand total Tons In-Place :</b>		<b>124,220,300</b>	
<b>Grand Total Acres:</b>		<b>73,989</b>	



# Proposed Location of Pilot Plant

610 Trus Joist Lane  
Chavies, Kentucky 41727-8669  
Perry County  
Congressional District: KY 005

# General Area Location Map of Proposed Hydro-Met Pilot Plant

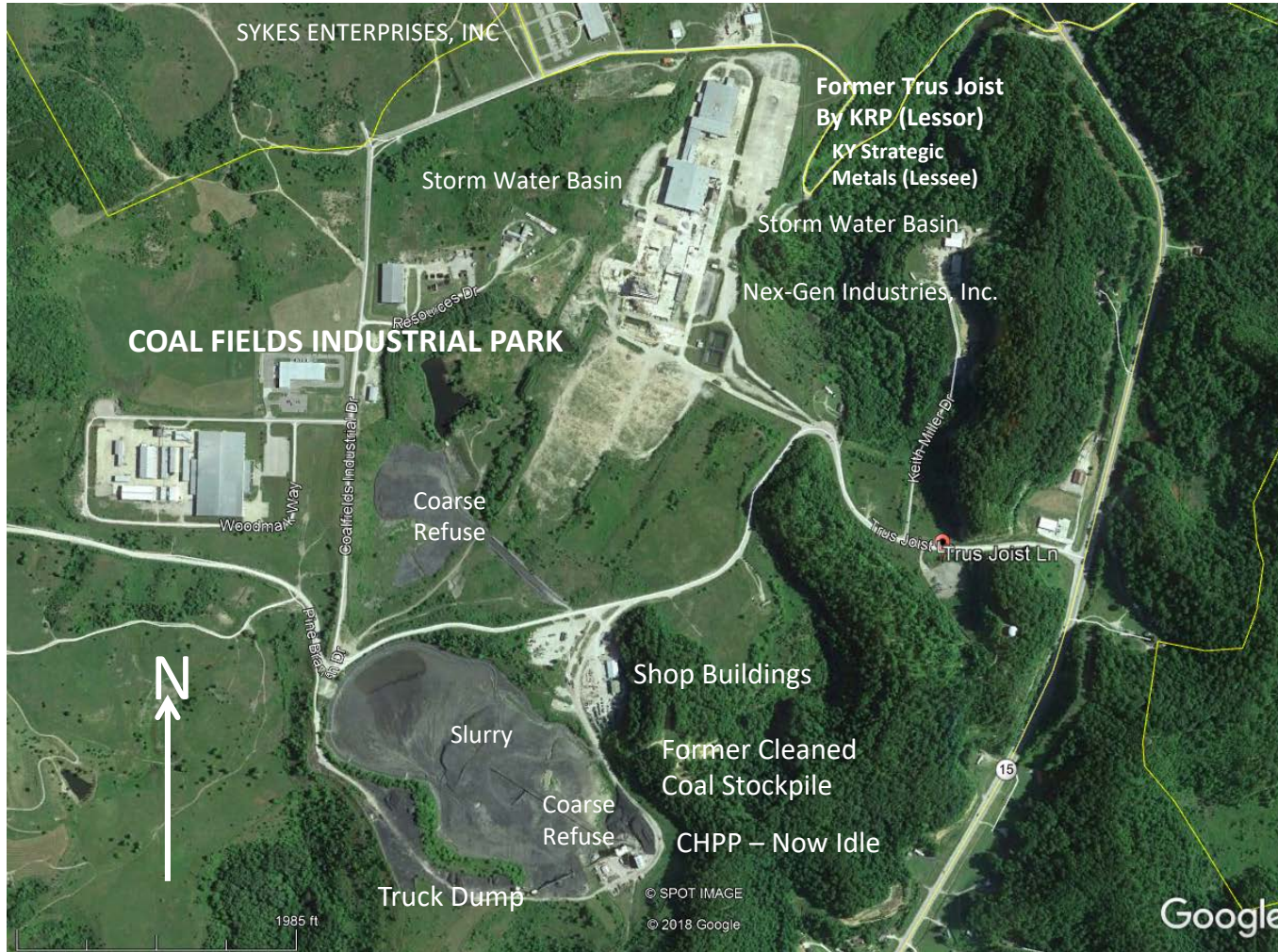


Current Property Owner:  
Kentucky River Properties, LLC, 2017

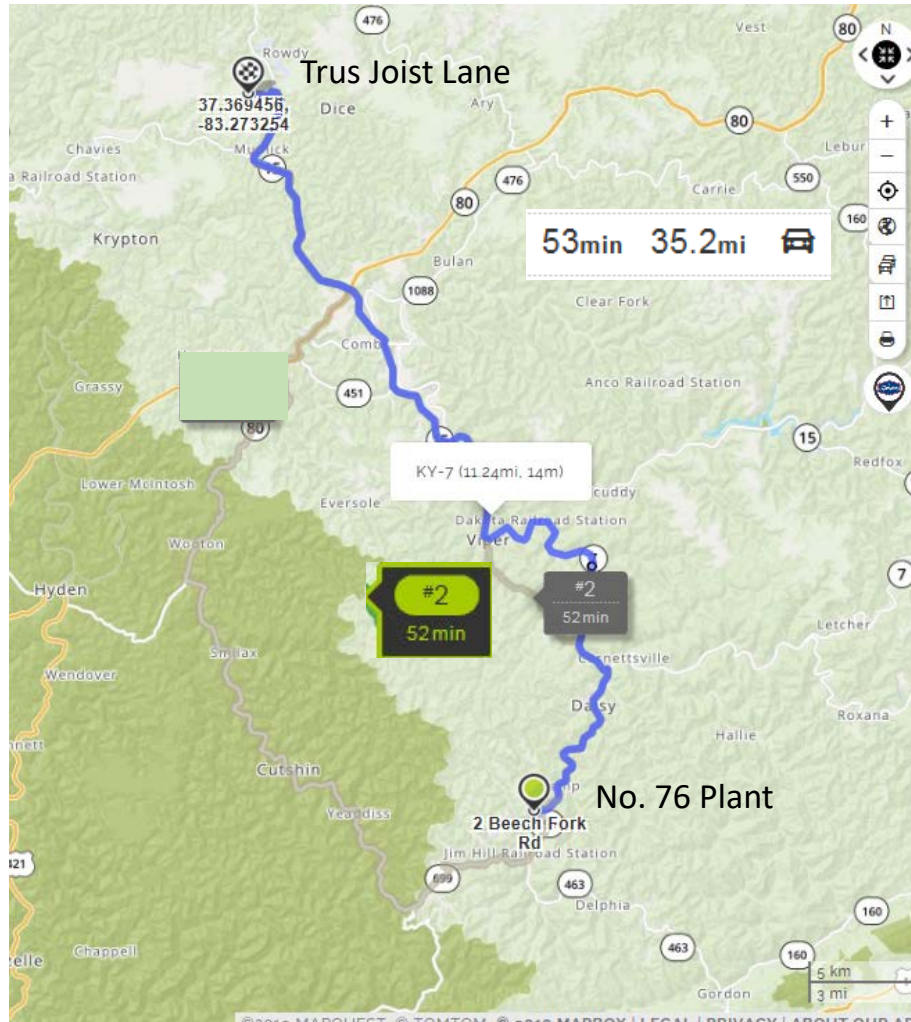
Physical Address:  
610 Trus Joist Lane  
Chavies, Perry County, KY, 41727-8669



# Enlarged View of Location Map of Proposed Hydro-Met Pilot Plant



# Haul Distance from No. 76 Plant (Slemp, Ky) to Trus Joist Lane, Chavies, KY



Source: MapQuest

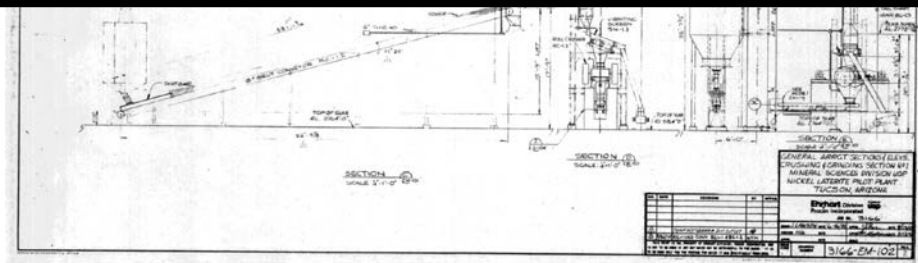
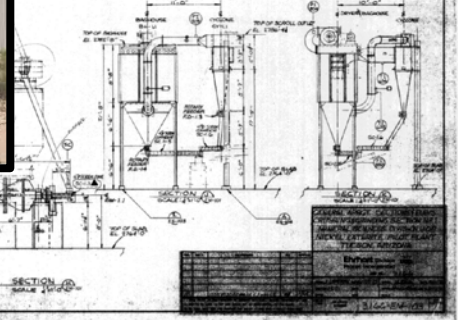
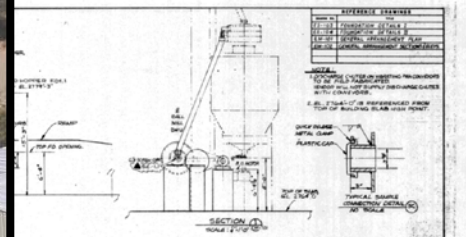
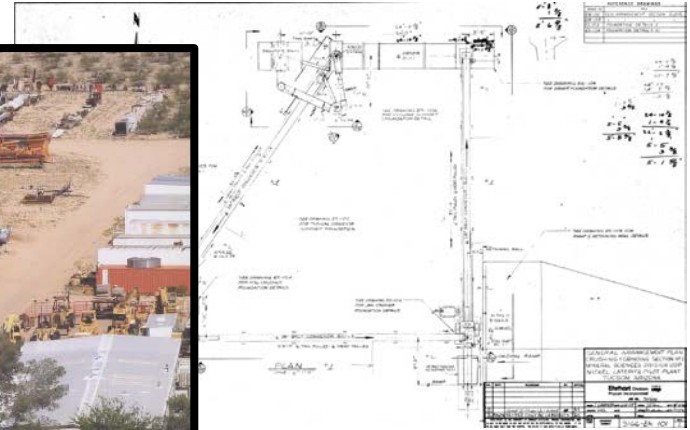


# Proposed Relocation of Arizona Pilot Plant



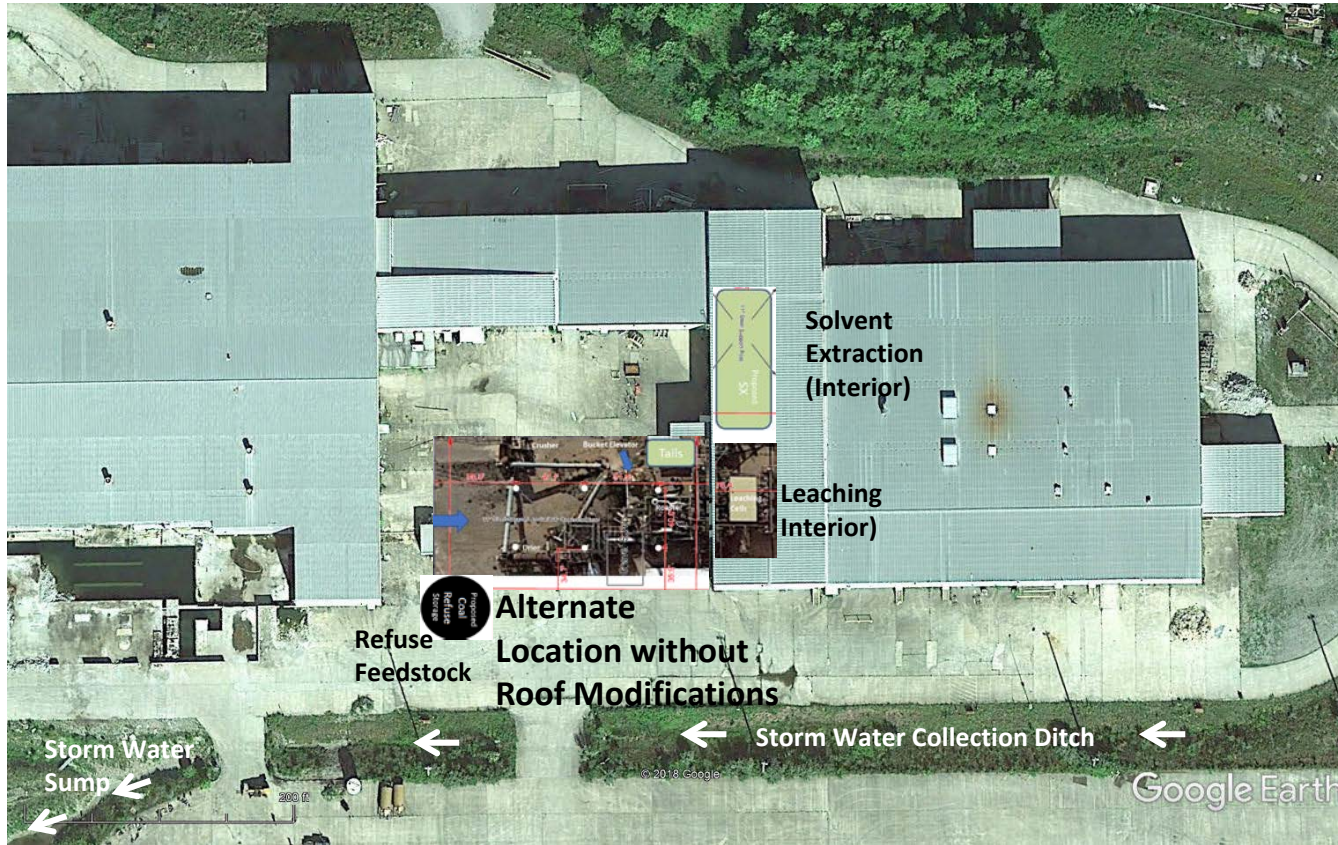


# Previous Operated Ni/Co Pilot Plant Potentially Suited for Reutilization

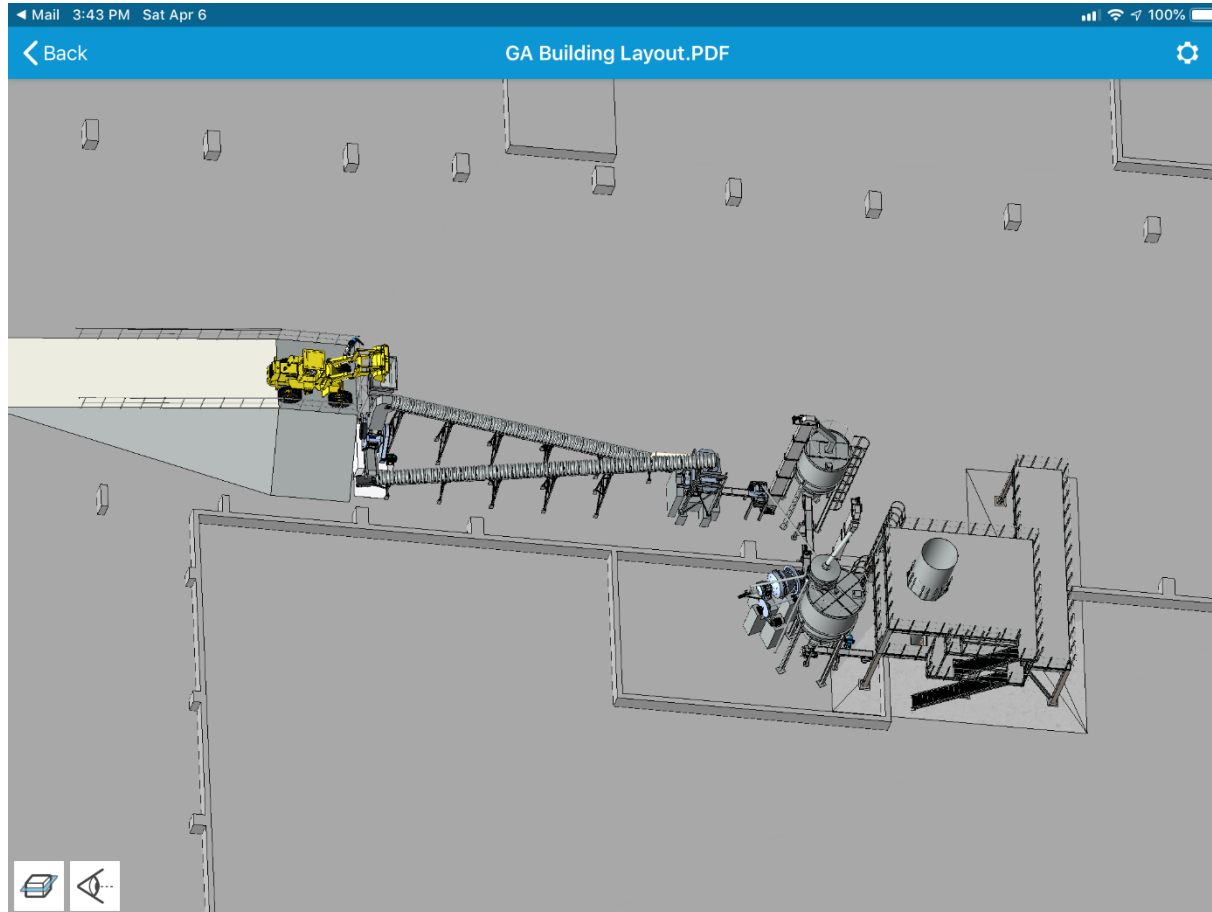




# A Pilot Plant Location Option at Trus Joist



# Alternate Rendition of the Pilot Plant

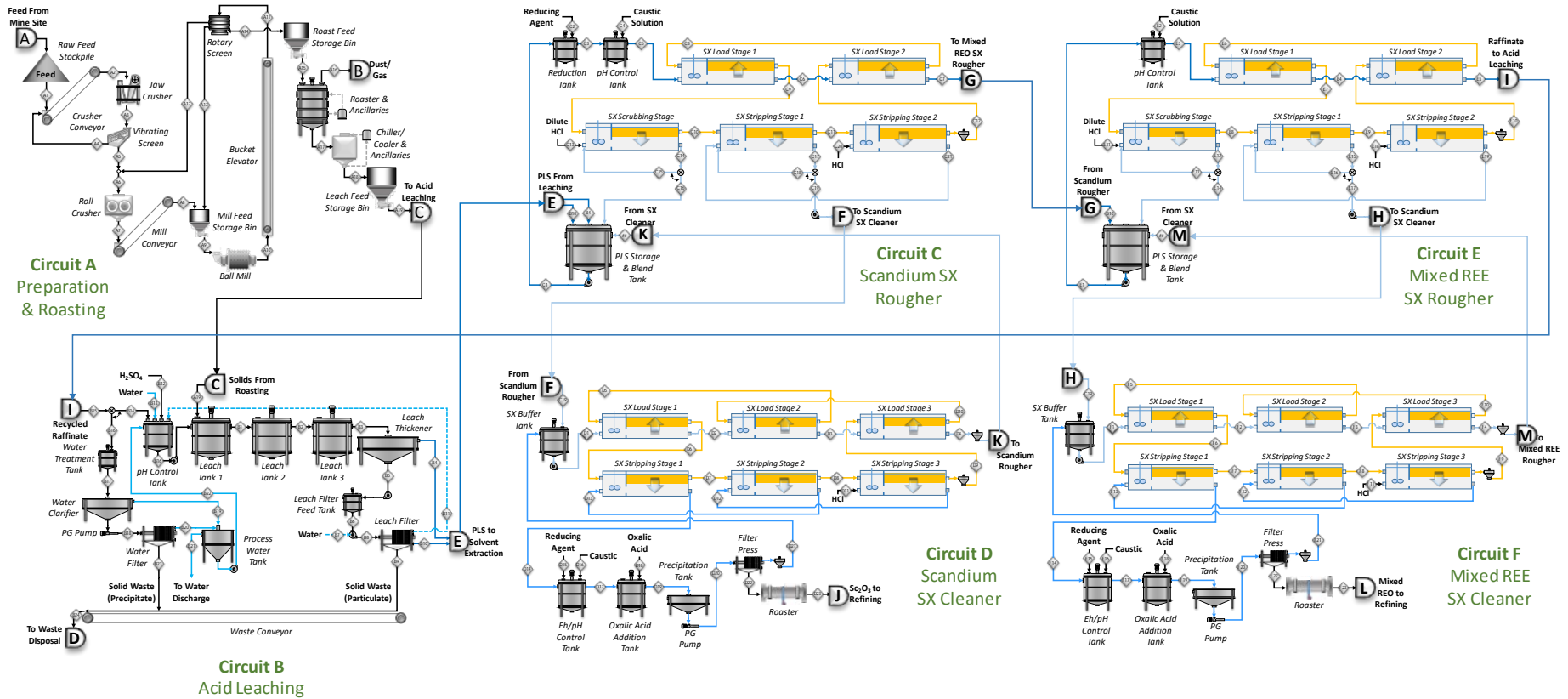


Source: University of Kentucky

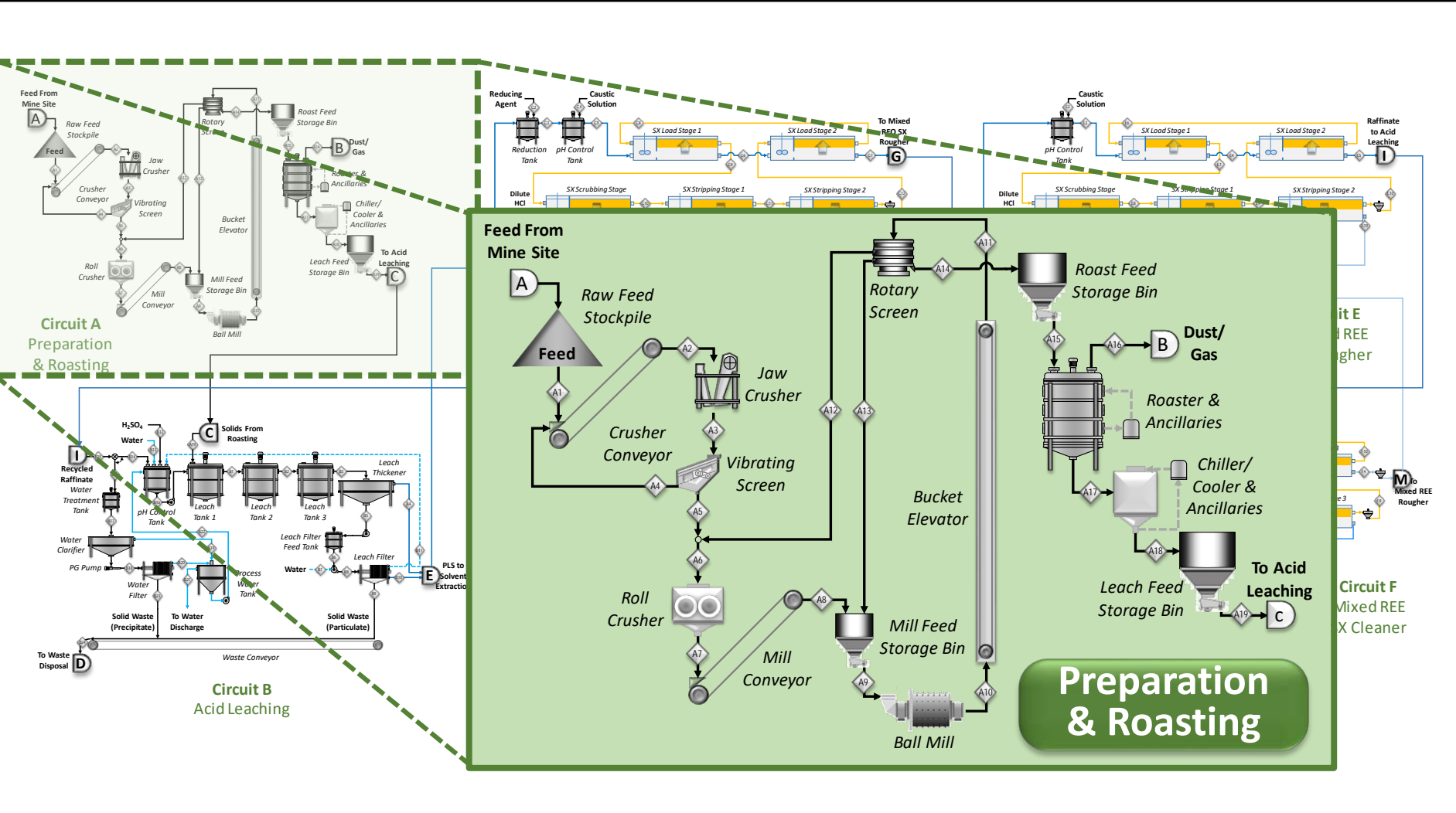
# Flowsheets

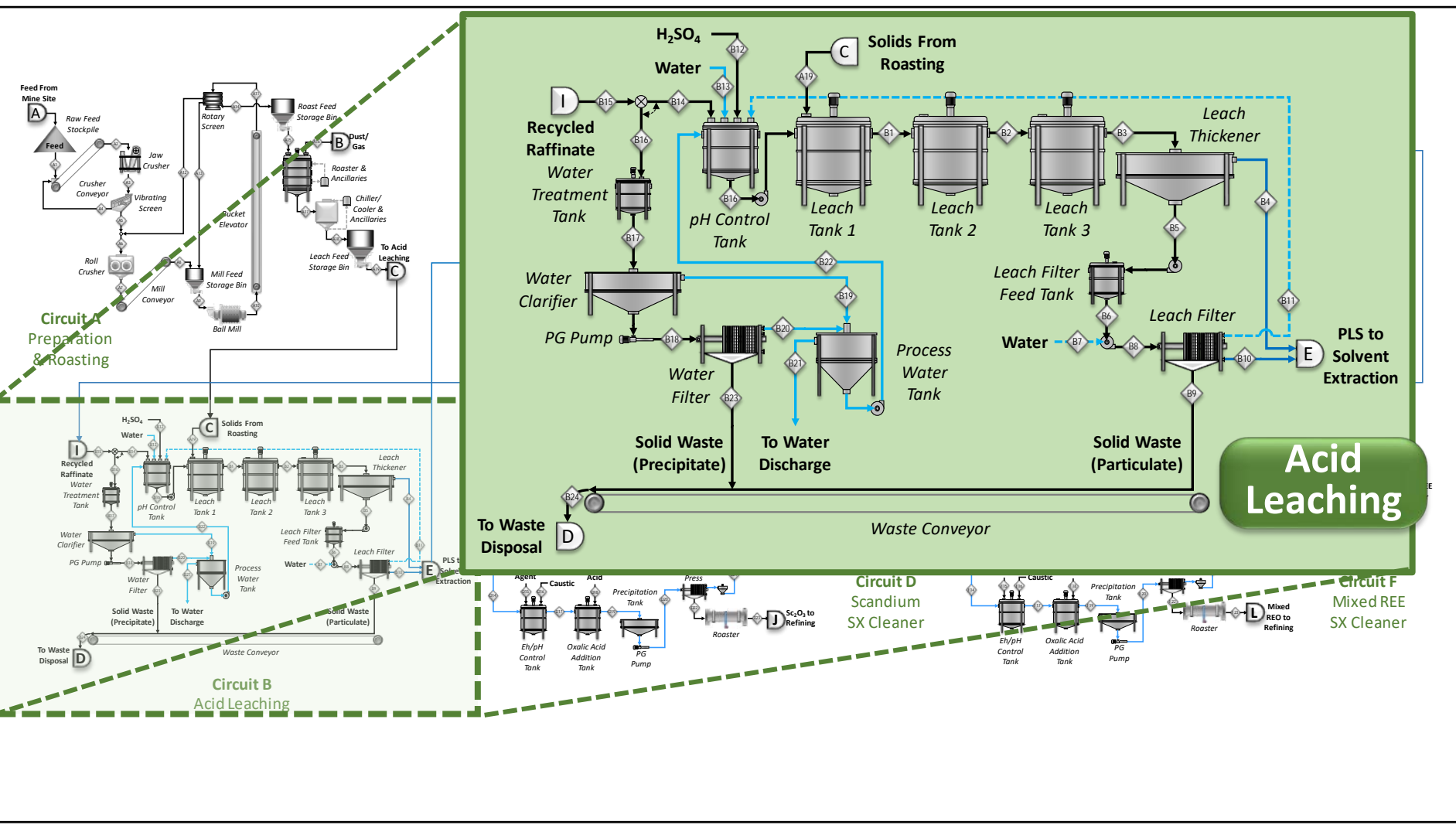
- Several alternative flowsheet configurations considered that incorporated both physical and chemical separations processes.
- For available feedstocks, most promising flowsheet included sequential stages of:
  - Size Reduction
  - Mild Roasting
  - Acid Leaching
  - Solvent Extraction





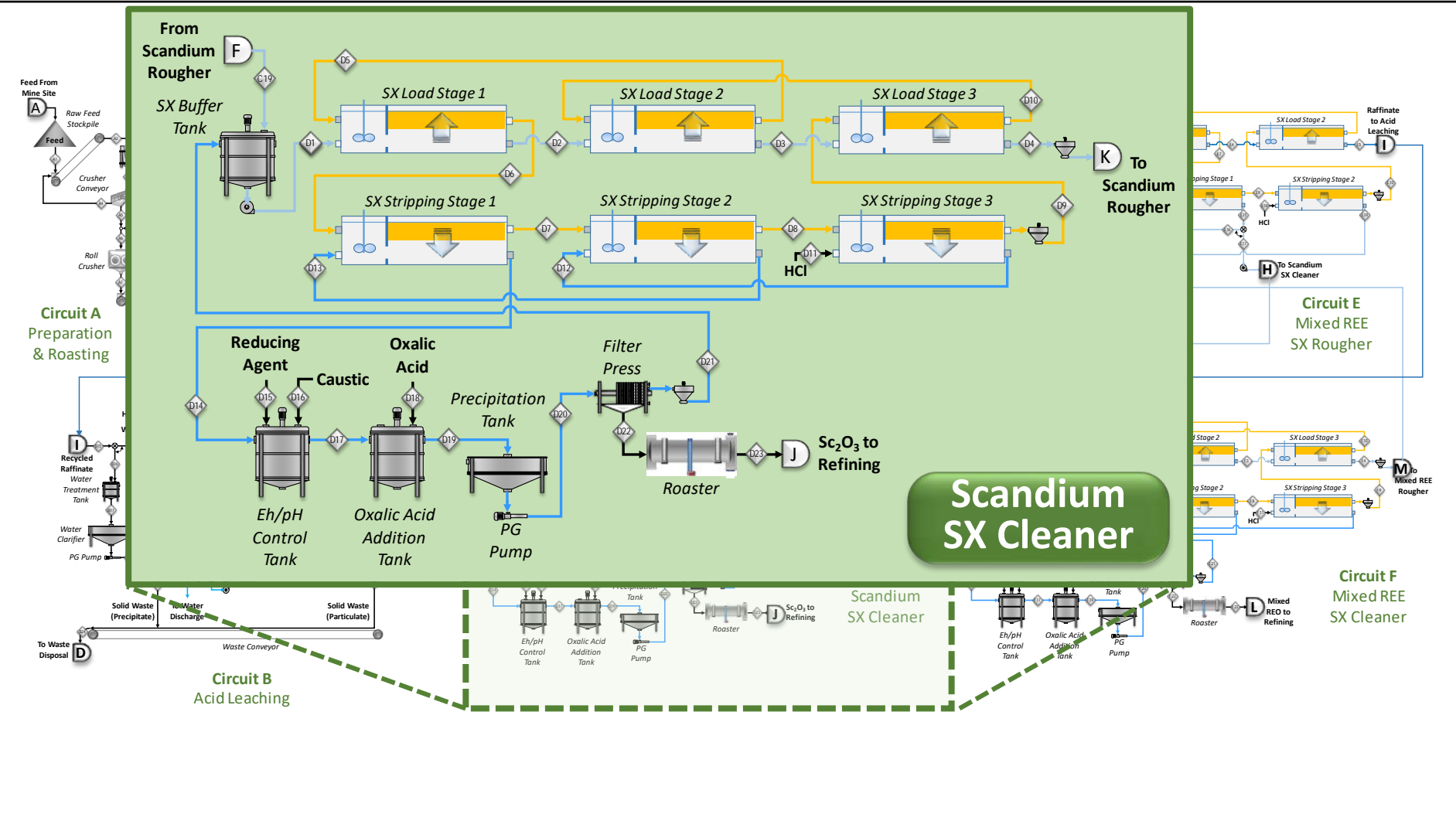




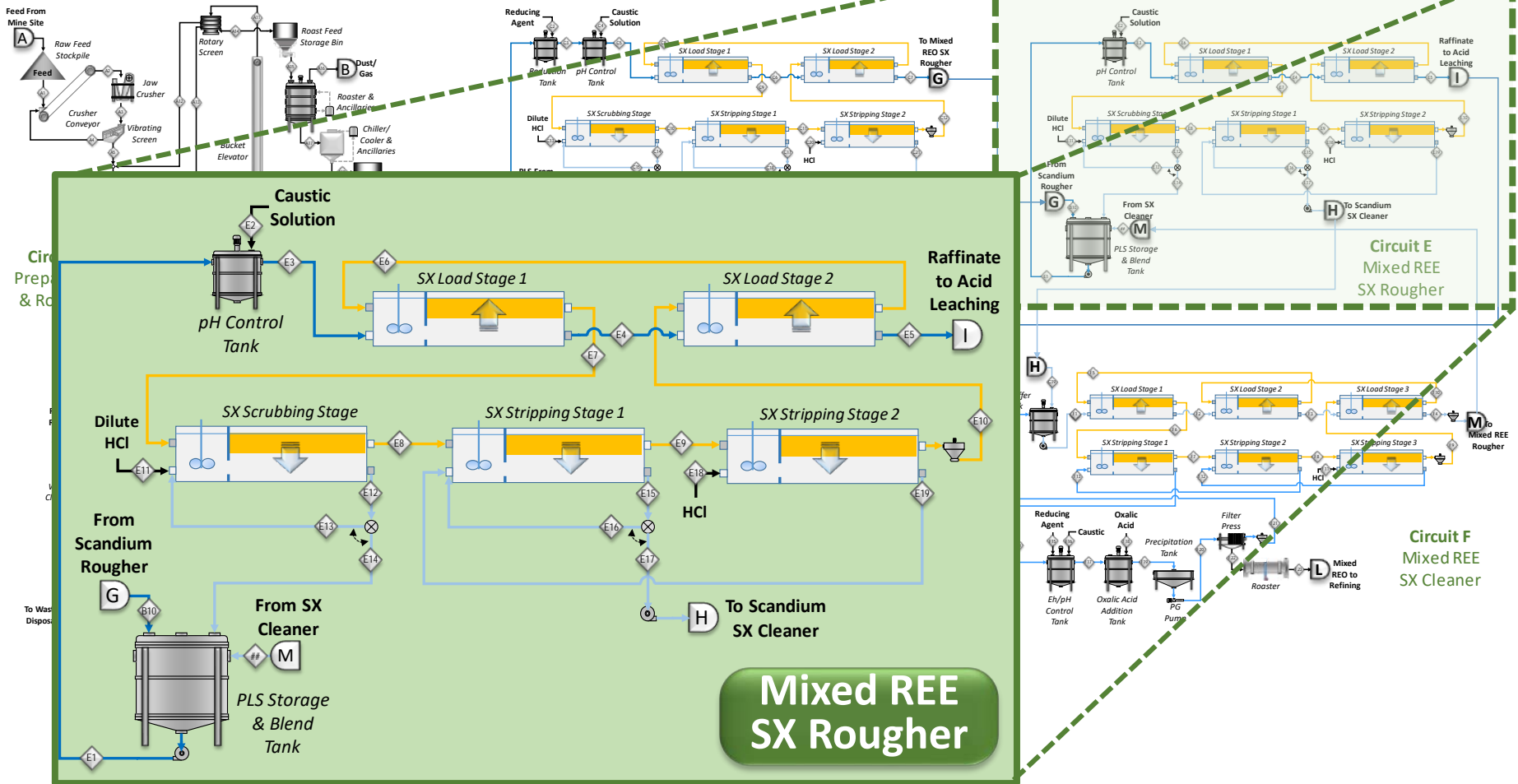


**Acid Leaching**

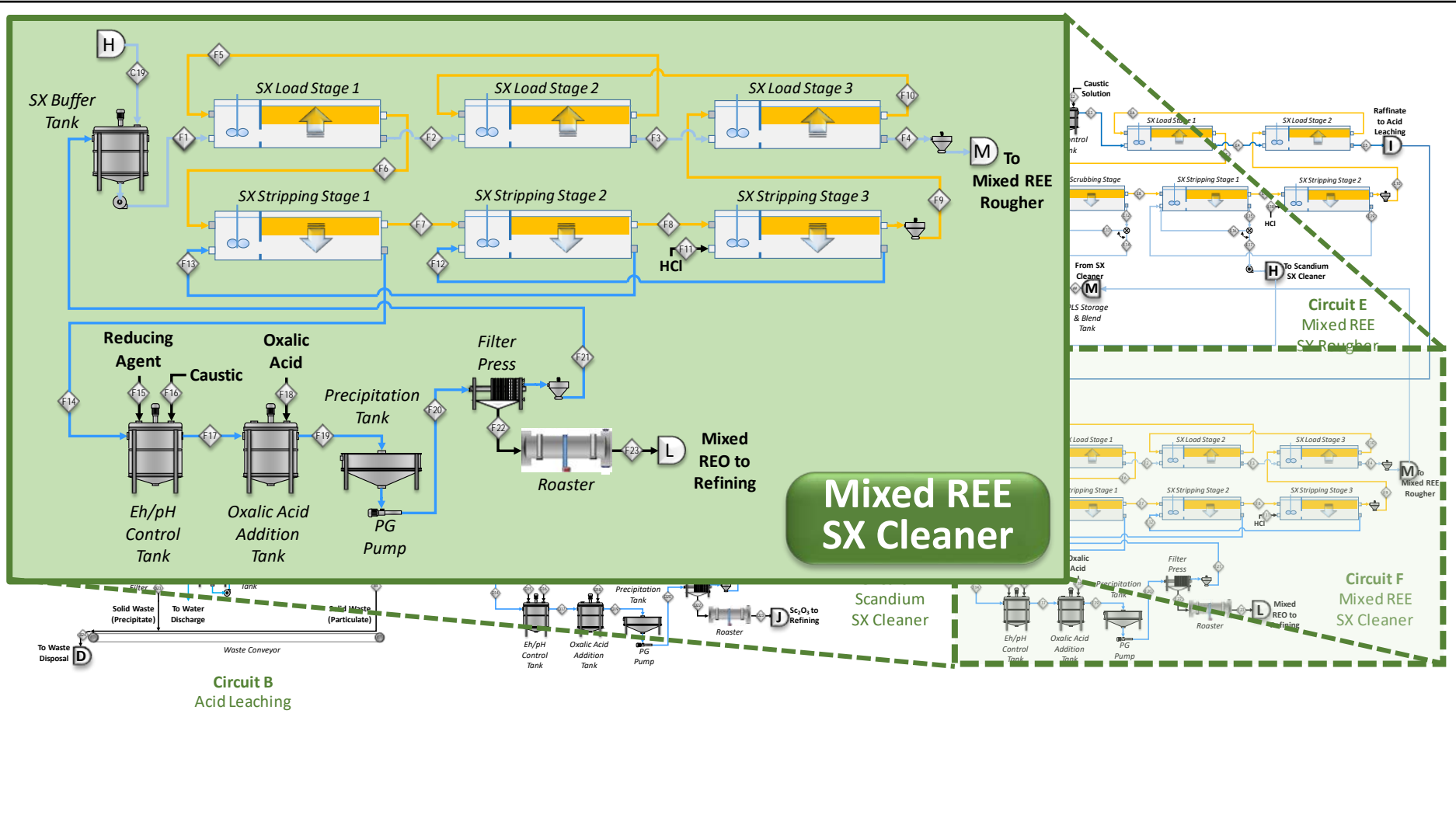








**Mixed REE SX Rougher**





**Mine No. 89**

Note: This presentation should be taken in concert with the discussion prepared by Dr. Honaker of the University of Kentucky

# Discussion

