Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois

Paul T. Behum, Ph.D.[1] and Angie Mick[2]

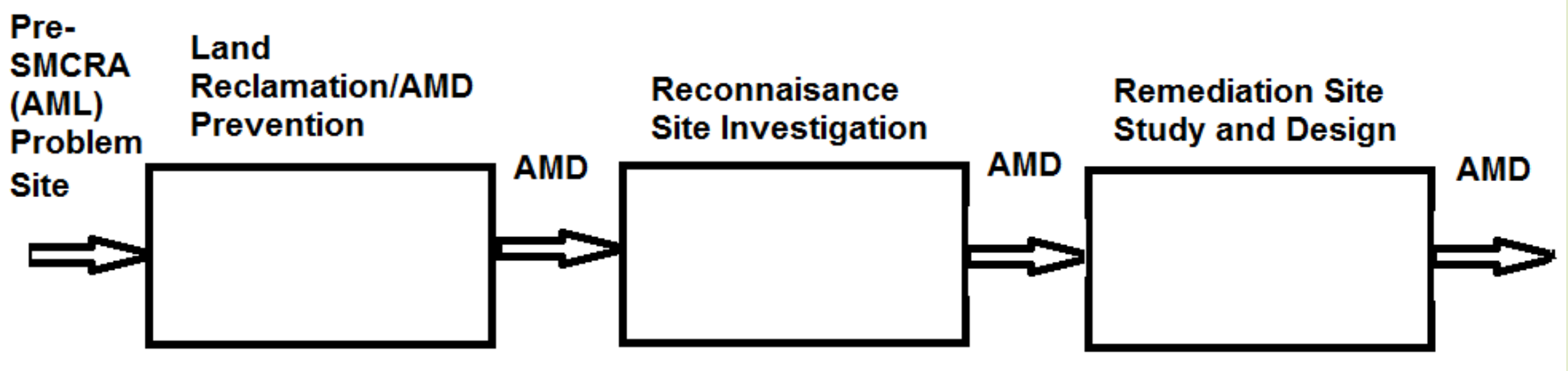
1. Sr. Hydrologist, Office of Surface Mining Reclamation and Enforcement, Alton, IL 62002;

2. Environmental Protection Specialist, Illinois Department of Natural Resources Office of Mines and Minerals, Springfield, IL 62702.

What we will be Discussing

- Geology and geochemistry of the lower part of the Carbondale Formation in Saline and Williamson Counties - Davis and Dekoven Coal Beds and associated strata surface mined primarily in the 1950's -1980's.
- Reclamation history and AMD at the Saxon Walnut Grove Mine
- Historic AMD abatement measures at the Will Scarlet Mine.
- An update on site investigations at the Palzo AML site.

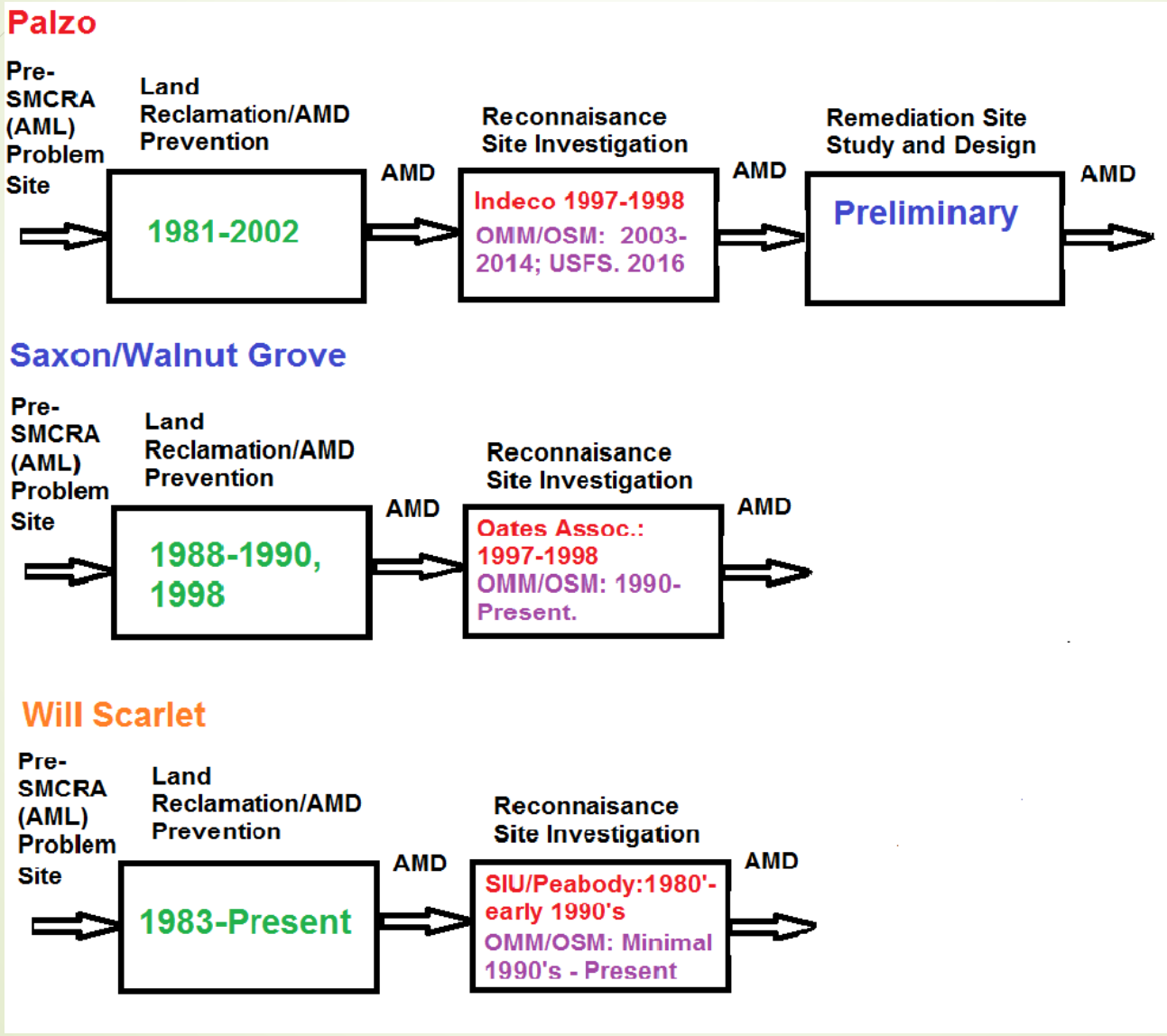
Typical Workflow Diagram for a Site Investigation at an AMD-impacted Mine Site



Rectangular weir installation at the Monahan Discharge Kansas

Baseline sampling for engineering design: Hartford Shaft discharge, Arkansas

Status of Site Investigations: Pre-SMCRA AMD Discharges Davis and Dekoven Coal Mining.



See: ASMR 2014 Proc. (Behum et.al., 2014)

See: Nawrot et. al. 1994 (International Coal Conference)

Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois

Geology and Geochemistry of the Davis and Dekoven Interval

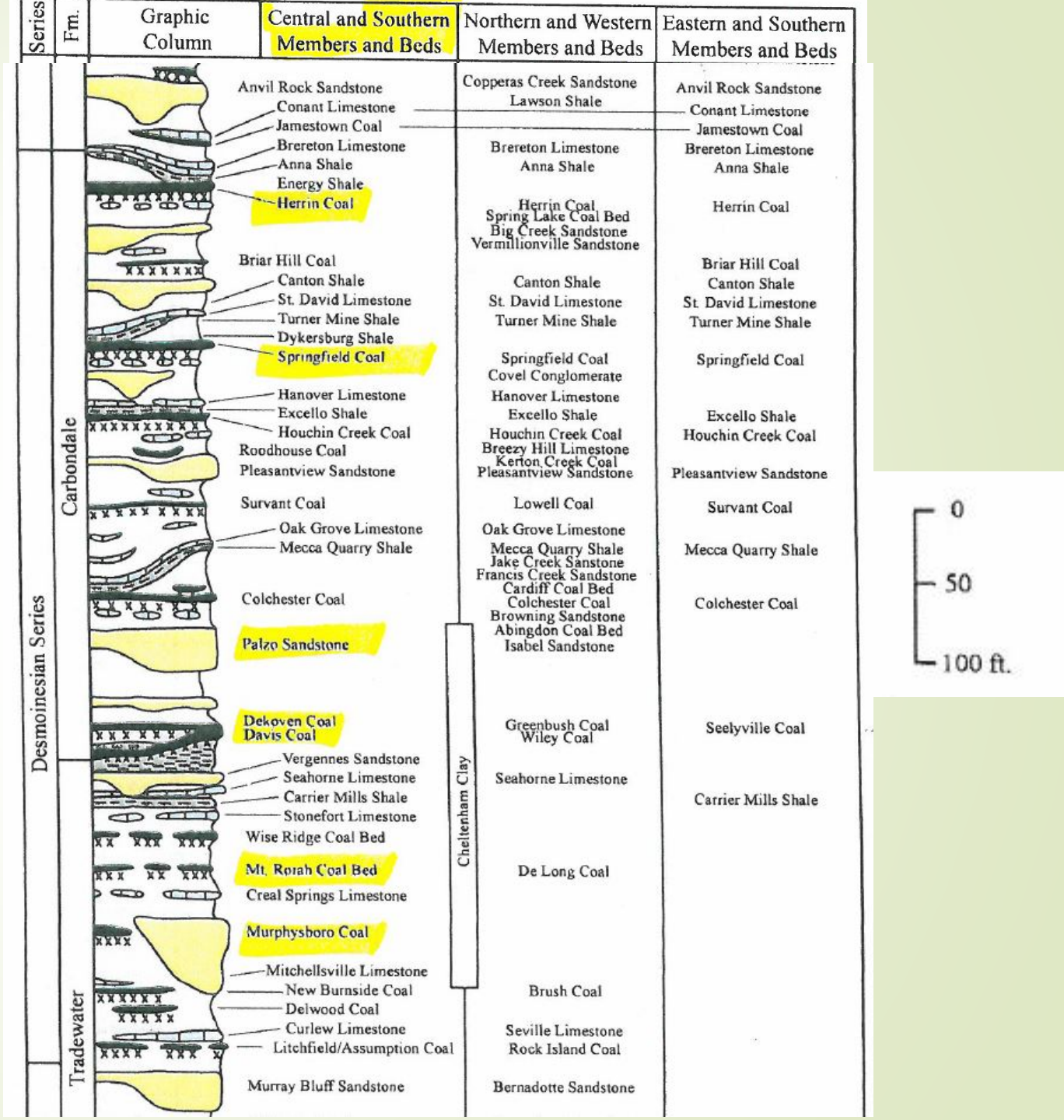
Geology of the Davis and Dekoven Coal Beds in Saline and Williamson Counties

1)One of the lowest mineable seams in the Illinois Coal Basin.

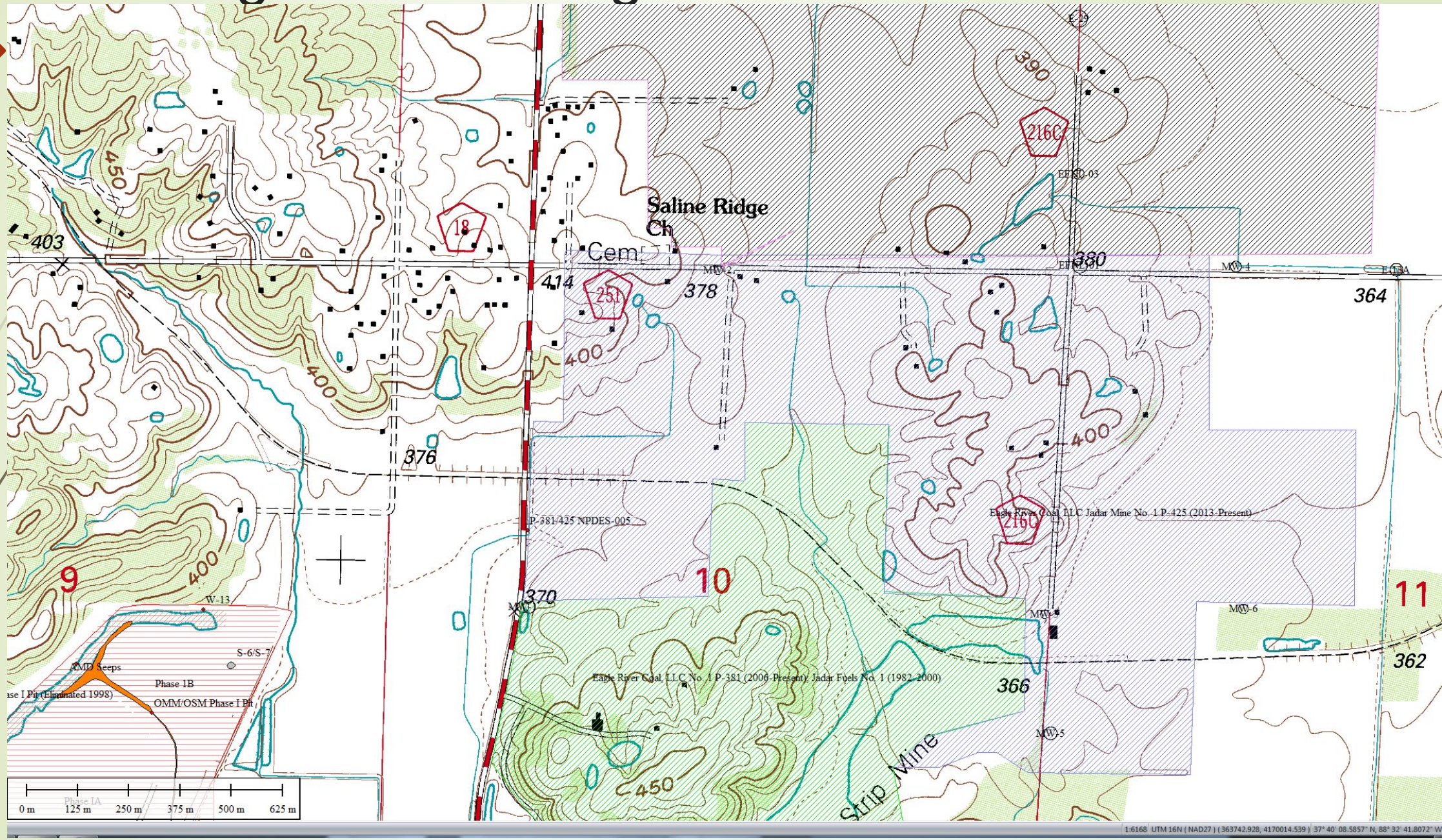
2)Near the base of the Carbondale Formation.

3)Typically separated by a shale and clay parting.

4)Overlain by the massive Palzo Sandstone.



Geologic Data: Eagle River No. 1 Mine Permit

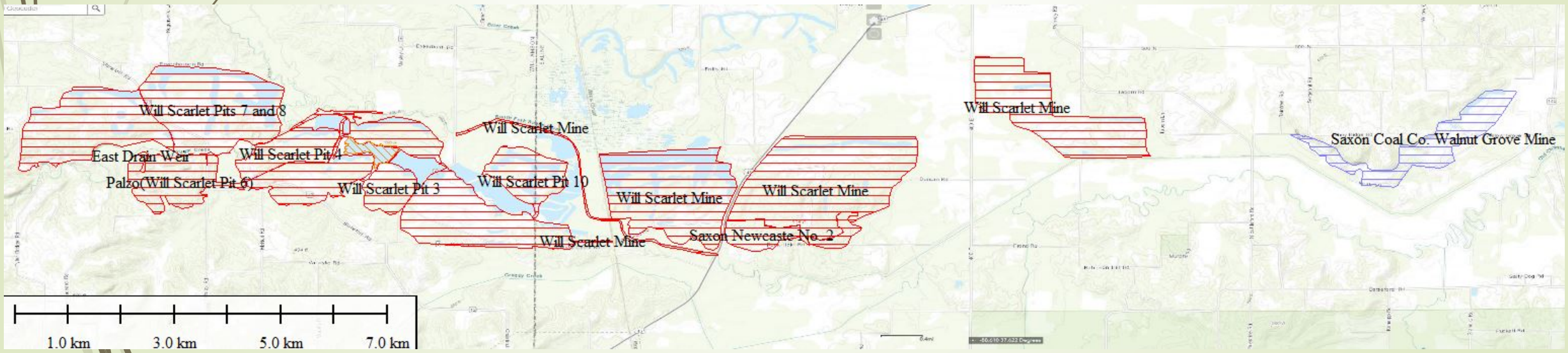


Acid Base Accounting Data: Palzo AML Site and Saxon Walnut Grove Mine

Well ID	Site	MPA (T/1,000 T)	NP (T/1,000T)	NNP (T/1,000T)
E-29	Eagle R. No. 1	21.78	38.31	16.54
INDECO	Palzo AML	32.98	0.97	-32.01

Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois

Saxon Walnut Grove Mine, Saline County, IL



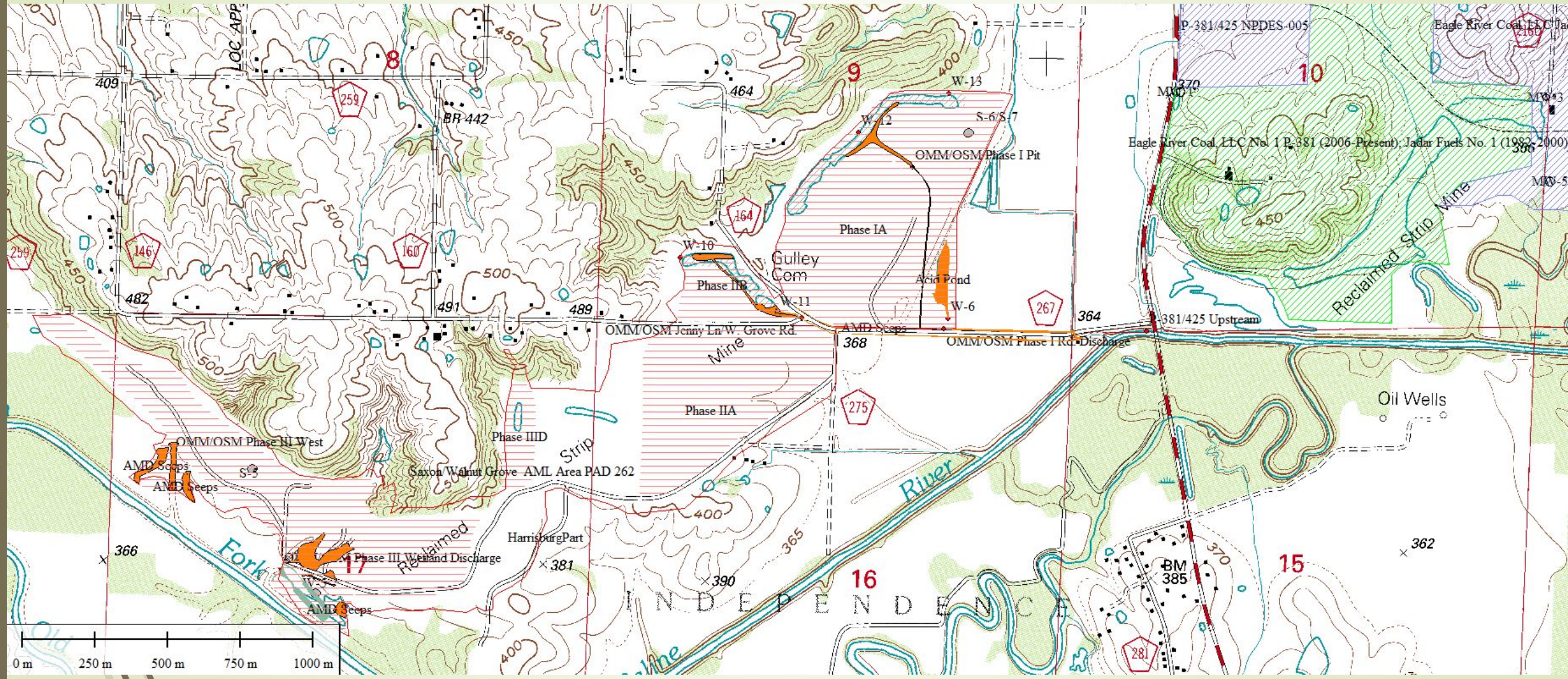
Pre-SMCRA Multi-seam Surface Mining at the Nearby Newcastle Mine

1) Lower dragline rests on the Dekoven seam bench.
2) Coal loading shovel rests on the Davis seam bench.
3) Note the thickness of the Davis/Dekoven parting (interburden).

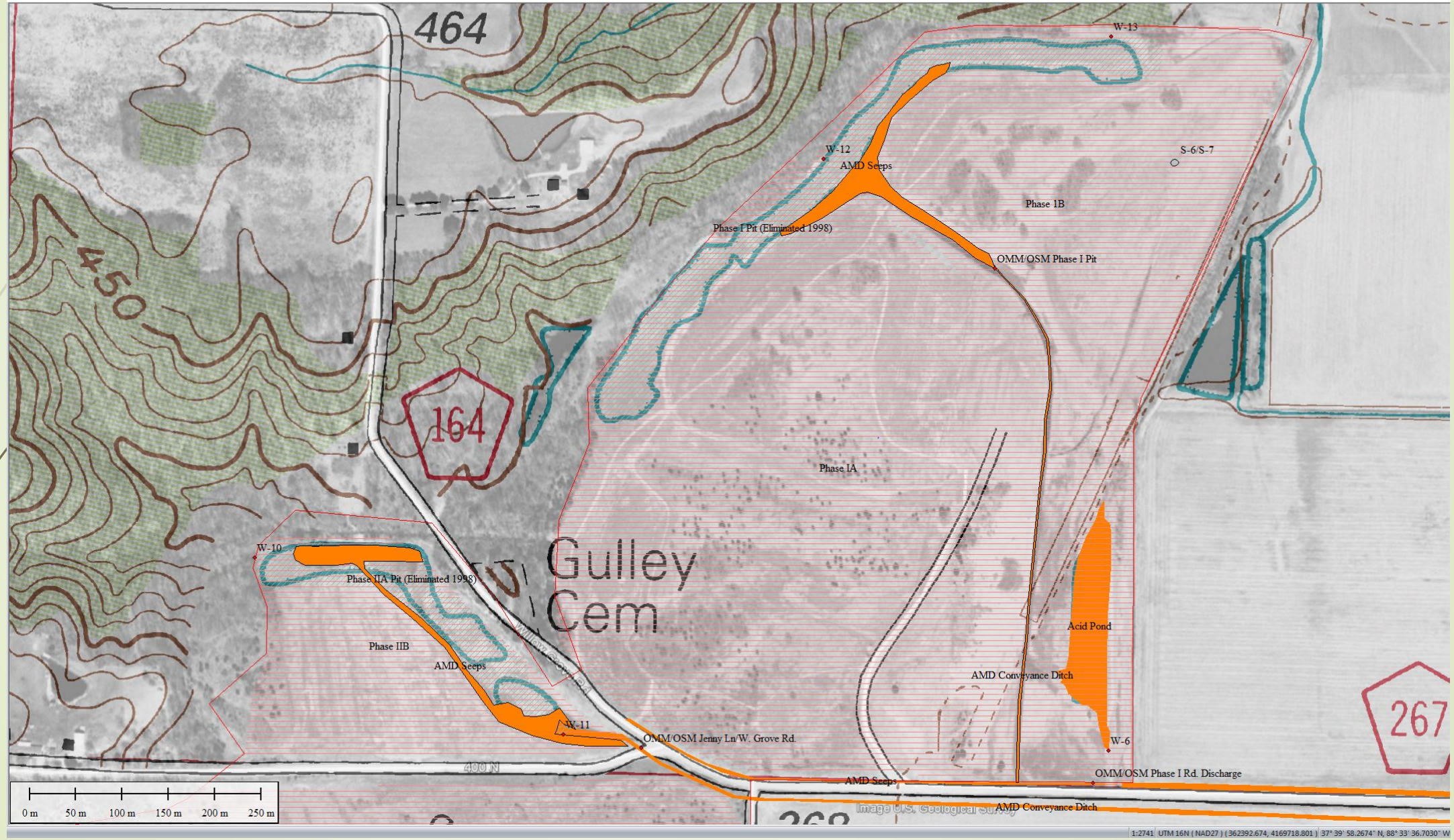
Mining and Reclamation History at the Saxon/Walnut Grove Mine

- Saxon Coal Company: 2-seam surface mining 1956 -1962 – 3,931,518 S. Tons.
- Young Coal Corp.: 2-seam surface mining 1962 -1965 – 1,578,156 S. Tons.
- Illinois Abandoned Mine Land Reclamation Council (AMLRC)--1986 - ~1990.
- Oates Associates (Collinsville, IL) site investigation -- March,1998.
- AMLRC Phase VI - Highwall elimination/offsite sedimentation control – 1998.
- Post-reclamation monitoring – ~1990 – Present (OMM/OSM).

Overview of the Saxon AML Site



AMD Occurrences in the Phase I and IIB



AMD Occurrences in the Phase IIA , IIIC & IIID

AMD Occurrences in the Phase III A & IIIB

Reconnaisance Water Quality Data for AMD Discharges at the Saxon-Walnut Grove AML Site[1]

Site	Lab pH	SpecC	D. Al	D. Fe	D. Fe^{2+}	D. Mn	Sulfate	Non-Mn Acidity
Phase I Pit Discharge[2]	3.00	2,985	4.19	76.6	45.1	13.95	1,605	372.6
Phase I @ Willow Grove Rd.	2.80	3,121	12.8	58.4	3.18	23.02	1,866	354.9
Phase IIA Discharge @ Jenny Ln. [2]	3.39	2,411	34.0	49.0	30.5	23.43	994	439.6
Phase III E./Keith Ln. Discharge	2.79	2,368	25.6	12.0	1.29	44.06	1,450	183.2
Phase III Wetland Outlet	2.76	2,421	37.1	15.6	4.58	27.00	1,237	287.9
Phase III West Discharge	3.15	3,560	105.9	33.6	3.47	56.53	2,350	663.2

1. Phase I reclaimed in 1987, Phase II reclaimed in1988, and Phase III reclaimed in 1990.
2. Phase I & Phase IIA final cut pits backfilled during a 1998 highwall elimination project.

Preliminary Contaminant Load Estimates for AMD Discharges at the Saxon-Walnut Grove AML Site[1]

Site	Discharge (GPM)	D. Al (lbs./day)	D. Fe (lbs./day)	D. Mn (lbs./day)	Sulfate (lbs./day)	Non-Mn Acidity (lbs./day)
Phase I Pit Discharge[2]	40.1	2.0	36.9	6.7	773	179
Phase I @ Willow Grove Rd.	137.3	21.0	96.2	37.9	3,075	585
Phase IIA Discharge @ Jenny Ln. [2]	115.5	47.2	68.0	32.5	1,377	609
Phase III E./Keith Ln. Discharge	87.8	26.9	12.6	46.4	1,527	193
Phase III E./Wetland Outlet	60.0	26.7	11.2	19.4	891	207
Phase III West Discharge	17.5	22.2	7.1	11.9	493	139

1. Contaminant Load: Flow (GPM) x Contaminant (mg/L) x 0.012 = Load (lbs./day)

Treatment of the Phase I Discharge may result in the largest reduction in contaminant load!

Possible AMD Abatement Measures:

Phase I and II

- Remining
- Passive Treatment
  - High acidity and Al levels in the AMD Suggest construction of Sulfate-reducing Bioreactor.

Phase III

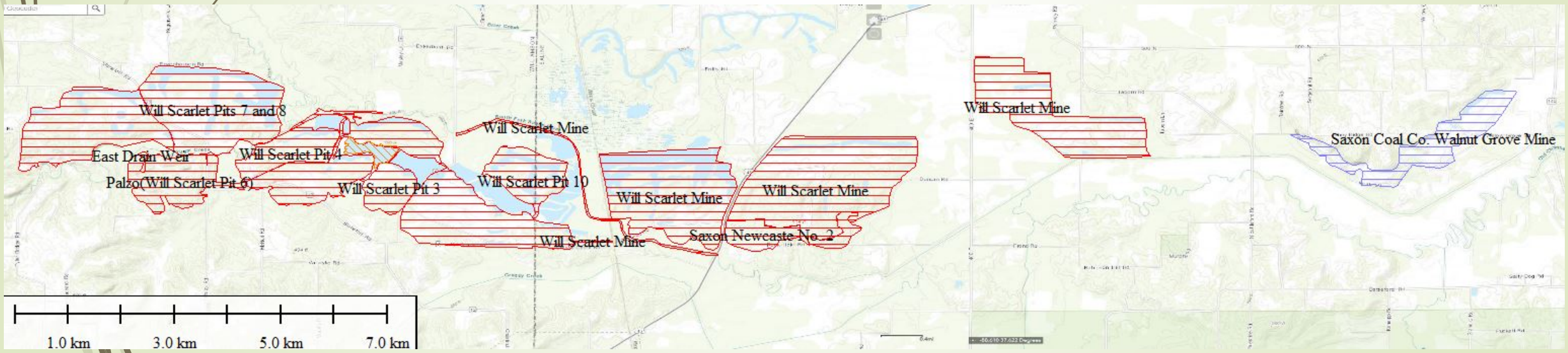
- Remining
- Passive Treatment
  - Lower acidity and moderate Fe and Al levels in the AMD suggest construction of a Flushable Limestone Bed.
  - (treats the discharge from the existing “treatment” wetland).

Suggested Investigation Activity

- Install continuous flow measurement facilities at all 4 major seep areas.
- Collect additional water samples to access seasonal variations.
- Conduct additional geochemical modeling.
- Conduct open-topped jar tests for the Phase III East Discharge with limestone derived from a local source.
- Conduct barrel testing of limestone-amended organic substrate LBOS with materials derived from local sources.

Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois

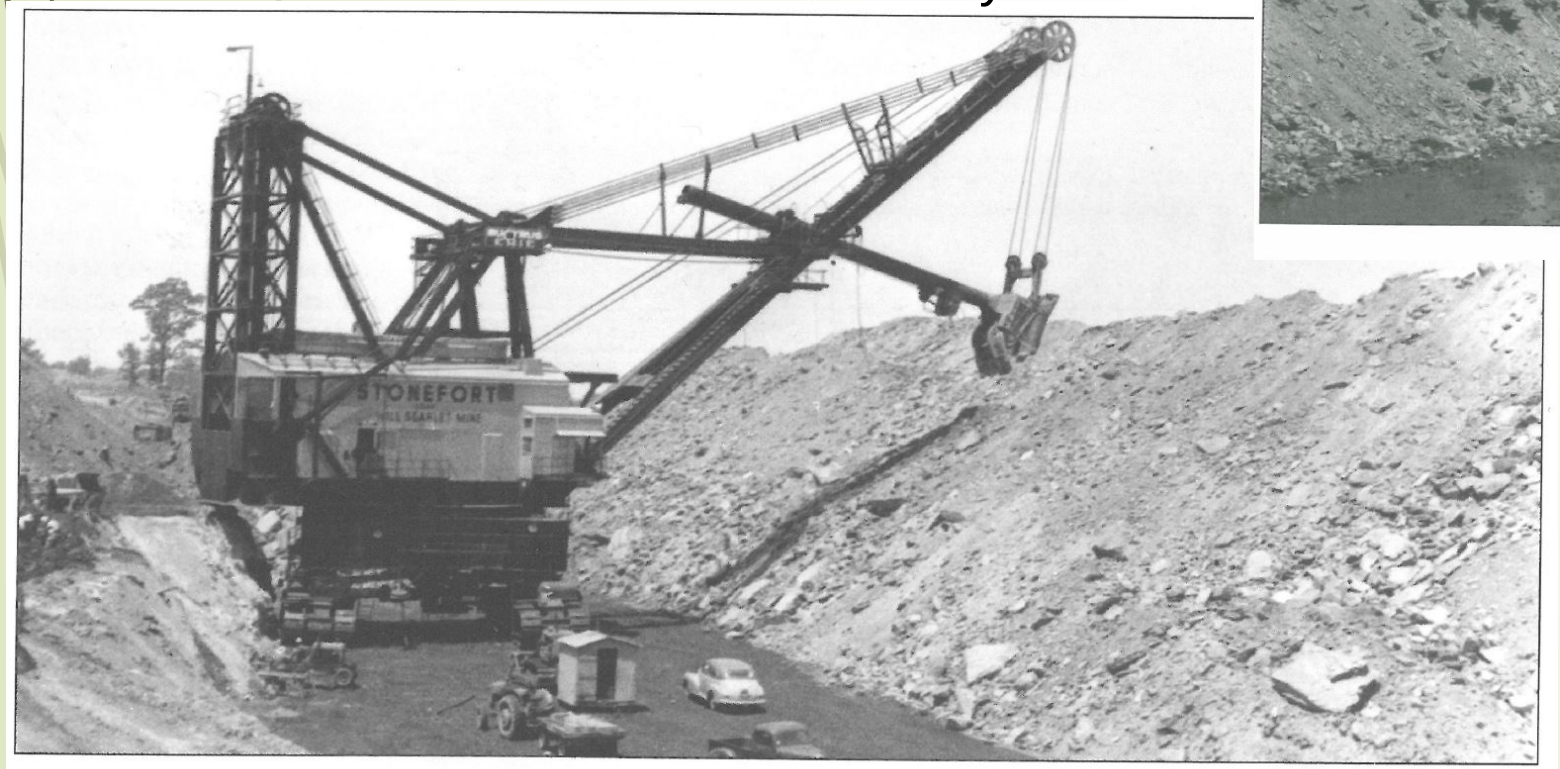
Will Scarlet Mine, Saline County, IL



Pre-SMCRA Area-type Surface Mining at the Will Scarlet Mine.

1968 to 1987: Large dragline Operated by the Peabody Coal Co.

W. John Nelson, ISGS | 1976



ISGS | Circa 1955

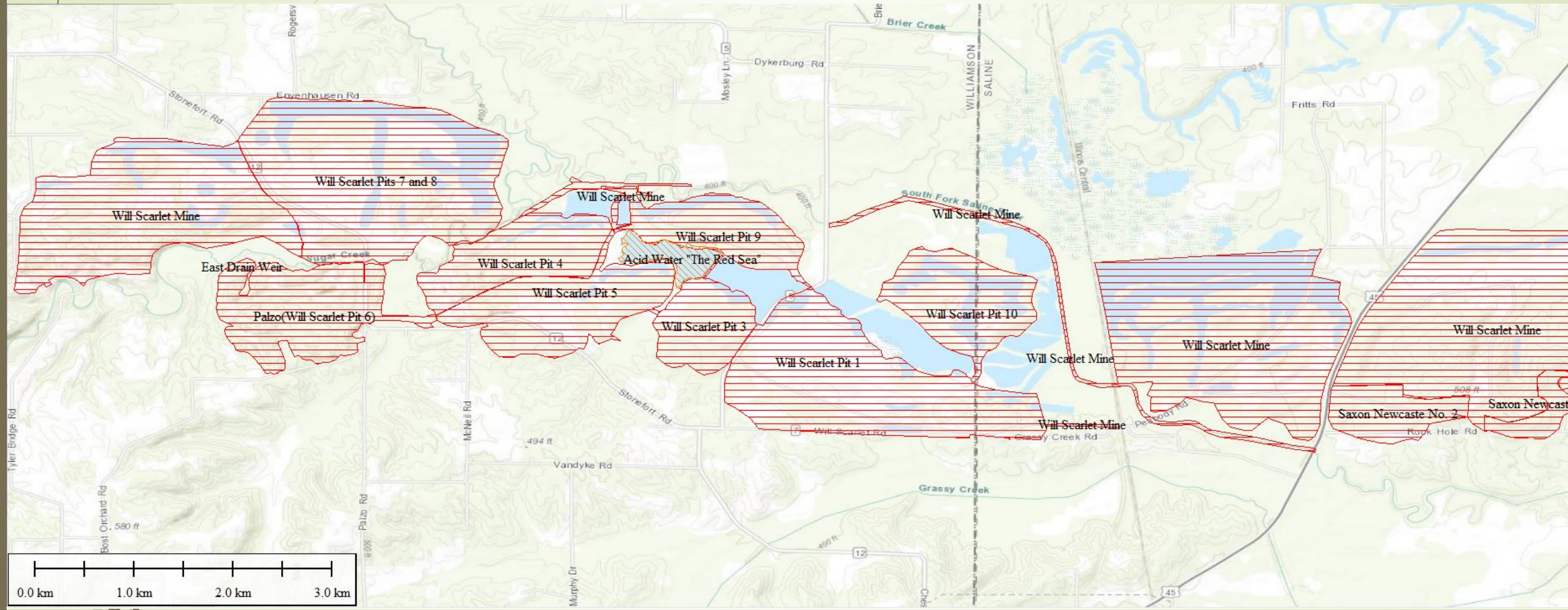
1953 to 1967: Large stripping shovel operated by the Stonefort Mining Co.

Photos from ISGS Circ. 572 (Chenoweth et al. 2008).

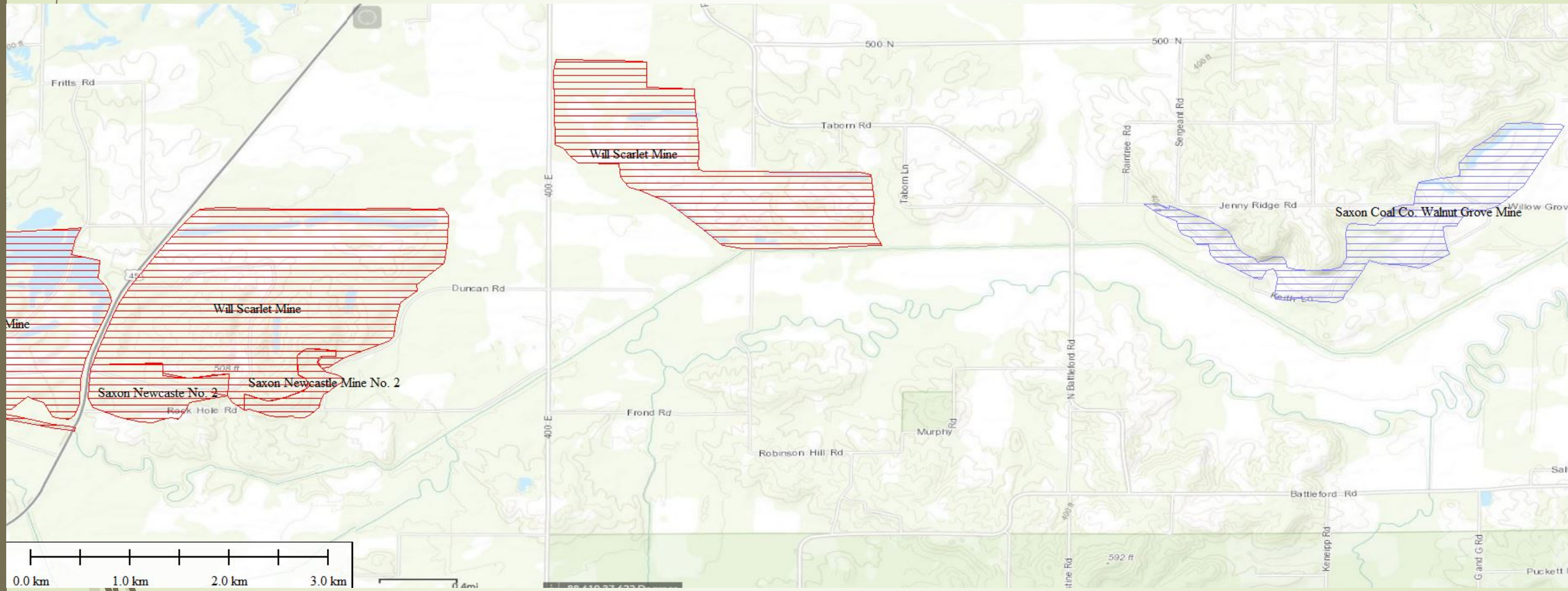
Mining and Reclamation History at the Will Scarlet Mine

- Saxon Coal Company (Newcastle No. 2 Mine): 2-seam surface mining 1954-1956 – 391,346 S. Tons.
- Stonefort Coal Co.: 2-seam surface mining 1953 -1967 – 11,054,878 S. Tons.
- Peabody Coal Co. 2-seam surface mining 1968 -1987 –15,006,143 S. Tons.
- Illinois AMLRC AML Fund land reclamation –1980'-2011.
- Peabody/SIU Coop. Wildlife Research Lab. (CWRL) site investigation/CARP construction -- March,1989-1994.
- Office of Mines and Minerals (OMM) Cement Kiln Dust (CKD) backfill of Eastern Pit 4 - 2010-2012.
- Periodic Post-Reclamation monitoring –2006-2008 OMM/OSM reconnaissance investigation.

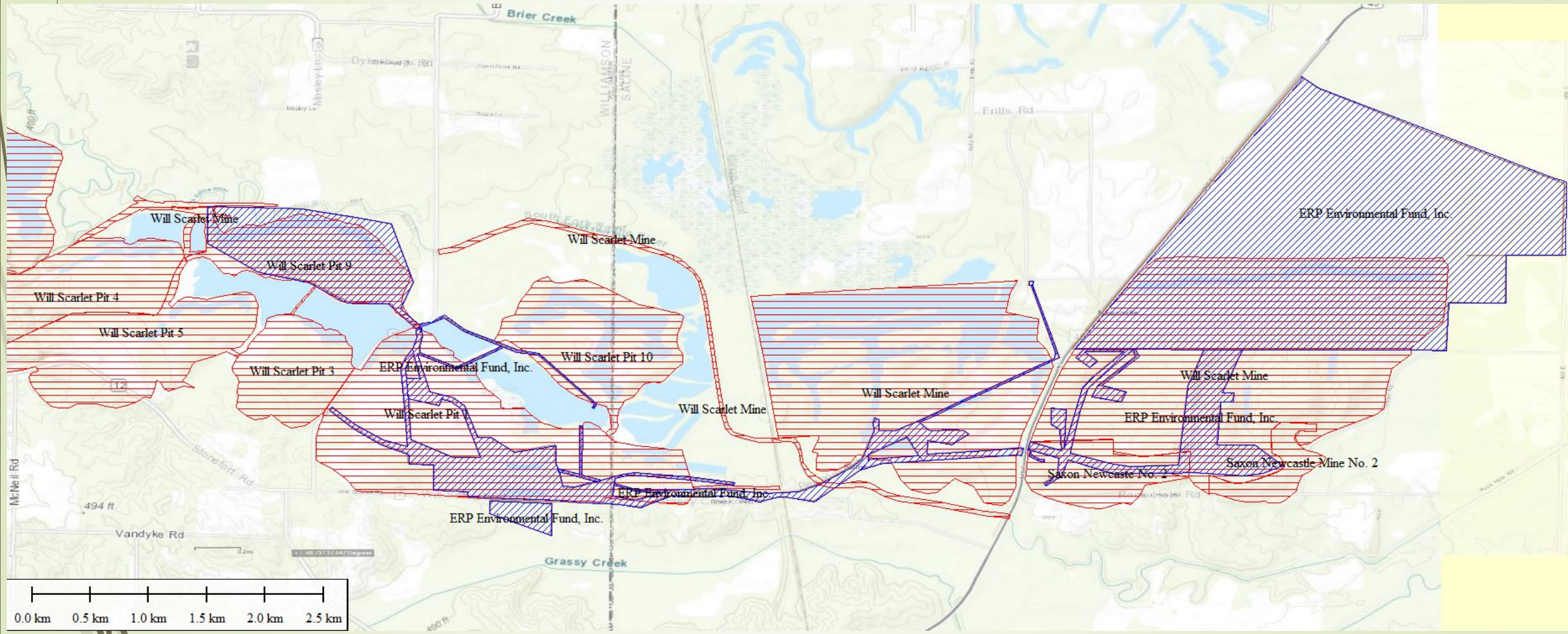
Will Scarlet Mine Principle Production Area



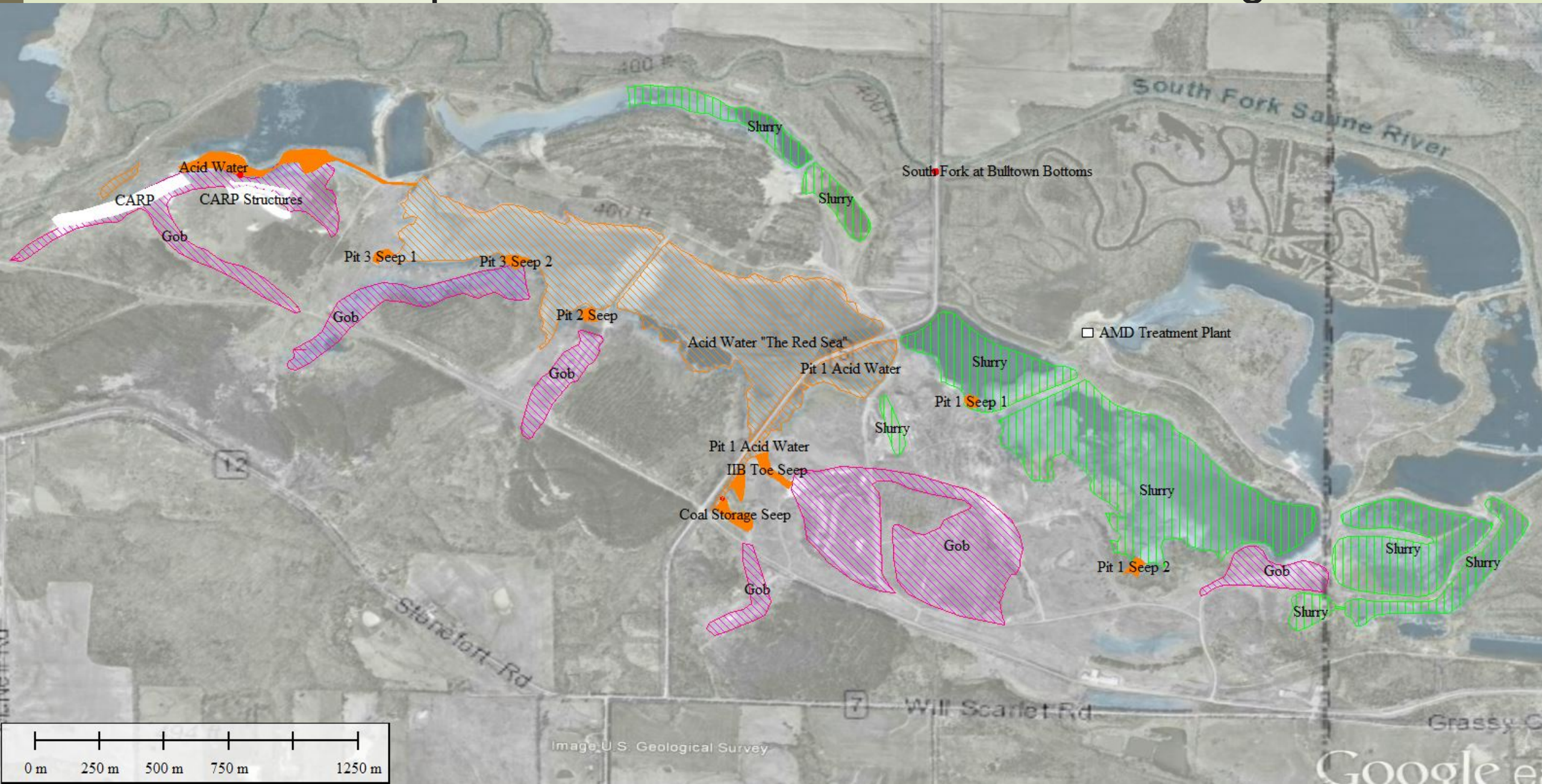
Will Scarlet Mine Eastern Production Areas



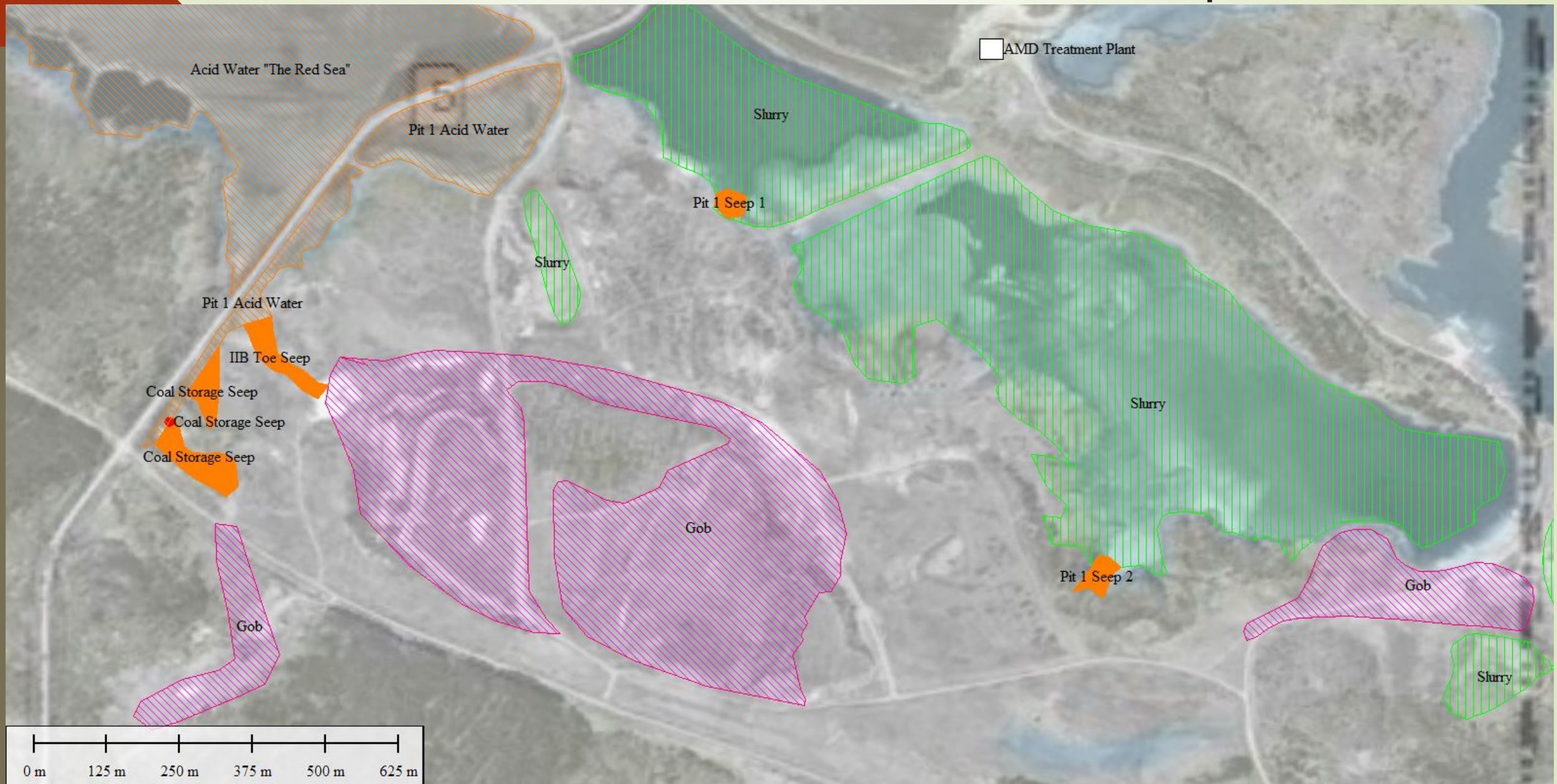
Will Scarlet Mine Active Permitting Area



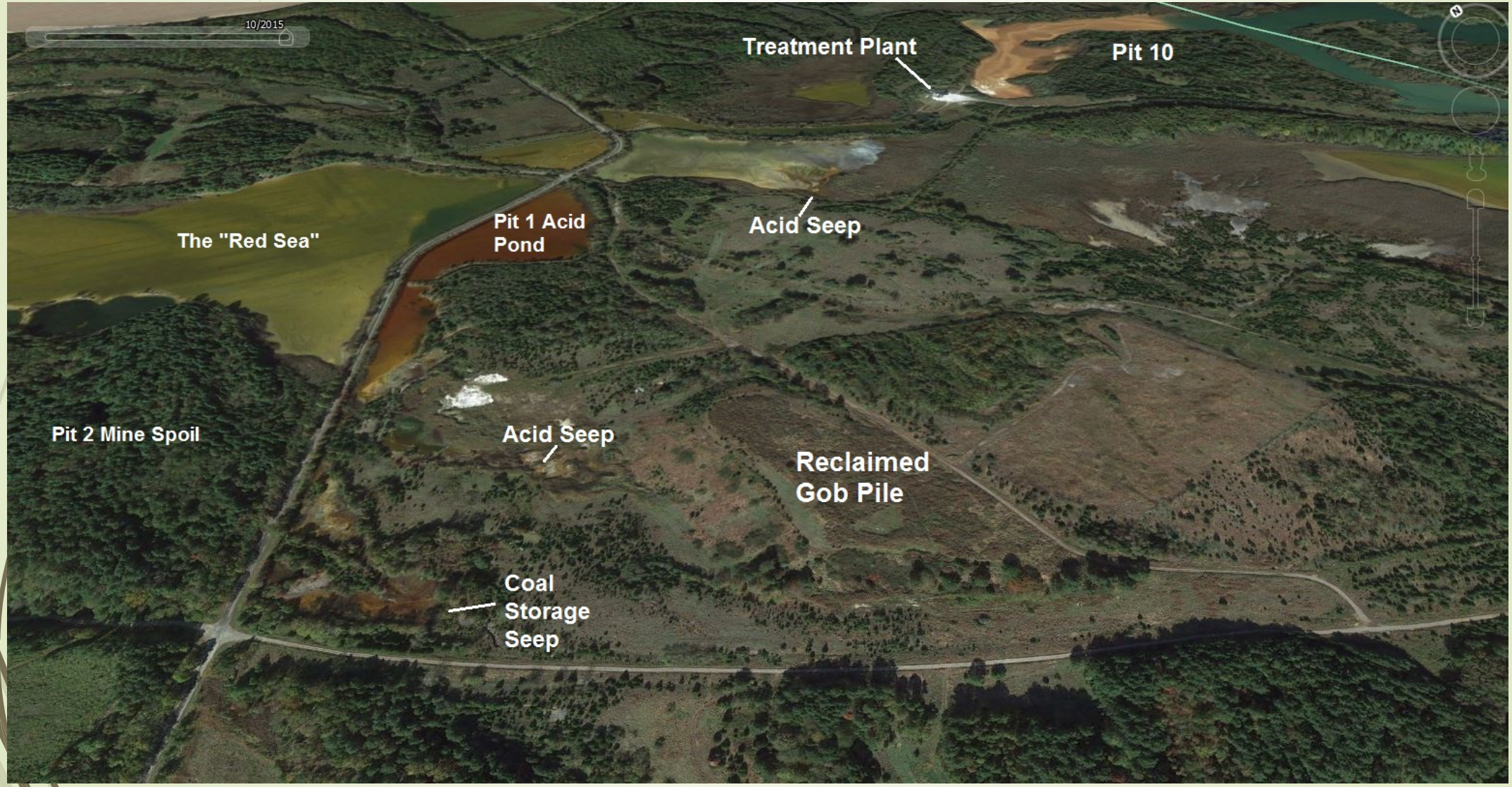
AMD Impact Areas: Stonefort Coal Mining Areas



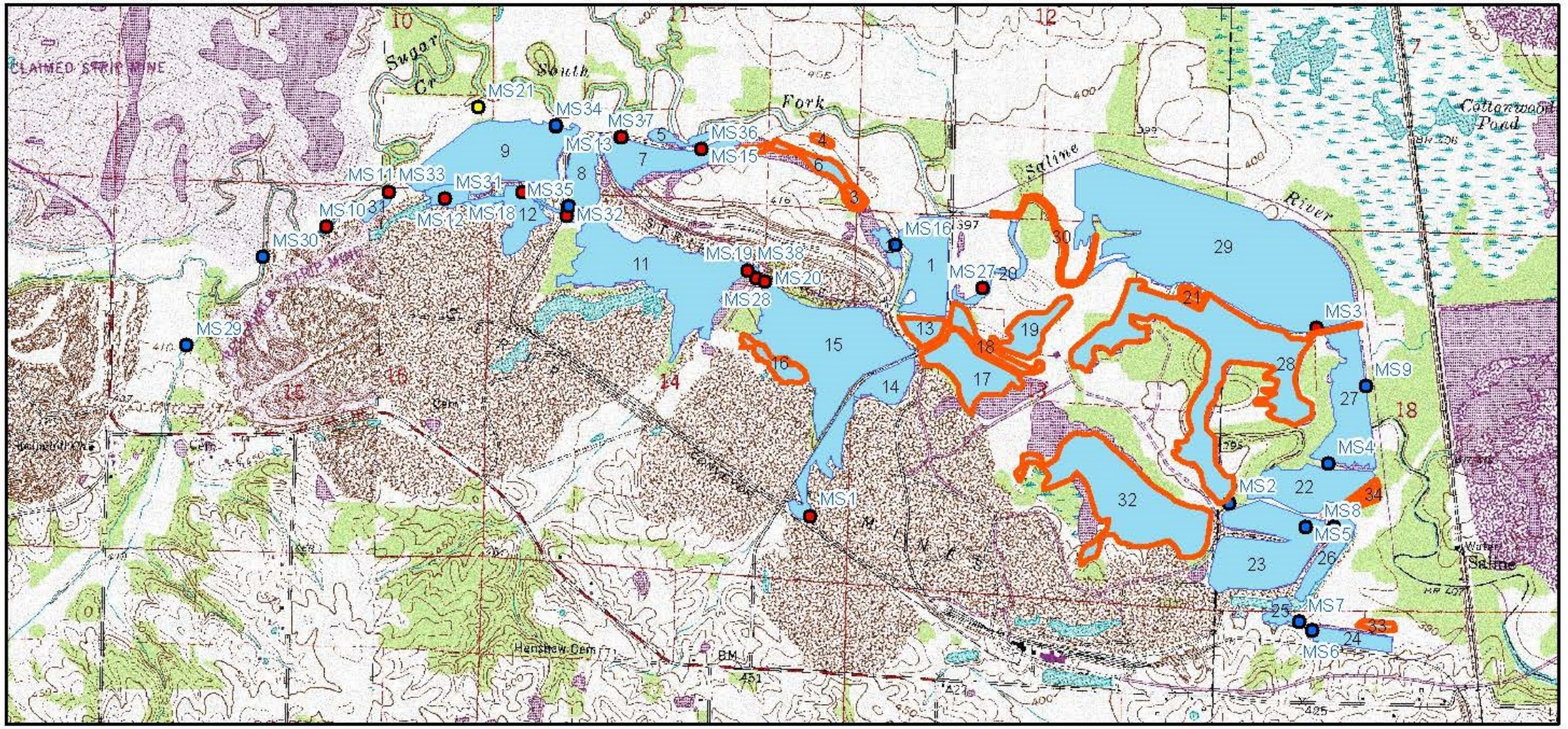
AMD Features of Pit 1 and the Gob Disposal Area



Perspective view of Will Scarlet Pit 1& Refuse Disposal Area AMD Sites



OMM/OSM 2007/2009 Field Study



Will Scarlet Pit 1 and Gob Area AMD Sites

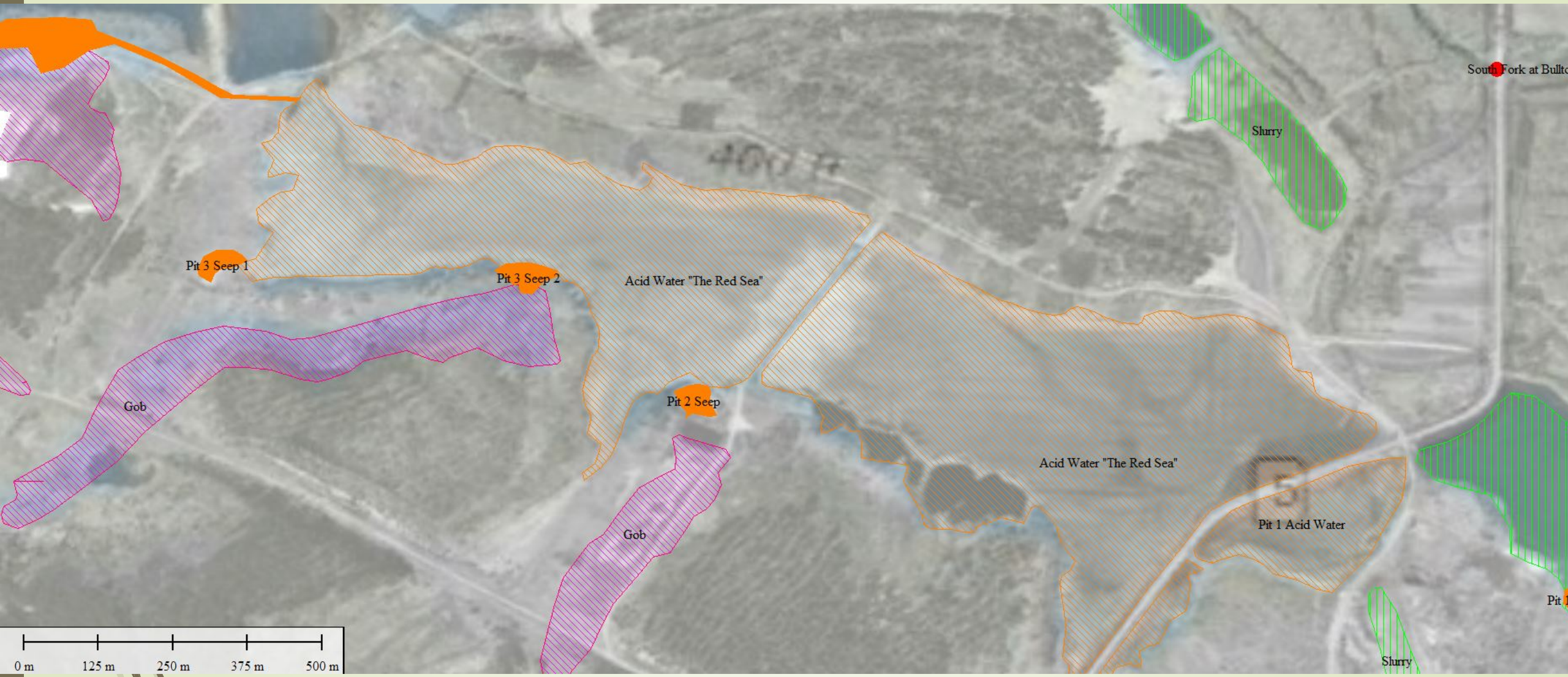
Site	Date/ID	pH	Al	Fe	Mn	Sulfate	Acidity
Coal Storage Seep	9/8/2009 MS-1	3.08	169.3	405.0	39.7	2,200	2,024
Coal Storage Seep	11/13/15 OSM	2.48	36.7	22.5	36.4	2,150	487
Coal Storage Seep	2/23/17 022317W3	2.90	25.0	254.7	27.6	2,725	819

SIUC/Peabody Coal constructed Pit 1 area CARP structures in 1990? (Nawrot et al.).

Two large seeps discharge from the west side of an AML coarse refuse area (Coal Storage and Toe Seeps).

The “Pit 1/Coal Storage” AMD is occasionally monitored by OSM/OMM.

AMD Features of Pits 2 and 3 and “The Red Sea”

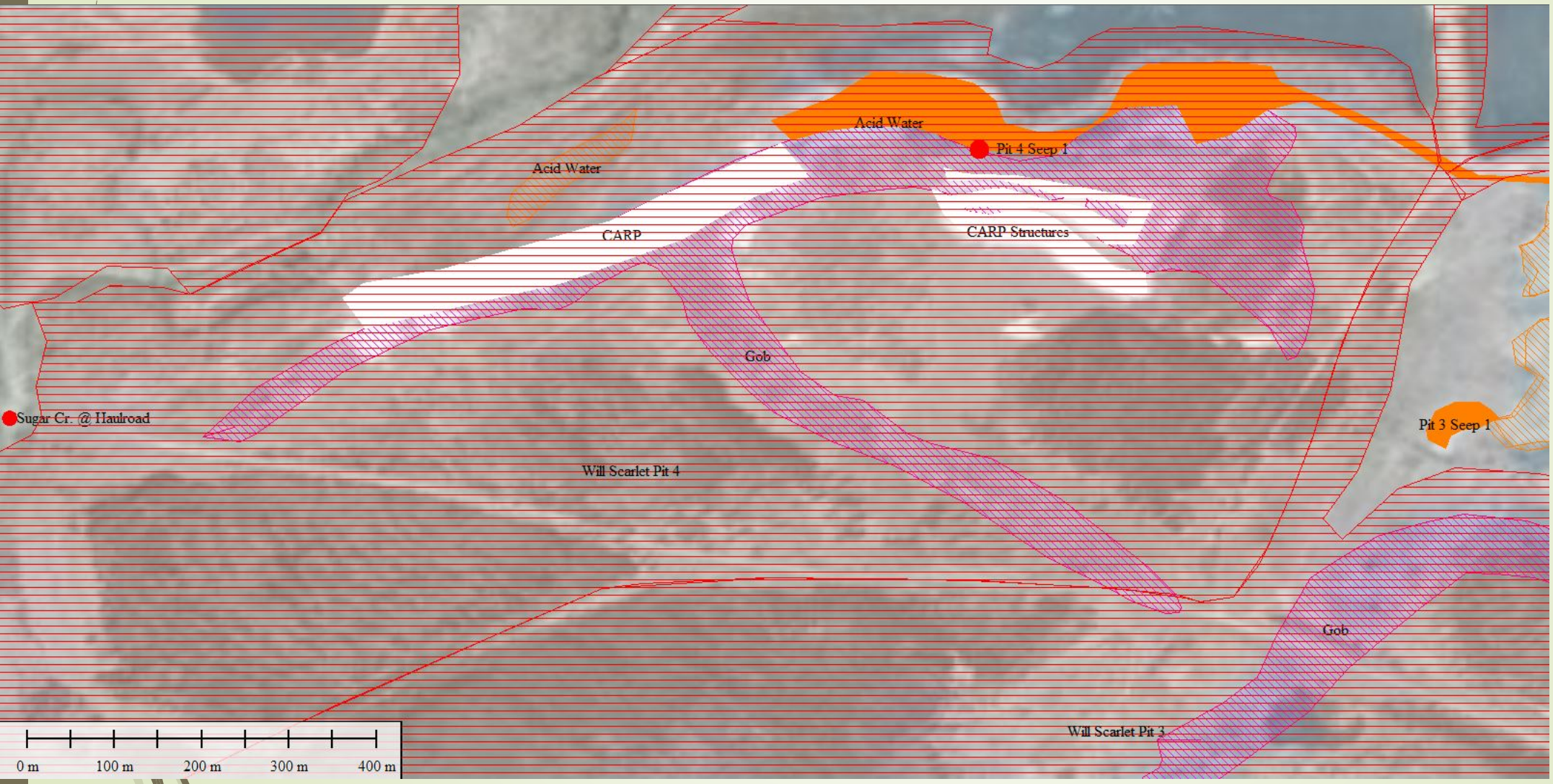


Acid Pit Impoundment at the Will Scarlet Mine known as the “Red Sea.”

The “Red Sea” view to the east.

The “Red Sea” view to the north.

Will Scarlet Pit 4 & Refuse Disposal Area AMD Sites



SIUC/Peabody constructed Pit 3 area CARP structures in 1988.

Three large seeps discharge from the west side of an AML coarse refuse disposal area.

The “Pit 4 Seep 1” AMD was occasionally monitored by OSM/OMM.

Will Scarlet Pit 4 AMD Sites

Site	ID	Al	Fe	Mn	Sulfate	Acidity
Pit 4 Seep 1	3/25/09 MS-31	241.7	183.1	36.96	--	1,977.6

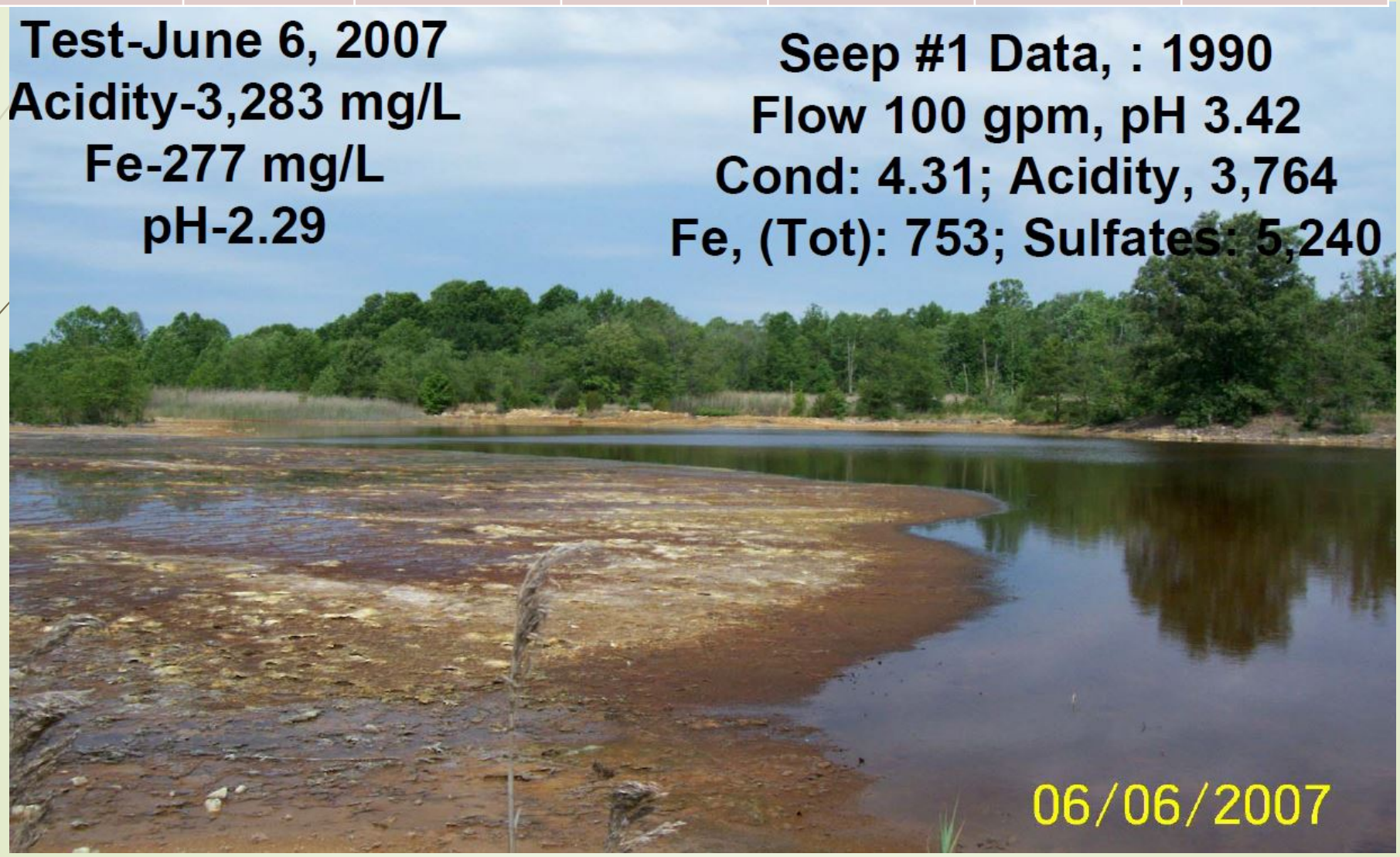


Photo by R. Kiser, OMM (retired)

Pit 4 Discharge Channel

Site	ID	Al	Fe	Mn	Sulfate	Acidity
"Red Sea" Feeder Ditch	5/15/07 MS-32	220.0	252.0	46.51	2,731.8	2,126.0

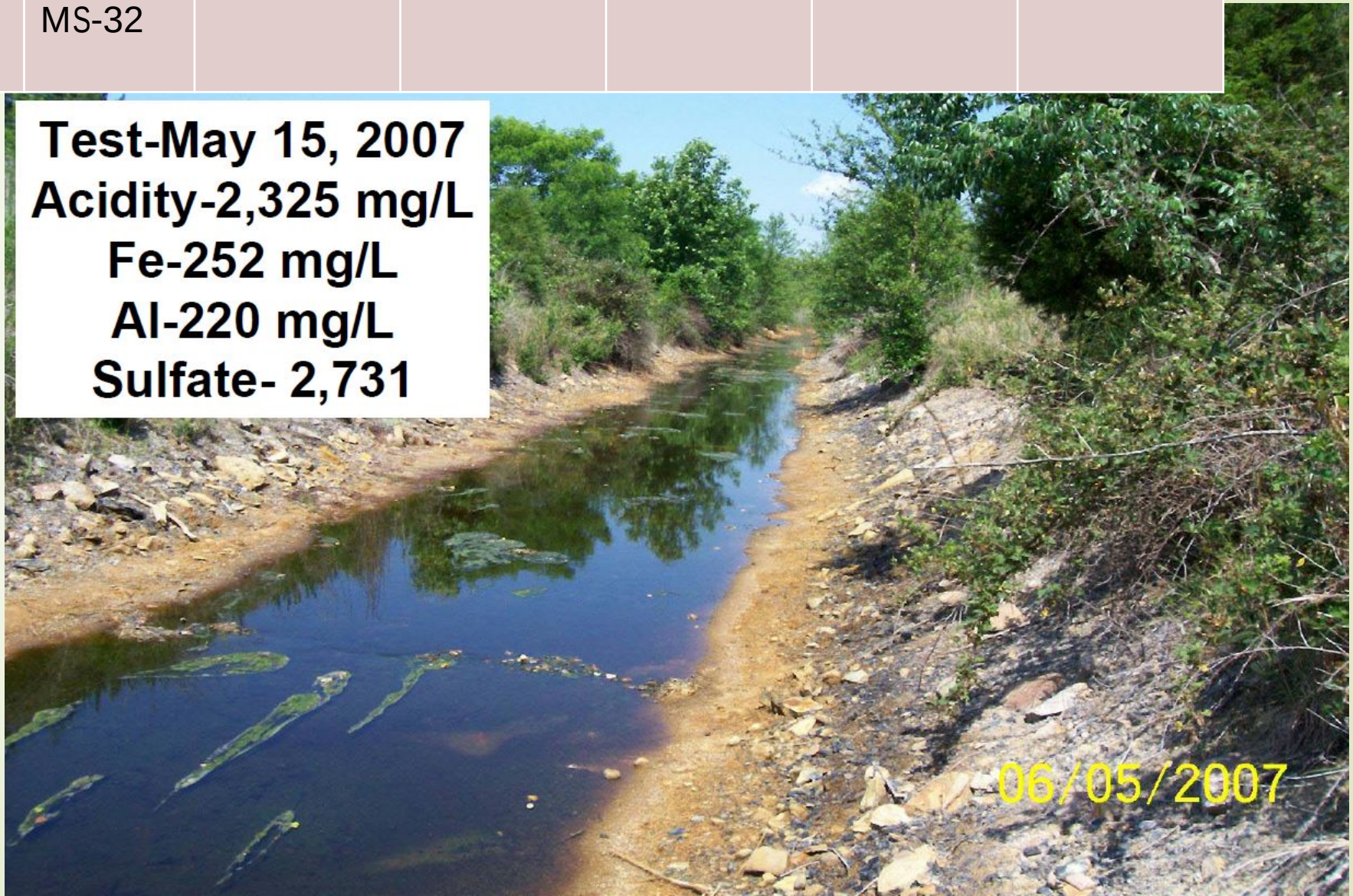
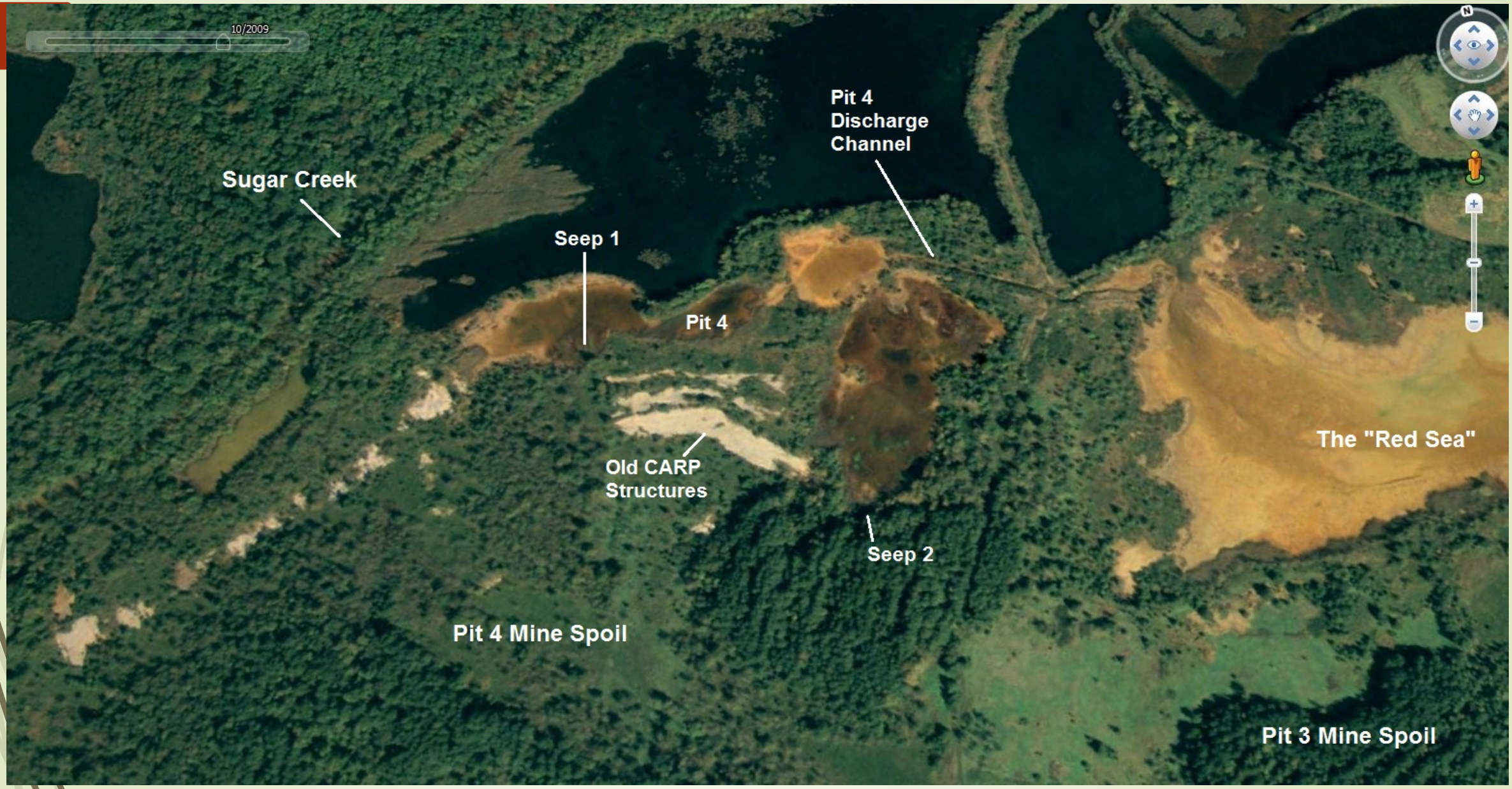
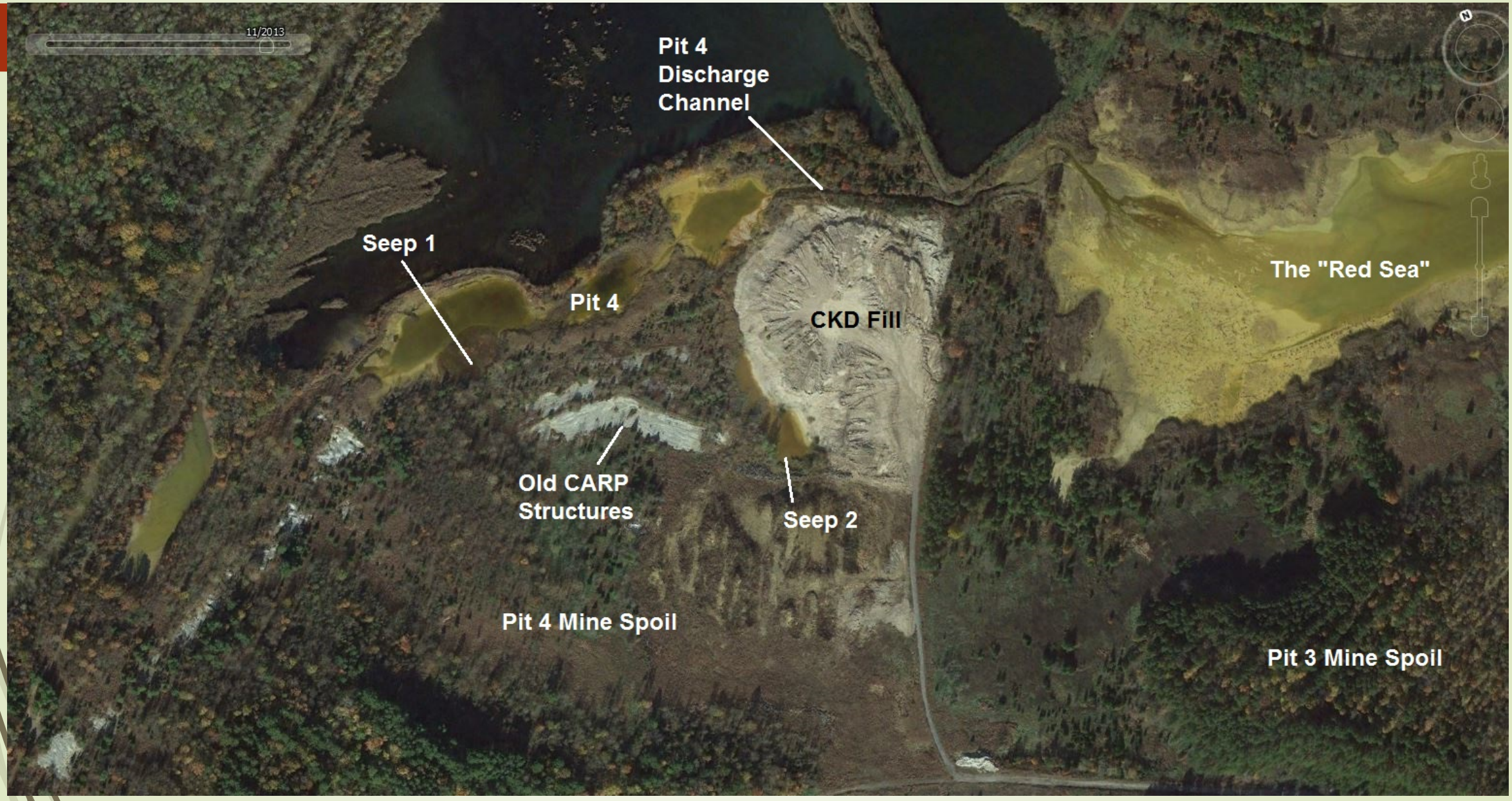


Photo by R. Kiser, OMM (retired)

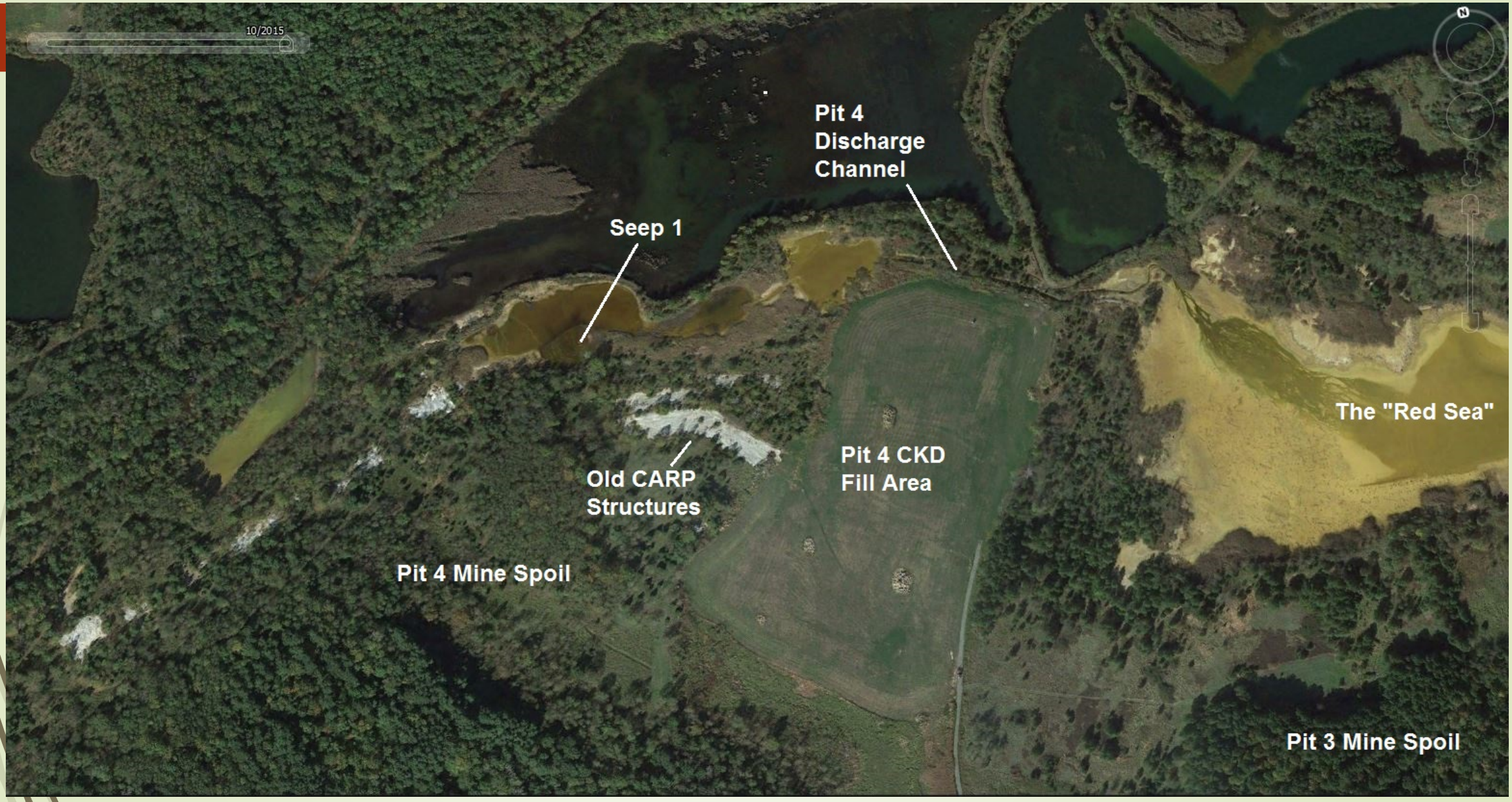
Will Scarlet Pit 4 2011 before Cement Kiln Dust (CKD) Backfill



Cement Kiln Dust (CKD) Backfill of Will Scarlet Pit 4 – 2013



Cement Kiln Dust (CKD) Backfill of Will Scarlet Pit 4 - 2011



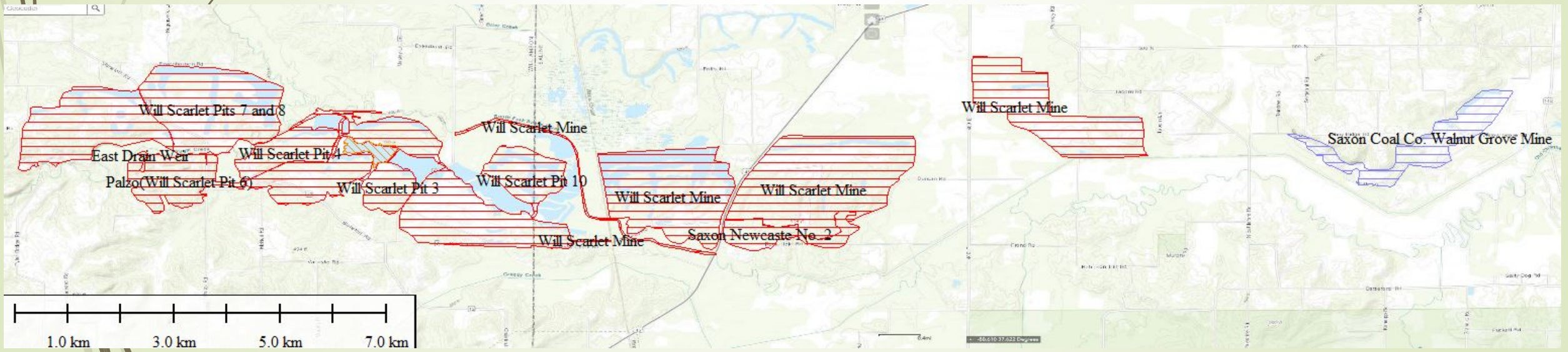
Suggested Investigation Activity

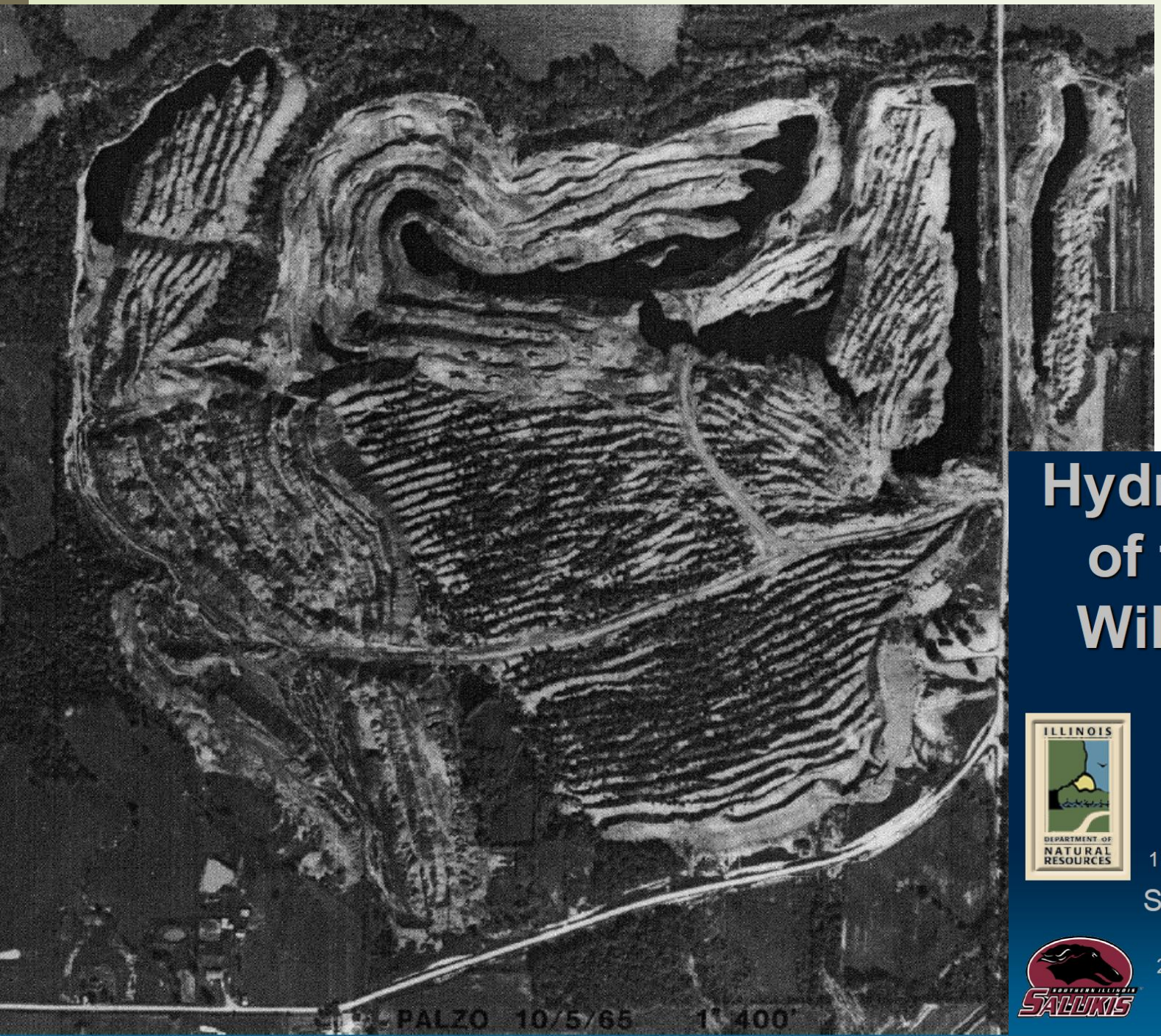
- Collect additional water samples to access seasonal variations.
- Conduct additional geochemical modelling.
- Install continuous flow measurement facilities at all major seep areas.
- Conduct barrel testing of limestone-amended organic substrate LBOS with materials derived from local sources.

Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois

Update on the Palzo AML Site

(Will Scarlet Mine Pit 6), Williamson County, IL



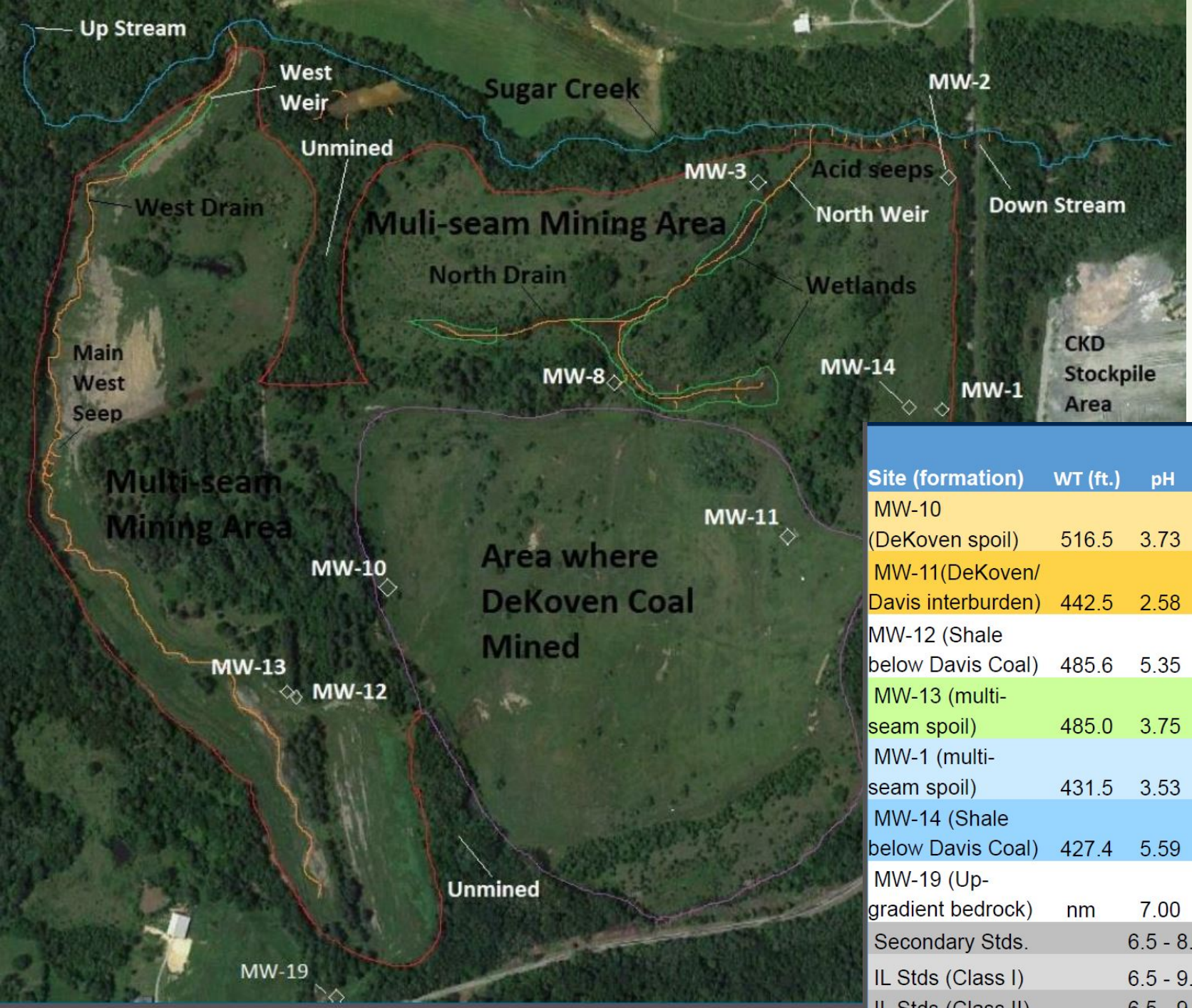


Palzo AML Site: 1965

Hydrology and Geochemistry of the Palzo Surface Mine, Williamson County, Illinois 2003-2013

Paul T. Behum,[1] Ron Kiser,[2] and Bryan Johnsrud[2]

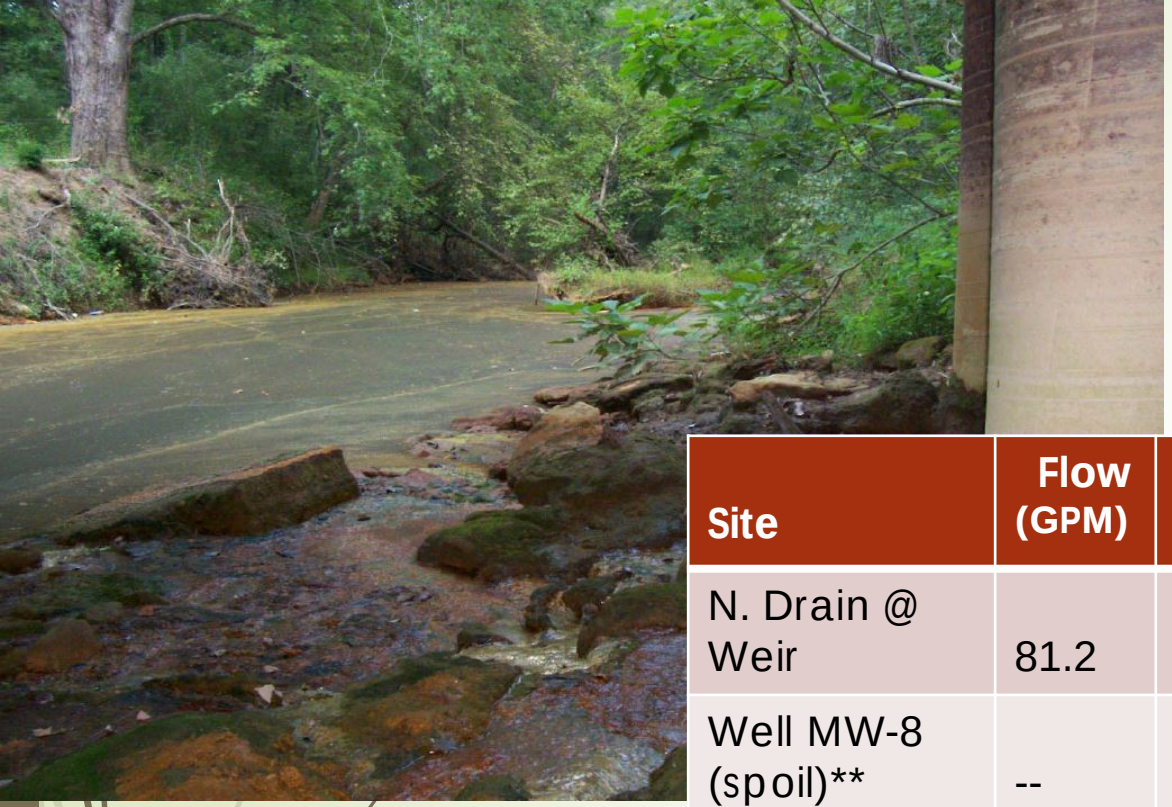
[1]Environmental Resources and Policy PhD Program, Southern Illinois University and Sr. Hydrologist, Office of Surface Mining Reclamation and Enforcement.
[2] Illinois Department of Natural Resources, Office of Mines and Minerals



Palzo AMD: Groundwater Quality

Data from Behum, et. al., 2014

Site (formation)	WT (ft.)	pH	D. Fe	D. Fe^{+2}	D. Al	D. Mn	SO_4^{2-}	Cl^-	Lab Acidity	Alkalinity
MW-10 (DeKoven spoil)	516.5	3.73	83.5	50.0	134.0	29.74	2,141	3.9	640	0.0
MW-11(DeKoven/ Davis interburden)	442.5	2.58	763.0	357.5	288.1	30.68	4,100	15.3	2,979	0.0
MW-12 (Shale below Davis Coal)	485.6	5.35	385.5	47.2	126.4	6.02	2,924	13.8	443	105.2
MW-13 (multi-seam spoil)	485.0	3.75	482.7	241.5	71.3	12.65	2,037	32.8	1,674	0.0
MW-1 (multi-seam spoil)	431.5	3.53	151.0	127.3	114.6	29.59	2,257	4.3	705	0.0
MW-14 (Shale below Davis Coal)	427.4	5.59	256.0	113.0	24.5	21.78	3,026	11.0	29	110.0
MW-19 (Up-gradient bedrock)	nm	7.00	2.00	0.06	0.7	4.61	1,759	64.7	0.0	633.6
Secondary Stds.		6.5 - 8.5	0.3	NS	50-200	0.05	250	250	NS	NS
IL Stds (Class I)		6.5 - 9.0	5.0	NS	NS	0.15	400	200	NS	NS
IL Stds (Class II)		6.5 - 9.0	5.0	NS	NS	10.0	400	200	NS	NS



Palzo AMD: Comparison of Surface and Groundwater

Site	Flow (GPM)	pH	D. Fe	D. Al	D. Mn	D. Ni	D. Zn	SO_4	Calc. Acidity	Alk-alinity
N. Drain @ Weir	81.2	2.72	99.6	119.7	23.4	0.98	2.27	2,352	1,017	0
Well MW-8 (spoil)**	--	2.77	308.0	259.4	42.0	2.16	3.92	2,187	2,341	0
W. Drain @ Weir	34.2	2.72	162.7	168.4	12.3	1.19	2.95	2,335	1,354	0
West Seep	4.0	2.80	260.2	183.6	14.4	1.52	3.46	2,430	1,735	0
Well MW-2 (spoil)***	--	3.04	296.6	126.4	43.7	1.53	2.92	1,904	1,311	0
Well MW-3 (spoil)***	--	3.10	186.6	140.3	31.0	1.36	2.79	2,340	1,387	0
Upstream	--	6.78	3.74	0.20	0.87	0.01	0.06	96.4	12.5	55.6
Downstream	--	3.57	48.2	23.7	7.89	0.34	0.80	405.0	257.8	0

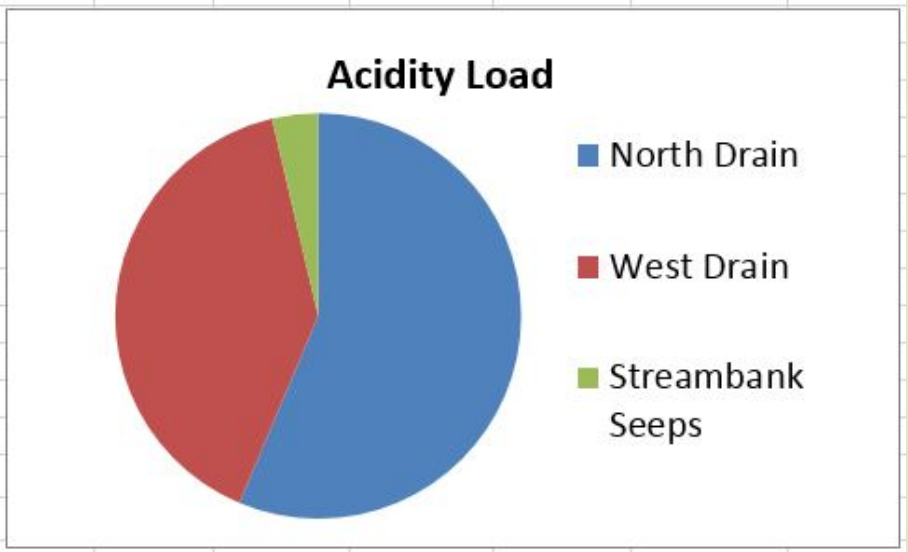
Updated water quality data

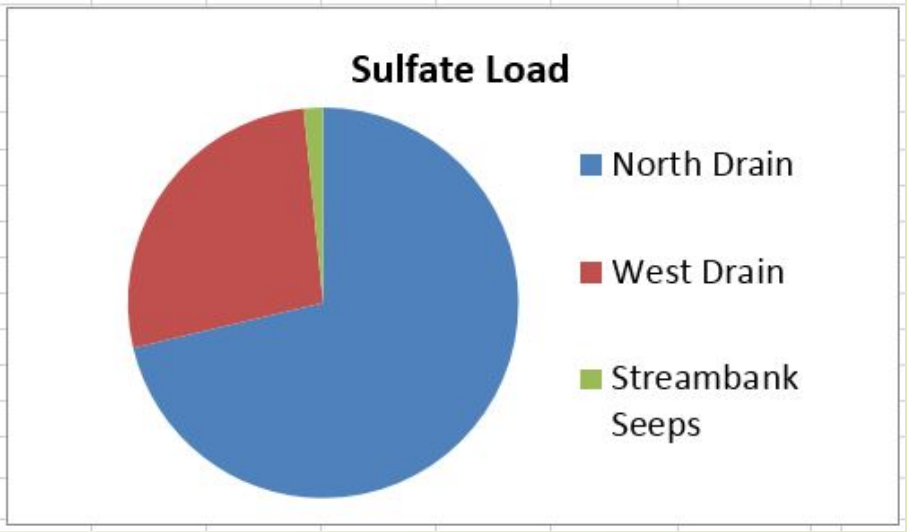
Contaminant Loading Estimate

Loading to Sugar Creek (Grams/day)

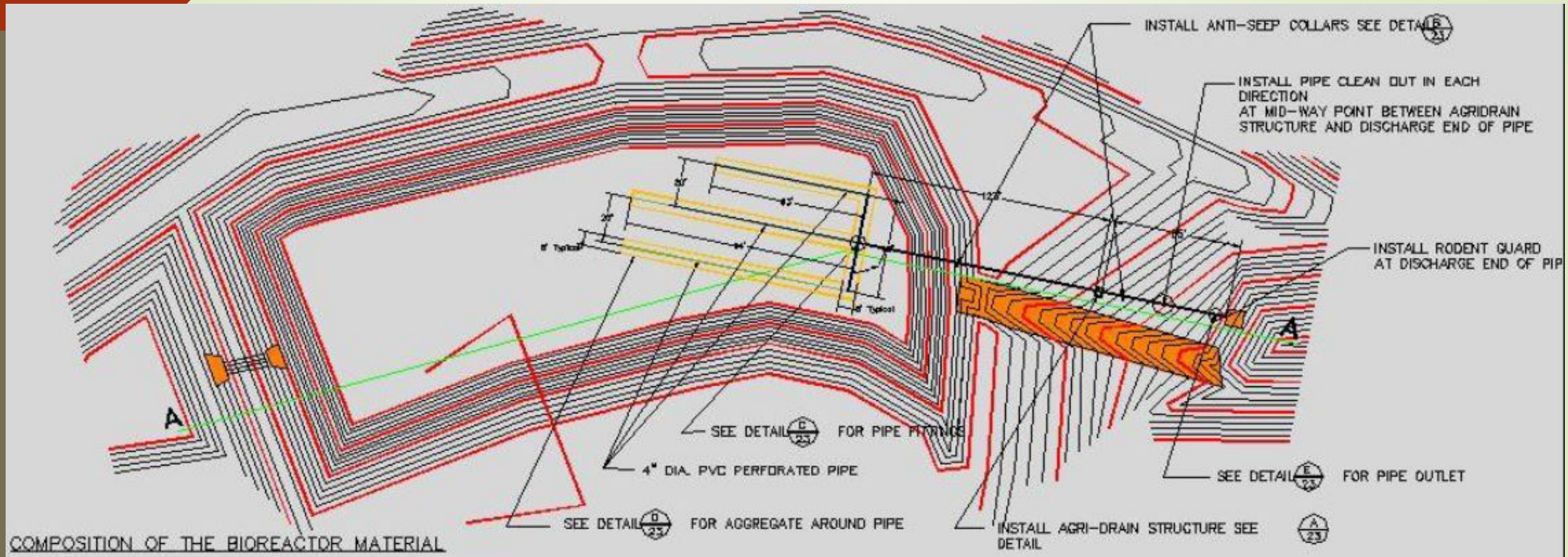
Site	Fe	Al	Mn	Sulfate	Acidity *
North Drain	44,573	53,546	10,464	1,052,368	396,884
West Drain	30,316	31,382	2,294	416,343	300,545
Stream Seeps	2,633	1,453	407	23,128	15,563

Site	Ni	Zn	Co	Cu	Cd	Cr
North Drain	438.5	1,015.7	134.2	44.7	35.8	13.4
West Drain	221.7	549.6	59.6	29.8	14.9	9.3
Stream Seeps	15.8	31.1	4.5	1.1	1.2	0.7





Palzo West Drain Draft Treatment Design



COMPOSITION OF THE BIOREACTOR MATERIAL

MATERIAL	% OF THE TOTAL	VOLUME BY %
COMPOST	11%	1,367 C.Y.
MULCH	27%	3,355 C.Y.
WOOD CHIPS	53%	6,585 C.Y.
AG. GROUND LIMESTONE	9%	1,733 TON

A 22 PLAN VIEW OF PIPING NETWORK

NOT TO SCALE

Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois

The End – Questions?