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

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The Palzo AML Site - Background

- An abandoned surface coal mine located southeast of Marion in Williamson County, Illinois and within the Shawnee National Forest.
- The 126-ha.(312-ac.) site was mined between 1950's and 1960's by the Stonefort Mining Company using area-type surface mining to extract the Davis and DeKoven coal beds of the Pennsylvanian age Spoon Formation.

Palzo AML Site Location

Aerial View of the Palzo Mine in 1970

Location Map

The Palzo AML Site - Background

- Land reclamation occurred between 1970 and 2005 which has re-established vegetation throughout most of the site.
- Poor-quality AMD discharges persists and both Sugar Creek and the South Fork of the Saline River have been severely impacted.
- Large areas of graded but barren spoil area are present in the western drain way.

Historical Reclamation Activities

Date	Project Description
1970	Illinois Sanitary Water Board request USFS abatement of AMD
1972	EIS completed for covering 192 acres with waste treatment sludge from the Metropolitan Sanitary District of Greater Chicago (MSDCG).
1972-1974	USFS/Job Corps vocational training rough grades multi-seam mining area.
1975-1977	Phase I - 57 million gallons of MSDCG sludge (17 T./ac. CCE) incorporated into the graded area.
1980-1982	Vegetation reestablishment methods identified in test studies.
1985	Phase II – Additional 285,000 CY grading in multi-seam mining area with rock removal, ditch construction and deep lime incorporation (AML-GWmE-8450).
1986	Phase III – Additional 1,000 CY grading in multi-seam mining area with ditch construction and deep lime incorporation; AMD persists (AML-GWmE-8454).

Historical Reclamation Activities

Date	Project Description
1997-1998	Indeco, Inc. hydrogeological study, 18 monitoring wells installed.
1999	RiverWatch macro-invertebrate study of Sugar Creek.
2002-2003	Clean Streams Initiative (CSI) Phase I - Grading of 67 ac. DeKoven mining area, construction of CKD/spoil (10 ac.) and scrubber sludge/spoil blend caps (18 ac.); 3 new monitoring wells (AML-GW-0019).
2005-2006	CSI Phase II -28-ac. grading Western drain way, construction of CKD fills/spoil cap (10-ac.; AML-GW-0212).
2003-2014	AMLRD/OSM hydrogeological study, 2 continuously monitored weirs and a recording rain gauge installed; semiannual surface water and annual well sampling; macro-invertebrate study of Sugar Creek.
Proposed	CSI Phase III – Increase depth of North drainage to collect AMD seepage and construct grout wall along Sugar Creek to intercept AMD stream bank seeps; 2 bioreactor-based treatment systems were designed for Western and Northern drainages.

Historical Reclamation Costs: Total = $3,240,992 (AML Funds)

Year Awarded	Phase	Project ID: AML-__-__	Contract Amount	Contact Agency	Description
1981	Phase I	CWmF-8103	~$50,000	Federal project	Evaluation & research
1982	Phase II	GWmE-8243	~$50,000	Federal project	Evaluation & research
1984	Phase I	GWmE-8419	$600,000	State Project	Reclamation
1984	Phase II	GWmE-8450	$745,000	State Project	Reclamation
1984	Phase III	GWmE-8454	$155,000	State Project	Reclamation
1987	Remedial	GSwE-8725A	$116.992	State Project	Reclamation
2000	CSI Phase I	GWmE-0019	$933,000	Federal/ State	67-ac. spoil grading
2002	CSI Phase II	GWmE-0212	$591,000	Federal/ State	28-ac. West drain way

Sugar Creek/South Fork Confluence

Saline River Summary

Water Shed Size: 1,177 miles- empties to the Ohio River.

Drains portions of 9 Southern Illinois Counties

Poorest WQ in lower sections of Sugar Creek and South Fork Saline River.

Aquatic life is "severely limited for 22 stream miles"

Cause? "Acid Mine Drainage from pre-law coal mines"

Land use:
48% Cropland
27% Woodland
18% Grassland
2% Urban
4% Mining

Palzo Mine - 1960

Palzo Mine - 1965

Palzo,1970 Prior to Reclamation

Palzo, 1972: Toxic Spoil & Gob Haul Roads

Palzo: Overburden Analysis

Depth (ft.)	Rock Type	pH (1:1)	% S	PA**	NP**	NNP**
0— 5.5	Silt Loam	6.0	0.02	0.63	1.85	1.23
5.5—25.5	Shale and sandstone	6.2	0.50	15.63	-5.00	-20.63
25.5-27.5	DeKoven Coal	nm	6.13	191.56	nil	-191.56
27.7-29.5	Black Shale	2.4	12.05	376.56	2.52	-374.04
29.5-31.5	DeKoven Coal	nm	6.13	191.56	nil	-191.56
31.5-34.0	Black Shale	6.5	0.6	18.80	1.78	-17.02
34.0-38.0	Davis Coal		4.83	132.81	nil	-132.81
38.0-38.5	Sandy Sh.	4.1	0.7	21.88	26.4	4.52

12 % Sulfur in Parting Shale - Requires 377 T. limestone/1,000 T.!!

Palzo West Drain Highwall Remnant

Palzo: Overburden Analysis

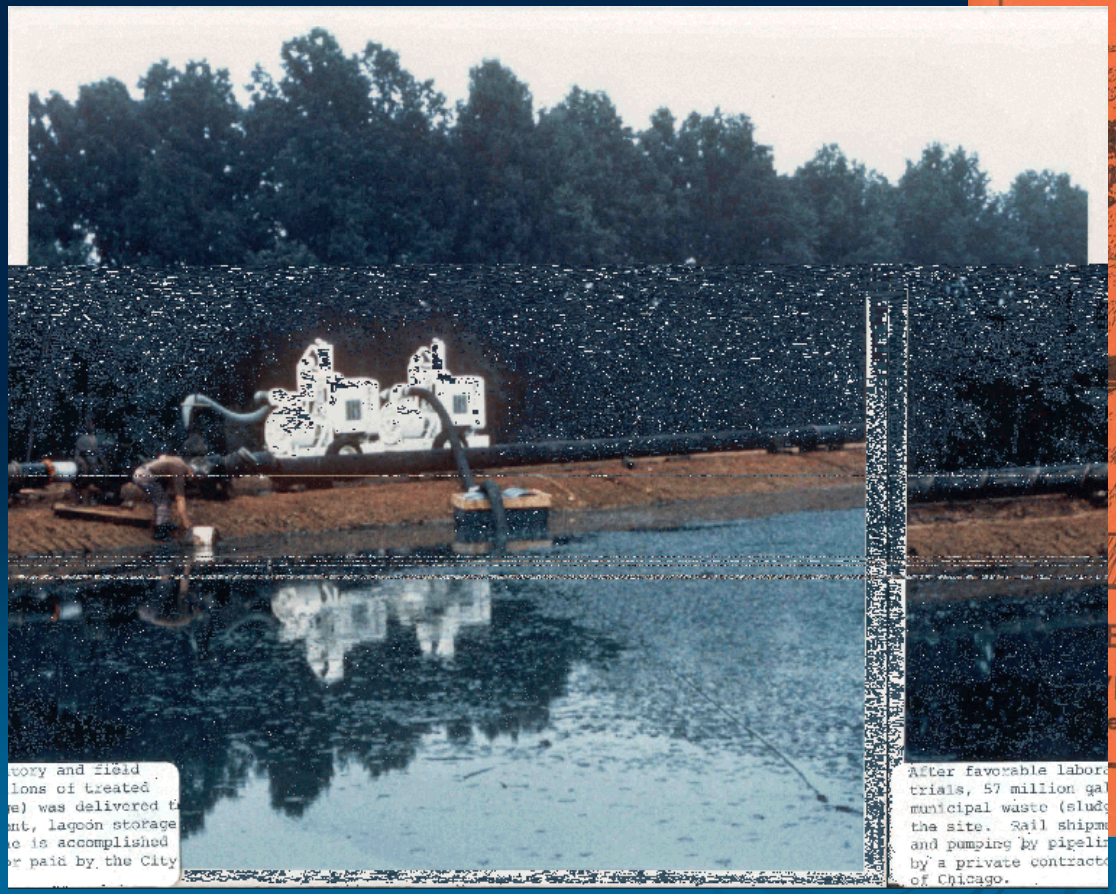
- Pennsylvania spreadsheet method the weighted ABA was -50.5 tons calcium carbonate equivalent (CCE)/1,000 tons of material with an allowance of 5% of the coal as lost during mining (95% recovery).
- All of the overburden is net acid producing (< -5 tons CCE /1,000 tons) except for the soil horizon.

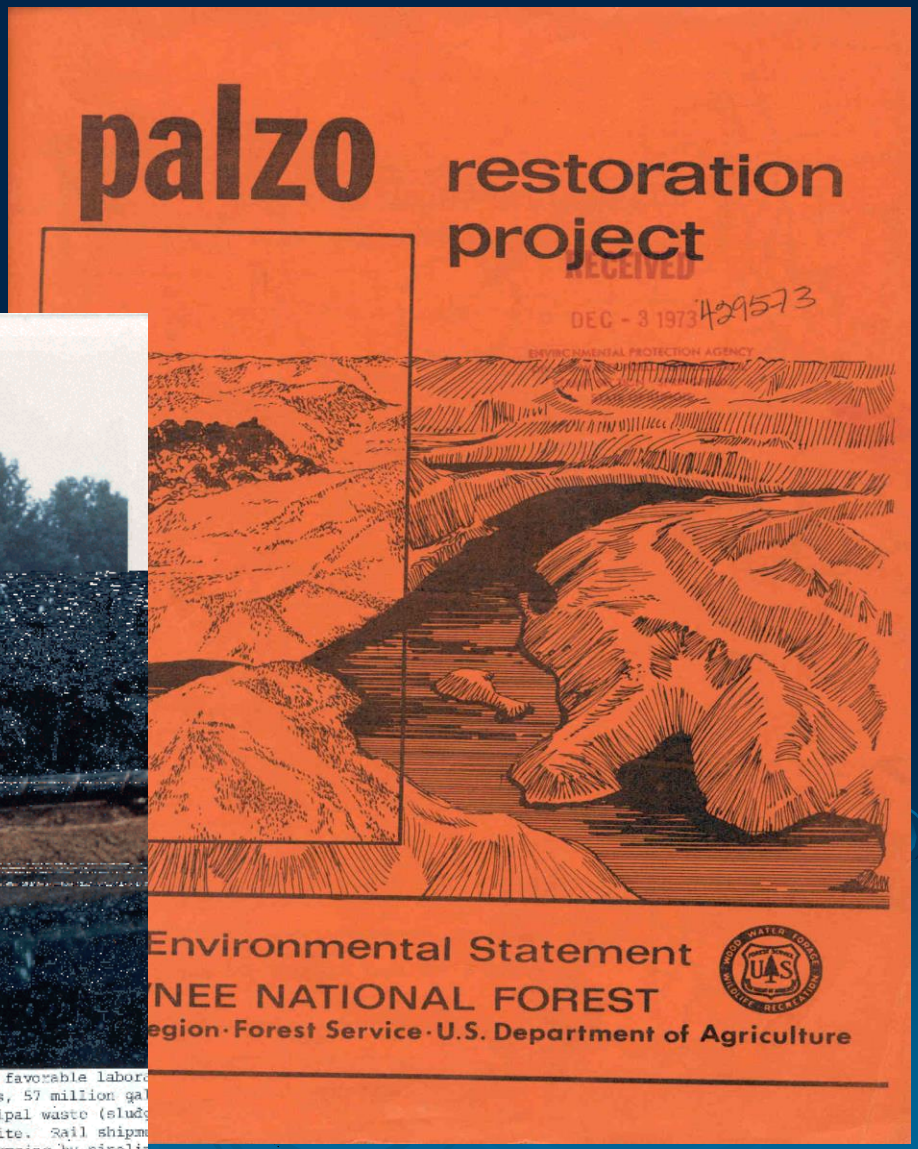
Palzo, USFS/Job Corps Grading 1972

1972 EIS & 1973 Sludge Application

57 million gallons sewage sludge from Calumet, IL

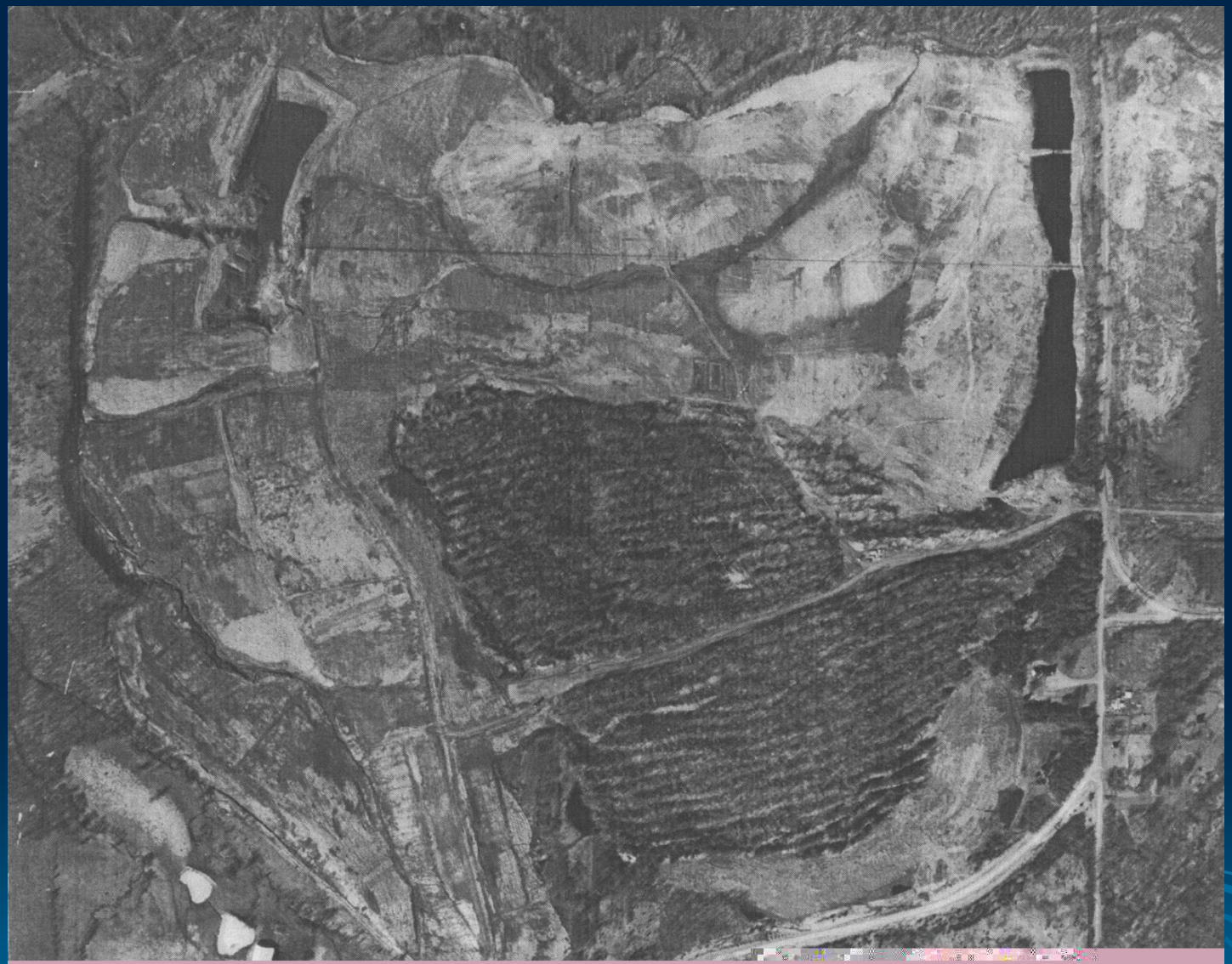
"Crude preliminary research work" Prairie Farmer, July, 1972





Palzo: Waste treatment sludge Incorporated into spoil

Aerial View - Palzo AML Site - 1979




Palzo AML Site - 1995
USFS 312 Ac
Drainage to Sugar Creek

Palzo, Sugar Creek in 1996

Sugar Creek in 2007: Downstream

AMD Sources: North Drain Discharge, 2007,

AMD Sources: West Drain in 1999

AMD Sources: Seeps Along Sugar Cr.

Palzo site: @
CR12 bridge
Flow ~20 GPM
pH = 2.97
DO = 0.6 mg/L

1980's AMD Remediation: Clogged Gabion Basket

Remediation: West Drain - Before 2005 CSI Phase II Reconstruction

West Drain Reconstruction: CKD base

Palzo: West Channel Reconstruction: 2005

Palzo: West Channel Reconstruction: 2014

2003-2013 Hydrologic Investigation

- AMLRD/OSM installed:
  - weirs in the Northern and Western drain ways.
  - a recording rain gauge
- Surface water was sampled semi-annually and wells were sampled ~ annually.
- Laboratory tests were conducted at DNR's EPA-certified lab in Benton, IL.
- Field measurements:
  - pH, conductivity, temperature.
  - dissolved oxygen and ORP.
  - Ferrous iron and alkalinity.


Up Stream
West
Weir
Sugar Creek
MW-2
Unmined
MW-3
Acid seeps
West Drain
North Weir
Down Stream
Muli-seam Mining Area
North Drain
Wetlands
Main
West
Seep
MW-8
MW-14
MW-1
CKD
Stockpile
Area
Multi-seam
Mining Area
MW-11
Area where
DeKoven Coal
Mined
MW-10
MW-13
MW-12
Unmined
MW-19

Ground Water Chemistry (median values).

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

nm = not measured, NS = no standard; MCL = maximum contaminant level; GW = groundwater.

Ground Water Chemistry (median values)

Site (formation)	D. Ca	D. Mg	D. Na	D. Ni	D. Zn	D. Co	D. Cu	D. Cd
MW-10 (DeKoven spoil)	255.4	79.2	8.2	1.410	2.480	0.73	0.04	0.048
MW-11 (DeKoven/Davis interburden)	233.6	101.9	24.9	2.750	4.930	0.67	0.16	0.210
MW-13 (multi-seam spoil)	131.4	39.5	15.1	0.630	1.280	0.00	0.16	0.010
MW-12 (Shale below Davis Coal)	509.4	249.8	174.2	0.455	0.170	0.20	0.31	0.020
MW-1 (multi-seam spoil)	375.9	61.3	17.7	1.350	2.875	0.30	0.05	0.030
MW-14 (Shale below Davis Coal)	393.1	198.5	163.1	0.535	0.620	0.33	0.03	0.010
MW-19 (Upgradient bedrock)	210.5	354.8	358.5	0.098	0.050	0.05	0.00	0.010
Federal MCLs	NS	NS	NS	NS	NS	NS	1.30	0.005
Secondary Stds.	NS	NS	NS	NS	5.00	NS	1.00	NS
IL Stds. (Class I)	NS	NS	NS	0.100	5.00	1.00	0.65	0.005
IL Stds. (Class II)	NS	NS	NS	2.000	10.00	1.00	0.65	0.050

Hydraulic Conductivity (Indeco, 1998)

Spoil: Constant Head Permeability and Slug Tests (cm/sec.)

Borehole	Vertical	Falling Head	Rising Head	Average
MW-5	2.18E-05	5.54E-03	4.41E-02	2.48E-02
MW-8		3.57E-04	7.42E-05	2.15E-04
MW-13	2.34E-05	6.86E-05	4.27E-04	2.48E-04
MW-10		3.41E-05	2.11E-04	1.22E-04
MW-1		1.12E-04	2.09E-04	1.61E-04

Bedrock: Constant Head Permeability and Slug Tests (cm/sec.)

Borehole	Vertical	Falling Head	Rising Head	Average
MW-11		5.54E-03	1.60E-02	1.08E-02
MW-12		5.23E-06	1.00E-05	7.62E-06
MW-14	1.32E-07	1.25E-06	3.30E-06	2.28E-06

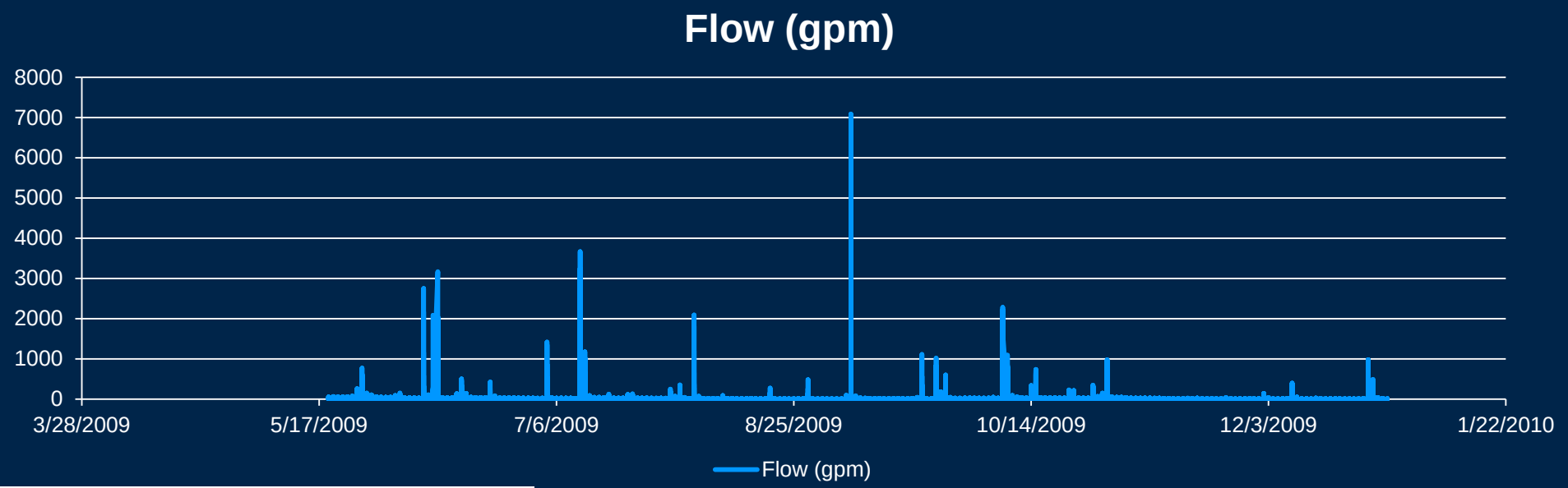

Up Stream
West
Weir
Sugar Creek
MW-2
Unmined
MW-3
Acid seeps
West Drain
North Weir
Down Stream
Muli-seam Mining Area
North Drain
Wetlands
Main
West
Seep
MW-8
MW-14
MW-1
CKD
Stockpile
Area
Multi-seam
Mining Area
MW-11
Area where
DeKoven Coal
Mined
MW-10
MW-13
MW-12
Unmined
MW-19

Surface Water Chemistry (median values)

Site	Flow** (GPM)	pH	SC (uS/cm)	D. Fe	Fe^{+2}	D. Al	D. Mn	SO_4	Lab Acidity	Non-Mn Acidity	Alk-alinity*	TDS
North Drain Weir	82.1	2.71	2,920	95.5	14.0	127.1	23.20	2,352	1,207	1,068	0.0	2,474
Well MW-8 (spoil)**		2.77	4,320	308.0	179.2	259.4	42.04	3,489	2,286	2,187	0.0	5,385
West Drain Weir	34.2	2.74	2,825	162.7	54.6	170.0	11.83	2,149	1,613	1,376	0.0	3,739
West Seep	3.0	2.78	2,810	261.9	154.8	187.7	12.86	2,450	1,891	1,759	0.0	4,858
Well MW-2 (spoil)***		3.01	3,275	309.7	181.0	126.4	43.72	1,904	1,475	1,248	0.0	4,729
Well MW-3 (spoil)***		3.12	3,370	200.0	113.3	142.1	31.48	2,442	1,381	1,315	0.0	4,687
Up Stream	nm	6.79	390	2.54	nm	0.56	0.79	101.2	5.0	13.0	55.6	186
Down Stream	nm	3.69	878	45.6	22.2	21.6	5.68	394.0	328.0	257.8	0.0	822

*CCE; **North and West Drain flow data from recording stations; ***spoil from multi-seam mining.

Palzo West Drain @ Weir: 2009 Discharge



Onset Computer's HOBO® Flow Logger or similar.

North Drain: Logger median = 82.1 GPM
Bucket and stopwatch median = 79.3 GPM

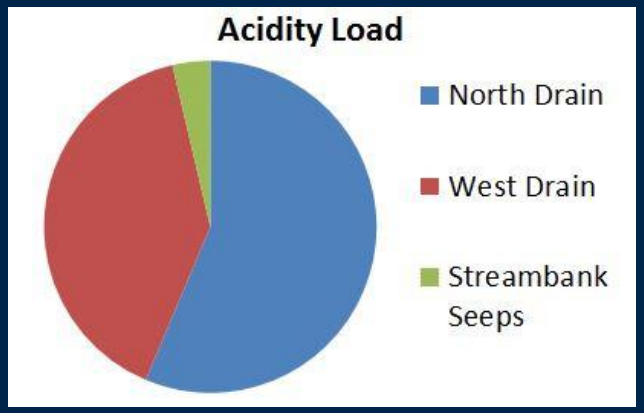
West Drain: Logger median = 34.2 GPM
Bucket and stopwatch median = 27.7 GPM

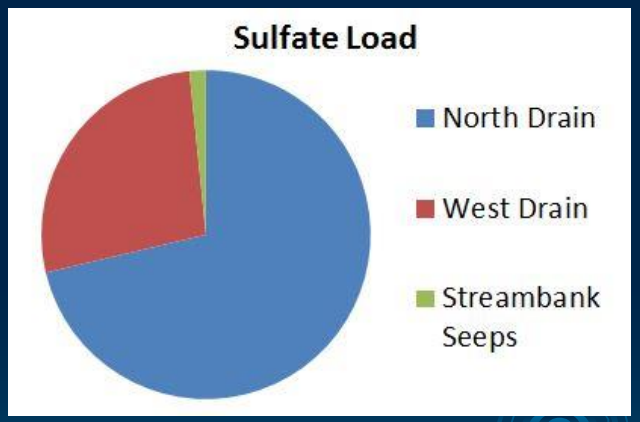
Contaminant Load

Contaminant Loading * (grams/day)

Site	Fe	Al	Mn	Sulfate	Acidity*
NorthDrain	42,727	56,881	10,381	1,052,368	540,156
West Drain	30,316	31,672	2,204	400,432	300,545
Stream Seeps	2,778	1,463	410	23,681	15,563

Site	Mn	Ni	Zn	Co	Cu	Cd
NorthDrain	10,381	541.4	1,114.1	163.3	49.2	44.7
West Drain	2,204	225.4	539.4	62.4	29.8	18.6
Stream Seeps	410	15.8	31.1	4.5	1.1	1.2





*Acidity Calculation Formula:
$50*(2*Fe2+/56+3*Fe3+/56+3*Al/27+2*Mn/55+1000*10^{-pH})$

Results

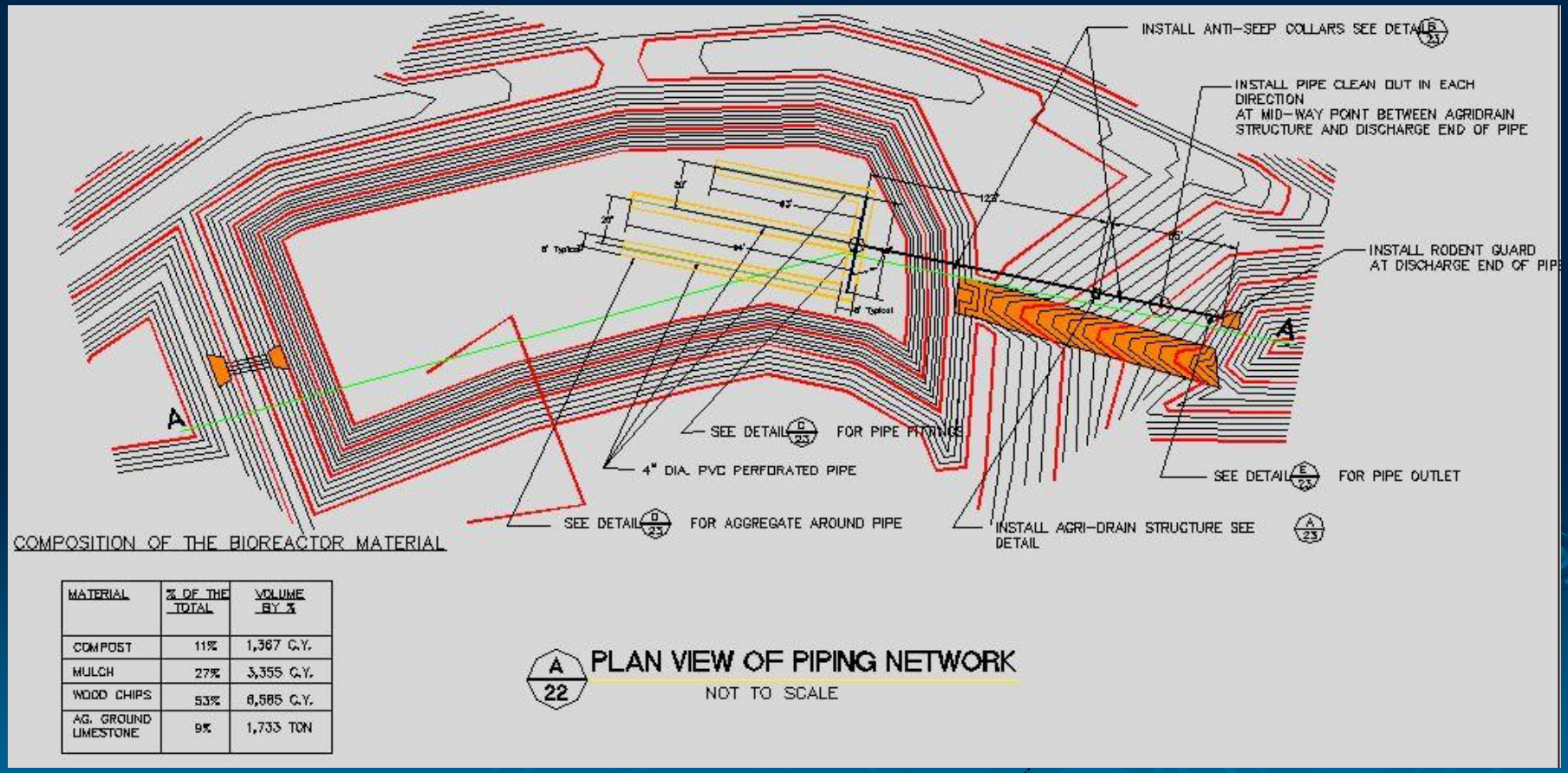
- SO_4, Fe, Mn, Al, Ni and Cd levels are problematic in groundwater resources.
- Well MW-8 had the poorest quality water is a surrogate for North drain seeps.
- MW-2 and MW-3 data is representative of seeps along Sugar Creek.
- The Northern Drain conveys the largest portion of the contaminant load.
- The West Drain AMD is more polluted but has a lower contaminant load.

AMD Remediation

- CSI Phase III:
  - Increase depth of North drainage to collect AMD seepage.
  - Construct grout wall along Sugar Creek to intercept AMD stream bank seeps.
  - Bioreactor-based treatment system - preliminary designs for Western and Northern drainages.
  - Pre-bioreactor treatment of AMD possible with Low-pH Iron Oxidation methods.
  - Post-bioreactor treatment with oxidation cells and aerobic wetlands.

CSI Phase III Plan: Grout Wall

AMD Abatement Plans:
Preliminary Bioreactor Treatment Cell for the West Drain



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

AMD Abatement Plans:
Preliminary Bioreactor Treatment Cell for the West Drain

AMD Abatement Plans:
Preliminary Bioreactor Treatment Cell for the North Drain

Acknowledgements

- Nick Grant, Joy Schieferstein and Brian Loges (formerly) of the OSMRE Mid-continent region assisted in the water data collection and biologic assessments.
- Greg Tanner and Jewel Brant if Illinois DNR also assisted in the hydrologic investigation.
- I also would like to thank the landowner, the US Forest Service for access and water quality data used in this data.

The End
Questions?

- Southern Illinois is known as “Little Egypt”

Centennial Building Centralia, IL