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 Mick²

¹. Sr. Hydrologist, Office of Surface Mining Reclamation and Enforcement, Alton, IL 62002;
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
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.
# Acid Base Accounting Data: Palzo AML Site and Saxon Walnut Grove Mine

<table>
<thead>
<tr>
<th>Well ID</th>
<th>Site</th>
<th>MPA (T/1,000 T)</th>
<th>NP (T/1,000T)</th>
<th>NNP (T/1,000T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-29</td>
<td>Eagle R. No. 1</td>
<td>21.78</td>
<td>38.31</td>
<td>16.54</td>
</tr>
<tr>
<td>INDECO</td>
<td>Palzo AML</td>
<td>32.98</td>
<td>0.97</td>
<td>-32.01</td>
</tr>
</tbody>
</table>
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

- Young Coal Corp.: 2-seam surface mining 1962-1965 – 1,578,156 S. Tons.
Overview of the Saxon AML Site
AMD Occurrences in the Phase IIA, IIIC & IIID
AMD Occurrences in the Phase III A & IIIB
Reconnaissance Water Quality Data for AMD Discharges at the Saxon-Walnut Grove AML Site

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

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

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

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 a 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-SMCR Area-type Surface Mining at the Will Scarlet Mine.

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

1968 to 1987: Large dragline operated by the Peabody Coal 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.
- **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
Compiled water samples Dec09

pH
- 0.54 - 4.0
- 4.0 - 6.0
- 6.0 - 8.0
Will Scarlet Pit 1 and Gob Area AMD Sites

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

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

<table>
<thead>
<tr>
<th>Site</th>
<th>ID</th>
<th>Al</th>
<th>Fe</th>
<th>Mn</th>
<th>Sulfate</th>
<th>Acidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit 4 Seep 1</td>
<td>3/25/09</td>
<td>241.7</td>
<td>183.1</td>
<td>36.96</td>
<td>--</td>
<td>1,977.6</td>
</tr>
<tr>
<td></td>
<td>MS-31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Test-June 6, 2007**

- Acidity-3,283 mg/L
- Fe-277 mg/L
- pH-2.29

**Seep #1 Data, : 1990**

- Flow 100 gpm, pH 3.42
- Cond: 4.31; Acidity, 3,764
- Fe, (Tot): 753; Sulfates: 5,240

Photo by R. Kiser, OMM (retired)
## Pit 4 Discharge Channel

<table>
<thead>
<tr>
<th>Site</th>
<th>ID</th>
<th>Al</th>
<th>Fe</th>
<th>Mn</th>
<th>Sulfate</th>
<th>Acidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Red Sea” Feeder Ditch</td>
<td>5/15/07</td>
<td>220</td>
<td>252</td>
<td>46.51</td>
<td>2,731.8</td>
<td>2,126.0</td>
</tr>
</tbody>
</table>

Test-May 15, 2007
Acidity-2,325 mg/L
Fe-252 mg/L
Al-220 mg/L
Sulfate- 2,731

Photo by R. Kiser, OMM (retired)
Will Scarlet Pit 4 2011 before Cement Kiln Dust (CKD) Backfill
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 AMD: Groundwater Quality

Data from Behum, et. al., 2014

<table>
<thead>
<tr>
<th>Site (formation)</th>
<th>WT (ft.)</th>
<th>pH</th>
<th>D. Fe</th>
<th>D. Fe$^{2+}$</th>
<th>D. Al</th>
<th>D. Mn</th>
<th>SO$_4^{2-}$</th>
<th>Cl$^-$</th>
<th>Lab Acidity</th>
<th>Alkalinity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW-10 (DeKoven spoil)</td>
<td>516.5</td>
<td>3.73</td>
<td>83.5</td>
<td>50.0</td>
<td>134.0</td>
<td>29.74</td>
<td>2,141</td>
<td>3.9</td>
<td>640</td>
<td>0.0</td>
</tr>
<tr>
<td>MW-11 (DeKoven/Davis interburden)</td>
<td>442.5</td>
<td>2.58</td>
<td>763.0</td>
<td>357.5</td>
<td>288.1</td>
<td>30.68</td>
<td>4,100</td>
<td>15.3</td>
<td>2,979</td>
<td>0.0</td>
</tr>
<tr>
<td>MW-12 (Shale below Davis Coal)</td>
<td>485.6</td>
<td>5.35</td>
<td>385.5</td>
<td>47.2</td>
<td>126.4</td>
<td>6.02</td>
<td>2,924</td>
<td>13.8</td>
<td>443</td>
<td>105.2</td>
</tr>
<tr>
<td>MW-13 (multi-seam spoil)</td>
<td>485.0</td>
<td>3.75</td>
<td>482.7</td>
<td>241.5</td>
<td>71.3</td>
<td>12.65</td>
<td>2,037</td>
<td>32.8</td>
<td>1,674</td>
<td>0.0</td>
</tr>
<tr>
<td>MW-1 (multi-seam spoil)</td>
<td>431.5</td>
<td>3.53</td>
<td>151.0</td>
<td>127.3</td>
<td>114.6</td>
<td>29.59</td>
<td>2,257</td>
<td>4.3</td>
<td>705</td>
<td>0.0</td>
</tr>
<tr>
<td>MW-14 (Shale below Davis Coal)</td>
<td>427.4</td>
<td>5.59</td>
<td>256.0</td>
<td>113.0</td>
<td>24.5</td>
<td>21.78</td>
<td>3,026</td>
<td>11.0</td>
<td>29</td>
<td>110.0</td>
</tr>
<tr>
<td>MW-19 (Up-gradient bedrock)</td>
<td>nm</td>
<td>7.00</td>
<td>2.00</td>
<td>0.06</td>
<td>0.7</td>
<td>4.61</td>
<td>1,759</td>
<td>64.7</td>
<td>0.0</td>
<td>633.6</td>
</tr>
</tbody>
</table>

Secondary Stds.

IL Stds (Class I)
6.5 - 9.0
5.0
NS
NS
0.15
400
NS
NS

IL Stds (Class II)
6.5 - 9.0
5.0
NS
NS
10.0
400
NS
NS
## Palzo AMD: Comparison of Surface and Groundwater Site Flow (GPM) pH D. Fe D. Al D. Mn D. Ni D. Zn SO₄ Calc. Acidity Alkalinity

<table>
<thead>
<tr>
<th>Site</th>
<th>Flow (GPM)</th>
<th>pH</th>
<th>D. Fe</th>
<th>D. Al</th>
<th>D. Mn</th>
<th>D. Ni</th>
<th>D. Zn</th>
<th>SO₄</th>
<th>Calc. Acidity</th>
<th>Alkalinity</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Drain @ Weir</td>
<td>81.2</td>
<td>2.72</td>
<td>99.6</td>
<td>119.7</td>
<td>23.4</td>
<td>0.98</td>
<td>2.27</td>
<td>2,352</td>
<td>1,017</td>
<td>0</td>
</tr>
<tr>
<td>Well MW-8 (spoil)**</td>
<td>--</td>
<td>2.77</td>
<td>308.0</td>
<td>259.4</td>
<td>42.0</td>
<td>2.16</td>
<td>3.92</td>
<td>2,187</td>
<td>2,341</td>
<td>0</td>
</tr>
<tr>
<td>W. Drain @ Weir</td>
<td>34.2</td>
<td>2.72</td>
<td>162.7</td>
<td>168.4</td>
<td>12.3</td>
<td>1.19</td>
<td>2.95</td>
<td>2,335</td>
<td>1,354</td>
<td>0</td>
</tr>
<tr>
<td>West Seep</td>
<td>4.0</td>
<td>2.80</td>
<td>260.2</td>
<td>183.6</td>
<td>14.4</td>
<td>1.52</td>
<td>3.46</td>
<td>2,430</td>
<td>1,735</td>
<td>0</td>
</tr>
<tr>
<td>Well MW-2 (spoil)***</td>
<td>--</td>
<td>3.04</td>
<td>296.6</td>
<td>126.4</td>
<td>43.7</td>
<td>1.53</td>
<td>2.92</td>
<td>1,904</td>
<td>1,311</td>
<td>0</td>
</tr>
<tr>
<td>Well MW-3 (spoil)***</td>
<td>--</td>
<td>3.10</td>
<td>186.6</td>
<td>140.3</td>
<td>31.0</td>
<td>1.36</td>
<td>2.79</td>
<td>2,340</td>
<td>1,387</td>
<td>0</td>
</tr>
<tr>
<td>Upstream</td>
<td>--</td>
<td>6.78</td>
<td>3.74</td>
<td>0.20</td>
<td>0.87</td>
<td>0.01</td>
<td>0.06</td>
<td>96.4</td>
<td>12.5</td>
<td>55.6</td>
</tr>
<tr>
<td>Downstream</td>
<td>--</td>
<td>3.57</td>
<td>48.2</td>
<td>23.7</td>
<td>7.89</td>
<td>0.34</td>
<td>0.80</td>
<td>405.0</td>
<td>257.8</td>
<td>0</td>
</tr>
</tbody>
</table>
Contaminant Loading Estimate

### Loading to Sugar Creek (Grams/day)

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

### Site Ni Zn Co Cu Cd Cr

<table>
<thead>
<tr>
<th>Site</th>
<th>Ni</th>
<th>Zn</th>
<th>Co</th>
<th>Cu</th>
<th>Cd</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Drain</td>
<td>438.5</td>
<td>1,015.7</td>
<td>134.2</td>
<td>44.7</td>
<td>35.8</td>
<td>13.4</td>
</tr>
<tr>
<td>West Drain</td>
<td>221.7</td>
<td>549.6</td>
<td>59.6</td>
<td>29.8</td>
<td>14.9</td>
<td>9.3</td>
</tr>
<tr>
<td>Stream Seeps</td>
<td>15.8</td>
<td>31.1</td>
<td>4.5</td>
<td>1.1</td>
<td>1.2</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Investigations of Acidic Discharges from the Historic Mining of the Davis and Dekoven Coal Beds in Southern Illinois

The End – Questions?