CREATIVE APPROACHES TO OLD RECLAMATION CHALLENGES
Bentonite strip mining requires the disturbance of large acreages of native land, ...
...all of which requires bonding. This bond is not released until revegetation performance is equal to, or greater than, native conditions.
The Big Horn Basin can be an unforgiving landscape (sodic soils with an average precipitation of 5”, and all with lots of invasive weeds).
What we’ve learned:
   #1: A minimum of 2’ of suitable cover over unsuitable overburden is essential
#2: Experiment to identify the best vegetation species for the conditions
#3: Monitor, monitor, monitor... Use your data to develop new directions.
PART 1

INVASIVE WEED MANAGEMENT
Invasive weeds are transforming the landscape

- Note cheatgrass seed source on BLM lands upwind of our reclamation projects
Weeds can produce incredible volumes of seed
It’s not just cheatgrass:

- Annual Wheatgrass, Koshia, Halogeton, Russian Thistle, etc, etc, etc.
Ground spraying cheatgrass with Plateau (pre-emergent treatment)
Aerial spraying cheatgrass with Plateau
Chemical treatment does work, but it’s costly and is not a permanent solution

Note line of T-posts (treatment in front, not behind, the posts)
**Alternative solutions:** Is “live” topsoiling all it’s cracked-up to be??

- Note strip of live topsoil within an area topsoiled from a stockpile)
The competitive advantage: Note absence of cheatgrass in this sage plot
Assisted succession with aggressive perennials:
- Crested wheatgrass vs. cheatgrass
Greasewood vs. cheatgrass (maybe GW’s not the demon it was once thought to be?)
PART 2

OVERBURDEN EVALUATION AND MANAGEMENT
Some sites offer great reclamation materials (chiefly sand/sandstone)

BEAVER BED MATERIAL PROFILE
(Johnson, Beaver Rim, Barnett)

Topsoil (vegetation and upper root zone)

Suitable (sandy, brown, sometimes white, some clay)

NOT Suitable Overburden (gray, clayey)

Ash (poor quality bentonite)

Bentonite

Floor (hard rock)
And some don’t:
- Flat Bed material profile (poor reclamation materials, chiefly shale)
The ideal situation: Again, a 2’ cap, to include both suitable sub-material and topsoil, over unsuitable overburden is essential
When the “ideal” is not possible: (Example Mining Flat Bed at Bear Creek)

• Note AML (Abandoned Mine Lands) lands in the foreground, and mixed vegetated and barren lands in the background
EXAMPLE: BEAR CREEK MINE

In this example, past vegetation mapping did not necessarily reflect current restoration objectives.
This area was re-mapped to:

- Better reflect current objectives,

- Better meet conditions required for revegetation success,

- Create procedures that would be more easily understood by equipment operators

(re-mapping 2012)
Soil samples were collected from each vegetation map unit, with the chemistry analyzed for soil suitability

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Date</th>
<th>Vegetation Type/Other</th>
<th>Depth (in.)</th>
<th>pH</th>
<th>Saturation</th>
<th>Electrical Conductivity dS/m</th>
<th>Calcium meq/L</th>
<th>Magnesium meq/L</th>
<th>Sodium meq/L</th>
<th>SAR</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
<th>Texture</th>
<th>Total Sulfur %</th>
<th>T.S. AB 1/10000</th>
<th>Neutral Potential 1/10000</th>
<th>Pyr+Org Sulfur %</th>
<th>Pyr+Organic AB %</th>
<th>Pyr+Org ABP 1/10000</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS.1</td>
<td>3/16/12</td>
<td>Salt Desert Shrub</td>
<td>0-12</td>
<td>8.4</td>
<td>58.4</td>
<td>6.51</td>
<td>17.6</td>
<td>3.63</td>
<td>103</td>
<td>31.7</td>
<td>43.8</td>
<td>26.0</td>
<td>31.0</td>
<td>Clay Loam</td>
<td>1.06</td>
<td>33.7</td>
<td>-24.3</td>
<td>0.51</td>
<td>15.8</td>
<td>-8.37</td>
</tr>
<tr>
<td>TS.2</td>
<td>3/29/12</td>
<td>Salt Desert Shrub</td>
<td>0-6</td>
<td>8.2</td>
<td>64.1</td>
<td>6.95</td>
<td>21.2</td>
<td>3.39</td>
<td>97.2</td>
<td>24.9</td>
<td>22.0</td>
<td>26.0</td>
<td>32.0</td>
<td>Clay</td>
<td>0.05</td>
<td>28.9</td>
<td>30.2</td>
<td>1.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SU.1</td>
<td>3/16/12</td>
<td>Sub-material beneath SDS alluvial soils</td>
<td>12-26</td>
<td>8.0</td>
<td>55.7</td>
<td>6.79</td>
<td>17.5</td>
<td>8.23</td>
<td>92.3</td>
<td>25.7</td>
<td>57.8</td>
<td>21.0</td>
<td>22.0</td>
<td>Sandy Clay Loam</td>
<td>0.28</td>
<td>8.89</td>
<td>14.5</td>
<td>5.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SU.2</td>
<td>3/29/12</td>
<td>Sub-material beneath SDS alluvial soils</td>
<td>12-24</td>
<td>8.0</td>
<td>48.0</td>
<td>3.29</td>
<td>25.1</td>
<td>8.65</td>
<td>19.4</td>
<td>4.72</td>
<td>54.0</td>
<td>14.0</td>
<td>32.0</td>
<td>Sandy Clay Loam</td>
<td>0.12</td>
<td>3.81</td>
<td>8.17</td>
<td>4.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SU.3</td>
<td>3/10/08</td>
<td>gravelly sub-material beneath SDS</td>
<td>comp</td>
<td>7.6</td>
<td>42.9</td>
<td>6.72</td>
<td>17.8</td>
<td>6.56</td>
<td>67.2</td>
<td>17.8</td>
<td>47.5</td>
<td>27.5</td>
<td>25.0</td>
<td>Gravelly Loam</td>
<td>0.17</td>
<td>5.40</td>
<td>104</td>
<td>98.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SU.4</td>
<td>3/16/12</td>
<td>annual forbs barren</td>
<td>0-12</td>
<td>6.7</td>
<td>75.6</td>
<td>11.0</td>
<td>16.3</td>
<td>9.44</td>
<td>180</td>
<td>29.7</td>
<td>20.0</td>
<td>38.0</td>
<td>42.0</td>
<td>Clay</td>
<td>0.60</td>
<td>16.8</td>
<td>6.37</td>
<td>-12.4</td>
<td>0.03</td>
<td>1.06</td>
</tr>
<tr>
<td>TS.3</td>
<td>3/29/12</td>
<td>annual forbs barren</td>
<td>0-6</td>
<td>5.0</td>
<td>69.9</td>
<td>11.5</td>
<td>16.0</td>
<td>115</td>
<td>191</td>
<td>22.9</td>
<td>3.0</td>
<td>46.0</td>
<td>54.0</td>
<td>Silty Clay</td>
<td>0.58</td>
<td>18.1</td>
<td>7.87</td>
<td>-10.3</td>
<td>0.09</td>
<td>2.84</td>
</tr>
<tr>
<td>SU.5</td>
<td>3/17/12</td>
<td>Sub-material beneath AFS soils</td>
<td>12-18</td>
<td>5.1</td>
<td>59.8</td>
<td>21.0</td>
<td>21.5</td>
<td>231</td>
<td>202</td>
<td>10.3</td>
<td>28.0</td>
<td>44.0</td>
<td>28.0</td>
<td>Clay Loam</td>
<td>0.65</td>
<td>26.7</td>
<td>5.88</td>
<td>-20.8</td>
<td>-0.04</td>
<td>1.31</td>
</tr>
<tr>
<td>SU.6</td>
<td>3/29/12</td>
<td>Sub-material beneath AFS soils</td>
<td>12-24</td>
<td>4.3</td>
<td>62.3</td>
<td>16.8</td>
<td>18.3</td>
<td>94.2</td>
<td>201</td>
<td>13.4</td>
<td>4.0</td>
<td>53.0</td>
<td>43.0</td>
<td>Silty Clay</td>
<td>0.43</td>
<td>13.4</td>
<td>12.1</td>
<td>-1.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS.5</td>
<td>3/16/12</td>
<td>Barren</td>
<td>0-12</td>
<td>4.6</td>
<td>58.7</td>
<td>10.5</td>
<td>17.3</td>
<td>39.7</td>
<td>272</td>
<td>29.9</td>
<td>19.0</td>
<td>47.0</td>
<td>34.0</td>
<td>Silty Clay Loam</td>
<td>0.50</td>
<td>15.7</td>
<td>0.73</td>
<td>-15.0</td>
<td>0.12</td>
<td>3.87</td>
</tr>
<tr>
<td>TS.6</td>
<td>3/29/12</td>
<td>Barren</td>
<td>0-6</td>
<td>4.6</td>
<td>60.9</td>
<td>10.1</td>
<td>15.5</td>
<td>188</td>
<td>201</td>
<td>26.3</td>
<td>7.0</td>
<td>41.0</td>
<td>52.0</td>
<td>Silty Clay</td>
<td>0.71</td>
<td>22.1</td>
<td>10.6</td>
<td>-11.6</td>
<td>0.07</td>
<td>2.33</td>
</tr>
</tbody>
</table>
Based on the chemistry, salvage and replacement instructions were developed in “operator-speak”

**Soil Salvage Priority Order**  
(Refer to Appendix D8 Vegetation: Addendum A Photo Record for an illustration of the vegetation/soils types listed in this section, and Maps D8.1 and D8.2 for location reference)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1)</strong></td>
<td><strong>SDS and BSBB topsoil</strong></td>
</tr>
<tr>
<td></td>
<td>Salvage the top 6&quot;.</td>
</tr>
<tr>
<td></td>
<td>Spread as topsoil to a depth of 6&quot; on suitable capping material (if no suitable capping material is available, then spread on clean overburden).</td>
</tr>
<tr>
<td><strong>2)</strong></td>
<td><strong>SDS and BSBB alluvial sub-material</strong> (gravel, sand, and silt)</td>
</tr>
<tr>
<td></td>
<td>Salvage all available alluvial materials from beneath SDS topsoil.</td>
</tr>
<tr>
<td></td>
<td>Spread as suitable capping material (minimum of 1' depth).</td>
</tr>
<tr>
<td></td>
<td>Where there are insufficient volumes of SDS topsoil, spread this material as topsoil (minimum 6&quot; depth on clean overburden).</td>
</tr>
<tr>
<td><strong>3)</strong></td>
<td><strong>AML vegetated topsoil</strong> (SDS, AFB, or Greasewood/Barren)</td>
</tr>
<tr>
<td></td>
<td>Salvage 4&quot; of only those surface materials that are vegetated.</td>
</tr>
<tr>
<td></td>
<td>Spread as topsoil to a depth of 6&quot; on suitable capping material (if no suitable capping material is available, then spread on clean overburden).</td>
</tr>
<tr>
<td><strong>4)</strong></td>
<td><strong>Native AFB topsoil</strong></td>
</tr>
<tr>
<td></td>
<td>Use as top dressing to blend reclaimed lands with the adjacent native.</td>
</tr>
<tr>
<td></td>
<td>Spread only on lands intended to be postmine barren.</td>
</tr>
<tr>
<td><strong>5)</strong></td>
<td><strong>Native Barren top material</strong></td>
</tr>
<tr>
<td></td>
<td>Use as top dressing to blend reclaimed lands with the adjacent native.</td>
</tr>
<tr>
<td></td>
<td>Spread only on lands intended to be postmine barren.</td>
</tr>
<tr>
<td><strong>6)</strong></td>
<td><strong>Bedrock</strong> (non-soils)/Clean Overburden</td>
</tr>
<tr>
<td></td>
<td>These are any non-soil materials that do not contain bentonitic materials.</td>
</tr>
<tr>
<td></td>
<td>Use only as cover material to bury bentonitic spoil.</td>
</tr>
<tr>
<td></td>
<td>Not to be used as surface dressing.</td>
</tr>
<tr>
<td><strong>7)</strong></td>
<td><strong>Bentonitic spoil</strong> (low grade bentonite or bentonitic ash/waste)</td>
</tr>
<tr>
<td></td>
<td>This material will be buried at the bottom of the backfill profile.</td>
</tr>
</tbody>
</table>
What the BEAR CREEK MINE re-mapping showed us:

- The surface and subsurface materials were a mosaic of suitable and unsuitable reclamation materials

Photo 2012
A pattern became evident where some topsoils and subsoils, based on vegetation type, were found to be chemically suitable for topsoil replacement.
...and others were found to NOT be suitable for topsoil or subsoil replacement.
…and pockets of sub-surface alluvial material were located and found to be more suitable than many of the topsoils.
Example: Successful reclamation using suitable sub-material as soil
This is a 5-year old reclamation project at Bear Creek that was covered and topsoiled with sub-surface alluvial sands and gravels
When there’s not enough soil: Take what you have, and “splash” it on clean backfill to create a mosaic of growing medium – make sure that, where it is spread, the soil is at least 6” in depth and use your best “bomb-proof” seed mix)
PART 3

MITIGATING FAILED SITES
The Problem: The lands targeted for M-I’s 2012 interventions were mined and reclaimed at a time when the variables of cover depth and suitability were not fully understood.
PART 1: 2012 Mitigation of failed reclamation sites (total 143.1 acres)

Identified portions of the North Hinckley, Gary Good, East Tanner, and Coyote mines were re-mined, in 2012, for the purpose of:

- recovering remnant bentonite to offset mitigation costs;
- recovering additional suitable reclamation cover materials.

In addition, other topsoil resources were identified outside of the area, and were long-hauled to these mitigation projects.
A mine pit was opened in an adjacent area for the purpose of providing additional suitable materials to the mitigation projects.
Seed mixes were customized for successful vegetation establishment specific to the soils types.
And, if necessary, we will consider using soil amendments... (no, we don’t use antelope to fertilize)
Where soil quality was in question, surface mulch was applied to the soil surface.
Results from an earlier pilot project, on the Gary Good Mine, where successful techniques were transferred to M-I’s 2012 mitigation projects.
Results from another pilot project, on the adjacent Smith Mine, where successful techniques were transferred to M-I’s 2012 mitigation projects.
Wahoo!!
PART 4

PARTNERING WITH COUNTY, STATE AND FEDERAL AGENCIES
Partnering not only can result in additional resources, ....
...but more importantly it can also:
- Encourage your company’s “buy-in” on a project
- Lead to more-flexible working relationships with regulatory entities
Examples:
Cooperative cheatgrass treatments with the BLM
  • Cost share on chemical (2004) – 44 acres affected
  • Treatment of upwind seed source (2012) – 411 acres affected
Sage brush research projects – a cooperative effort with Michigan Tech University with assistance from the WWNRT (Wyoming Wildlife and Natural Resource Trust Fund)
Sage brush revegetation projects – A cooperative effort supported, in part, by the Big Horn Basin Sage Grouse Lower Working Group
Livestock grazing control fencing supported with resources from the Bureau of Land Management
Habitat restoration project supported by the Wyoming Game and Fish Department
Tamarisk and Russian Olive removal supported by the **Shell Valley CRM** (Coordinated Resource Management)

**CRM:** A consortium consisting of Big Horn Basin Weed & Pest, BLM, NRCS, WWNRT, private landowners

*Project 2008*
Chemical cost share with Big Horn Basin Weed & Pest
PART 5

DEVELOPMENT OF A MINE-WIDE MASTER PERMIT

(revisions 2010, 2012)
M-I, L.L.C.
MASTER PERMIT
PERMIT 278C

Revised:
May, 2010
Rationale behind a Master Mine Permit:

- Consolidates all individual permits into one mine and reclamation plan
- Removes the guess work from procedures and processes
- Makes procedures more easily understood by equipment operators
Serves as a reference manual for non-proprietary aspects of the company

MASTER PERMIT 278 C
TABLE OF CONTENTS

I. Appendix C – Tabulation of Lands
   Addendum A: Operator and Permit Details
   Addendum B: Patented Claims
   Addendum C: Unpatented Claims
   Addendum D: Stock Driveway Claims
   Addendum E: State Minerals Leases and Grazing Lessees
   Addendum F: Private Grazing Allotments
   Addendum G: Haul Road Details
   Addendum H: Permit 278C and Bonded Haul Road Legal Descriptions

II. Mine Plan
   Part I: Generalized Mine Plan
      Addendum A: A-1: Generalized Mine Plan Diagram
      A-2 & 3: Generalized Drainage Stabilization Diagrams
      A-4: Mining Along Ephemeral Drainages
   Part II: Storm Water and Spill Prevention Plan
   Part III: Mine Compliance Checklist

III. Reclamation Plan
      Generalized Reclamation Plan
      Addendum A: Currently Approved Seed Mix and Species Evaluation

IV. Appendix D
   D1: Land Use Summary and Local Socioeconomic Conditions
   D2: Historical Site Summary
   D3: Archaeological and Paleontological Resources Summary
   D4: Climatology
   D5: Geologic Summary
   D6: Hydrology
   D7: Soils
   D8: Vegetation
   D9: Wildlife
   D10: Wetlands
   Addendum A: Local Socioeconomic Conditions

V. Appendices A & B - Land Ownership
   Land Ownership Maps 1-11
Expedites permitting with the WYDEQ and BLM. Used as a reference resource, it eliminates the size of permit applications by reducing repetitive language and discourages the “rehashing” of previously-approved concepts.
CONCLUSION
Success measured by our #1 critics
GOOD reclamation is GOOD business for everyone
What’s outside YOUR box??
REFERENCE DATA
OVERVIEW MAP
M-I SWACO's 2012 INNOVATIVE RECLAMATION PROJECTS

M-I LLC. WYDEQ Permit 278C
Date: January 2013
Scale: 1"=5000', or 1,60,000

LEGEND
- Township/Range Lines
- Section Lines
- M-I Haul Roads
- Mined Lands (M-I)
- Reclamation Mitigation
- Vegetation Re-Mapping
- Co-op Cheatgrass Treatment
- Assisted Succession Trails (M-I)
- Assisted Succession Trails (MTU & WYMTT)

M-I, LLC. - ROAD 26 LANE 33 -
GREYBULL, WY 28426 - (307) 765-9583
<table>
<thead>
<tr>
<th>Project</th>
<th>Total Acres</th>
<th>Legal Description</th>
<th>Project Type</th>
<th>Ownership Acres</th>
<th>Year First Affected</th>
<th>Year Reclaimed</th>
<th>Project Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Tanner</td>
<td>44.9</td>
<td>27,34-54/92</td>
<td>Reclamation mitigation</td>
<td>1.9</td>
<td>1996</td>
<td>8.3 ac 2008</td>
<td>2008, 2012</td>
</tr>
<tr>
<td>Hinckley</td>
<td>28.6</td>
<td>27,34,35-54/92</td>
<td>Reclamation mitigation</td>
<td>3.1</td>
<td>2002</td>
<td></td>
<td>2012</td>
</tr>
<tr>
<td>Asst. Succession (Middle Sinks)</td>
<td>6.4</td>
<td>27,34,35-54/92</td>
<td>Assisted succession techniques to combat cheatgrass</td>
<td>5.6</td>
<td>2011</td>
<td></td>
<td>2012</td>
</tr>
<tr>
<td>Bear Creek Re-Mapping</td>
<td>1248.2</td>
<td>3,4-54/93 - 2,3,11,12,13,53/93 - 17,18,19,20-52/93</td>
<td>Re-mapping of the vegetation and related soils for the purpose of revising reclamation procedures based on suitable materials</td>
<td>789.9, 458.3</td>
<td>Pre-1969</td>
<td>1980-present</td>
<td>2012</td>
</tr>
<tr>
<td>MTU - Assisted Succession</td>
<td>1</td>
<td>1-53/92, 26-51/91</td>
<td>Cheatgrass control with aggressive perennials to be followed by assisted succession to diverse vegetation community</td>
<td>1</td>
<td>2012</td>
<td></td>
<td>2012</td>
</tr>
<tr>
<td><strong>Total Acres</strong></td>
<td><strong>1809.7</strong></td>
<td></td>
<td></td>
<td><strong>1060</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>