SURVEY RESULTS
PRIME FARMLAND INTERACTIVE FORUM
PARTICIPANT COMMENTS AND RECOMMENDATIONS

MOST USEFUL TALKS

SESSION 1 STATE PROGRAMS

PREFERENCE	PRESENTATION	TOTALS
1st	Indiana	15
	Illinois	8
	All State Reviews	4
	Kansas	2
	North Dakota	2
	OSM	2
	Public	1
2nd	Kansas	9
	Illinois	5
	Indiana	4
	Public	4
	North Dakota	2

SESSION 2 RECLAMATION AND SOIL RECONSTRUCTION

1st	Dunker/Reclamation Methods	16
	Hooks/Compaction Measurement	9
	Bearden/Prime Farmland with Overburden	3
	Yingling/Small Mines	2
	Spindler/Reclamation of Ancillary Soils	1
2nd	Bearden/Prime Farmland with Overburden	8
	Hooks/Compaction Measurement	7
	Dunker/Reclamation Methods	6
	Spindler/Reclamation of Ancillary Soils	3
	Yingling/Small Mines	2

SESSION 3 MINE SOIL MANAGEMENT AND STEWARDSHIP

1st	Dunker/Long Term Effects	12
	Smout/CONSOL Restoration Techniques	9
	Phelps/Land Value	6
	Hooks/Soils Based Productivity	4
	Barnhisel/GPS	1
	Wiesbrook/Soil Classification	1

PREFERENCE	PRESENTATION	TOTALS
2nd	Dunker/Long Term Effects	11
	Smout/CONSOL Restoration Techniques	5
	Barnhisel/GPS	5
	Hooks/Soils Based Productivity	3
	Wiesbrook/Soil Classification	3
	Phelps/Land Value	2

SESSION 4 SUBSIDENCE

1st	Darmody/Reclamation of Agricultural Lands	10
	Bauer/Characteristics of Subsidence	9
	Barkley/Regulatory Perspective	5
	Booth/Impacts on Groundwater	2
2nd	Darmody/Reclamation of Agricultural Lands	9
	Bauer/Characteristics of Subsidence	4
	Booth/Impacts on Groundwater	4
	Barkley/Regulatory Perspective	1

TOPICS OR SPEAKERS THAT PARTICIPANTS FELT THAT SHOULD HAVE BEEN INCLUDED AT THE FORUM

- Future methods of reclamation.
- Cost of current methods vs new technology costs.
- Reclamation of non-prime cropland.
- Reclamation in non-glaciated regions.
- Comparison of reclamation processes. New innovative processes.
- Comparison of material handling equipment.
- Reclamation for forest use.
- Crop yield data from different crops at different soil thicknesses.
- Is there any other research on reducing compaction?
- Have a lawyer discuss prime farmland soil capability.
- Panel of landowners/farmers who were currently working with reclaimed prime farmland on their experiences both pro and con.
- Panel of permittees to identify problems with permitting prime farmland.
- No speakers from Indiana universities. Are they not interested in mined land restoration?
- Indiana legislators; Indiana Farm Bureau; David Joest, Peabody Coal Company.
- We need to look to new technology for soil placement that eliminates compaction so we do not need to have costly deep tillage.
- Would have liked to hear the presentation from Tom FitzGerald. Hope his paper will be in the publication.
- Indiana seems to have some proponents that believe that 48 inches of prime farmland soil is not necessary. These people should be invited to present their evidence or data that supports this position.

ADDITIONAL RESEARCH NEEDS

SOILS BASED PRODUCTIVITY

- Soil based productivity methods for bond release.
- Develop crop yield predictive models.
- Relationship between soil properties (physical, chemical, biological) and productivity that would allow for bond release on this basis.
- Develop a system of bond release utilizing both soil properties and crop production.

PRECISION AGRICULTURAL MANAGEMENT

- Incorporating precision agriculture into the evaluation of reclamation techniques.
- GPS/GIS provides a new management system for mining operators and land owners to assess the success or short comings of reclamation.

COMPACTION

- Zero traffic soil reconstruction.
- New technology for root media and topsoil replacement that reduces compaction and is cost effective.
- Need more research on how to avoid compaction rather than compaction amelioration.
- More on amelioration of compaction in place and ways to prevent or minimize its occurrence.
- Other physical/chemical methods to reduce compaction (i.e., incorporation of recycled by-

products, injection of chemicals).
- C Impact of soil microorganisms on productivity.
- C Use of irrigation systems on these reclaimed lands during years of drought.

ECONOMICS
- C Need to see more research on the values of reclaimed prime farmland in comparison to undisturbed prime farmland.

POST BOND RELEASE YIELD AND MANAGEMENT
- C Crop yield and management following bond release.
- C Test crop varieties for productivity versus local varieties used by area farmers. If the farmers can not afford varieties used by operators, should the SRA limit the crop varieties to those used by farmers?

SOIL CLASSIFICATION OF RECLAIMED SOILS
- C Develop new soil series that could be utilized to adequately classify and remap reclaimed soils.

TOPICS FOR FUTURE INTERACTIVE FORUMS

RECLAMATION
- C Reclamation of non-prime cropland.
- C Reclamation in non-glaciated regions.
- C Reclamation for forest use.
- C Data on land capability of reclaimed areas from 1966-1977.
- C Prime farmland returned to corn or soybean production.
- C Potential for flue gas desulfurization sludge to replace or amend soils to reduce compaction and improve stability.

BOND RELEASE
- C Resolving barriers to bond release.
- C Management of bond released reclaimed areas.
- C Land values before and after reclamation.

SOIL CLASSIFICATION
- C Soil classification and productivity in non-glaciated regions.

HYDROLOGY
- C Water quality and runoff from acid spoil.
- C All aspects of reconstructed ground water in reclaimed areas and its impacts to soils.

WILDLIFE
- C Wildlife habitat reclamation.
    - C Successful tree establishment.
    - C Wetland reconstruction.
    - C Warm season grasses.
    - C Impacts to specific species (i.e., bats, raptors, game mammals, etc.).
- C Impact of compaction to tree growth and methods for amelioration.

PRECISION MANAGEMENT
- C Site specific management using GPS on mine soils.
- C Ways to utilize GPS in mining and reclamation.

SUBSIDENCE
- C Impacts of subsidence to water, land use and value, agriculture, etc.

STATE PROGRAMS

C Caparison of state programs in other topic areas.

OVERALL VALUE OF FORUM

	TOTAL PERCENTAGE
EXCELLENT	53
GOOD	47
FAIR	0
POOR	0

COMMENTS ON VALUE OF FORUM:

- C **Excellent presentations!**
- C **Great information meeting!**
- C **Good content and organization in all sessions!**
- C **OSM Director Kathy Karpan's comments were very good!**
- C **Excellent format! Very informative! Excellent questions from participants!**
- C **Provided very informative information. Encompassed all affiliations to show all sides of reclamation. Displayed the applied technology in current mining operations**.
- C **This was the most useful conference I have been to since getting into the field nearly 4 years ago! I especially liked seeing what other states do and how to eliminate or ameliorate compaction! Very helpful!**
- **C** **This forum has been well worth my time to attend. My knowledge of this information was very low but I believe I am going away with a better working knowledge.**
- C **The forum was perhaps the best for providing me the information I can use immediately in the course of my job duties.**
- **C** **Had excellent speaker and audience participation!**
- **C** **Good speakers who were well prepared!**
- **C** **Enjoyed the forum very much. A good review and overview. Good to see what is happening in other states.**
- **C** **Really good mix of topics.**
- **C** **Although there were differences of opinion, all topics were professionally and factually handled. Moderators kept the flow going smoothly.**

APPENDIX 1: RECORDED DISCUSSIONS

Edited by Kimery C. Vories
USDI Office of Surface Mining

The following are the edited discussions that took place at the end of each speaker presentation and at the end of each session. The actual comments have been edited to translate the verbal discussion into a format that more effectively and efficiently communicates the information exchange into a written format. The organization of the discussion follows the same progression as that which took place at the forum. A topical outline has been developed to aid in accessing the information brought out in the discussions.

OUTLINE OF DISCUSSION TOPICS

Session 1: State Prime Farmland Programs

1. OSM
2. Illinois
   - ***Designation of Grandfathered Prime Farmland***
3. Indiana
   - ***Bond Forfeiture on Prime Farmland***
   - ***Capability to Grow Corn***
   - ***Grandfathering Definition***
   - ***Land Owner Notification***
   - ***Negative Determination on Prime Farmland***
   - ***Restoration of Soil Capability***
4. Kentucky
   - ***Extent of Grandfathering***
   - ***Restoration Standards for High Capability Crop land***
   - ***Soil Replacement Depths***
   - ***Soil Replacement Depth Verification***
5. North Dakota
   - ***Bond Release History***
   - ***Correlation of Soil Survey***
   - ***Proof of Productivity Limiting Factors***
   - ***Restoration Standard for Non-Prime Soils***
   - ***Standard for Non-Prime Soil Thickness***
6. Kansas
7. Public Concerns
   - ***Availability of yield Data when Crops Fail***
   - ***Variability Due to Rainfall***

Interactive Panel Discussion

- ***Adequacy of SMCRA in Prime Farmland Restoration***
- ***Variability in Farmer Expertise***

Session 2: Reclamation and Soil Reconstruction

1. Compaction Measurement Methods
   - ***Grid Density for Penetrometer Studies***
   - ***Use of Soil Strength and GPS Data***
2. Reclamation Methods Comparison
   - ***Best Methods for Reclaiming Prime Farmland***
   - ***Correlation of Soil Strength with yield***
   - ***Regulatory Use of Penetrometer Data***
   - ***Soils Based Productivity Index***
   - ***Use of Soil Measurements for Bond Release***
3. Small Mines and Future Techniques
   - Investigation ***of Crop Failures***
   - ***Land Owner Education about Regulations***

4. Surface Mining-Prime Farmland Soils Using Mixed Overburden
   - ***Applicability in Other Climates***
   - ***Bond Release History***
   - ***Bond Release Standard***
   - ***Land Use Trends***
   - ***Pasture Bond Release Standard***
   - ***Plans for Remining***
   - ***Relative Merits of Overburden to Original Soils***
   - ***Source of Clay Parent Material Related to Weathering***
5. Reclamation of Ancillary Surface Affected Soils
   - ***Comparison to Oil and Gas Regulations***
   - ***Length of Time to Publish Annual Yield Goal***
   - ***Response to New Proposed Regulations***
   - ***Time Frame for Proposed Regulations***

Interactive Panel Discussion
- ***Adequate Soil Depth Replacement for Prime Farmland***
- ***Cost of Deep Tillage***
- ***Positive Dialog for Problem Resolution***
- ***Possibility of Penetrometer Use during Dry Conditions***
- ***Prediction of Soil Compaction***
- ***Rate of Mining***
- ***Rate of Prime Farmland Creation***
- ***Seasonal Constraints to Penetrometer Use***
- ***Use of Hand Penetrometers***

Session 3: Minesoil Management and Stewardship
1. Long Term Effects of Deep Tillage
   - ***Bath Tub Effect of Deep Tillage***
   - ***Compaction Mitigation with Truck/Shovel***
   - ***Depth of Deep Tillage for Truck/Shovel***
   - ***Duration of Tillage Effects***
   - ***Effects of Deep Tillage***
   - ***Post-Deep Tillage Traffic***
2. Soils Based Productivity Evaluation
   - ***Data Gaps***
3. Mine Soil Classification and Mapping
   - ***Classification Concerns About In-Place Development of New A Horizon Material***
   - ***Classification Differences for Glacial and Non-Glacial Soils***
   - ***Productivity Values and Tax Base for New Soils***
4. Global Positioning Systems (GPS) and Site Specific Management
   - ***Calibration of Equipment***
5. Illinois Reclaimed Soil Productivity: Restoration Techniques
   - ***Duration of Settling on Reclaimed Areas***
   - ***Economics of Deep Tillage***
   - ***Row Spacing for Deep Tillage***
6. Land Use and Value after Reclamation
   - ***Incorporating Post-mining Land Values into Reclamation Planning***
   - ***Quantity of Permanent Program Crop Land Sold***
   - ***Speculation on Future Prime Farmland Sales***
   - ***Value of Subsided Agricultural Land***

Interactive Panel Discussion
- ***Acreage of Land that can be Deep Tilled per Year***
- ***Compaction Mitigation with Deep Rooted Plants***
- ***Effects of Excessive Rainfall***

- ***Effects of Prime Farmland Reclamation on Tree Growth***
- ***Land Value Related to Bond Release***
- ***Timing for Deep Tillage***

Session 4: Subsidence

1. Characteristics of Subsidence from Abandoned and Active Underground Coal Mines in the Illinois Coal Basin
   - ***Evidence for Sag Subsidence***
   - ***Evidence of Subsidence***
2. ***Coal*** Mine Subsidence/A Regulatory Perspective
   - ***Biggest Subsidence Mitigation Challenges***
   - ***Coal Production Trends***
   - ***Effects of Energy Policy Act***
   - ***Evidence of Subsidence***
3. Impacts of Mine Subsidence on Ground Water
   - ***Destination of Ground Water***
   - ***Time Frame for Taking Background Water Data***
   - ***Water Treatment Costs***
4. Reclamation of Agricultural Land After Planned Coal Mine Subsidence
   - ***Damage to Houses***
   - ***Differences Between Corn and Soybeans***
   - ***Remapping***
   - ***Tiling of Wet Areas***

Interactive Panel Discussion

- ***Correlation Between Subsidence and Depth of Mining***

DISCUSSION BY SESSION

Session 1: State Prime Farmland Programs

1. The Surface Mining Control and Reclamation Act of 1977 Charles Sandberg, Office of Surface Mining, Alton, Illinois.

No questions recorded.

2. Illinois Program Requirements, Experience, and Results Dean Spindler, Illinois Office of Mines and Minerals, Springfield, Illinois

Question ***(Designation of Grandfathered Pime Farmland):*** What happens to grandfathered prime farmland in Illinois.

Answer: It is all treated as High Capability Land.

3. Indiana Program Requirements. Experience, and Results Steve Wade and Dave Kiehl, Indiana Division of Reclamation, Jasonville, Indiana

Consultant Question ***(Land Owner Notification):*** ***You have*** stated in your talk that prime farmland can be grandfathered prior to going through a permit application process. This would appear to be avoiding the permitting process that would require public participation. In this case, does the regulatory authority actively notify private land owners that their prime farmland acreage has been grandfathered.

Answer: There is no active disclosure until after the permit application is submitted.

Consultant Response ***(Land Owner Notification):*** As a result of this forum, I would like to see the Indiana program provide private land owners with this type of disclosure.

OSM *Question #1* ***(Capability to Grow Corn):*** I am concerned about the operator's capability to grow corn on prime farmland in Indiana. You have said that some operators in Indiana have stopped growing corn on mined lands. What is Indiana doing to restore the capability to grow corn on Indiana prime farmland?

Answer: *If the* operator provides proof of productivity by growing corn or soybeans for a Phase III liability bond release, we have to accept that. There is no continuing effort after bond release.

OSM Question #2 ***(Restoration of Soil Capability):*** Do you think that reclaimed prime farmland capability will be eventually restored after growing hay or pasture for 20 years or so?

Answer: I hope so. I don't know.

Real Estate Question ***(Grandfathering Definition):*** What does the term grandfathering actually mean?

Answer: The company had control of the land prior to the passage of SMCRA and could be exempted from the prime farmland standards of the law. SMCRA would require that prime farmland soils disturbed by mining receive a minimum replacement of 48 inches of soil materials. When prime farmland soils are grandfathered, then these soils are regulated as non-prime farmland soils. In Indiana, non-prime farmland soils would require a replacement of a minimum of 18 inches of soil materials for Crop land and 12 inches for non-Crop land. The productivity would be required to achieve 90 percent of the pre-mining yield rather than the 100 percent required for prime farmland.

State Question ***(Bond Forfeiture on Prime Farmland):*** ***Has*** Indiana ever forfeited bond on a permit containing prime farmland soils? If so, how has the Indiana program handled that situation in the reclamation of the site?

Answer: I am sure there has been this type of situation. Depending upon how the order is written, would determine the standards for reclamation at that site.

State Question (Negative ***Determination on Prime Farmland):*** Concerning negative determination of prime farmlands in Indiana, how are they handled? Is hayland considered Crop land?

Answer: A negative determination would not be allowed if the area was cut for hay.

4. Kentucky Program Requirements, Experience, and Results Gary Welbom, Kentucky Department of Surface Mining, Madisonville, Kentucky.

USDA NRCS Question #I ***(Restoration Standard for High Capability Crop land):*** **What are the** Kentucky standards for reclaiming areas classified as High Capability Crop land?

Answer: These lands would be classified as non-prime farmland crop land which, under Kentucky regulations, would be hayland and pasture and would require the proof of productivity for 2 years with a grass/legume hay mixture with a target yield based on 90 percent of a 3 year average of the previous 3 years of yield.

USDA NRCS Question #2 ***(Soil Replacement Depths):*** How much soil material does Kentucky require to be replaced on these areas?

Answer: The minimum requirement would be 6 inches of soil material.

State Question #I ***(Extent of Grandfathering):*** How much grandfathering of prime farmland has been done in Kentucky?

Answer: I don't have any hard numbers available to answer that question. There were quite a few acres that were grandfathered during the early stages of the Kentucky program. You would be talking in the thousands of acres but I don't know the exact amount. You don't see too much of this now.

State Question #2 ***(Extent of Grandfathering):*** Were most of the lands you now classify as non-prime crop land originally grandfathered prime farmland?

Answer: Kentucky has more acres removed from the prime farmland soil category due to historical use rather than the grandfathering process.

OSM Question ***(Soil Replacement Depth Verification):*** How does Kentucky verify the depth of soil materials replaced on prime farmland?

Answer: There is nothing specific in the Kentucky regulations that requires a specific procedure to be followed in that area. Generally, what we do after a prime farmland area has been restored and prior to a Phase I bond release, we will go out either with the operator or with a crew of State people and spot probe these areas. Many times the operator will provide equipment to assist in conducting this probing in order to insure timely Phase I bond release.

5. North Dakota Program Requirements, Experience, and Results Dean Moos, North Dakota Public Service Commission, Reclamation Division, Bismark, North Dakota

Industry Question **(Correlation** ***of Soil Survey):*** Was the 2^{nd} round of soils surveys (at a 1:4800 scale) you mentioned done by or correlated by the USDA NRCS?

Answer: No. It was done by consultants hired by the mining company and it was not correlated by the NRCS.

State Question *#I* ***(Standard for Non-Prime Soil Thickness):*** What is the total soil thickness standard for your non-prime soils?

Answer: From 2 to 4 feet of replacement depth depending upon the spoil quality. With a low SAR (sodium adsorption ratio) and low EC (electrical conductivity) it would be a 2 foot requirement. With a high SAR and high EC it would be a 4 foot replacement requirement. There are gradations in between these two values.

State Question #2 (Bond Release History: What has been your relative success on bond releases?

Answer: ***North*** Dakota has not received any applications for prime farmland bond releases to date. On non-prime farmland releases, we have not had a problem attaining proof of productivity.

State Question #3 (Proof of Productivity Limiting Factors): ***Have you*** been able to determine any limiting factors related to proof of productivity? In the Midwest we have noted problems with productivity on reclaimed soils during dry years.

Answer: I think that compaction is the one issue where we may experience problems. We have no problem meeting productivity on normal to above normal precipitation years but may have problems during below normal precipitation years. The reclaimed soils do not perform as well during dry years.

State Question #4 (Restoration Standardfor Non-Prime Soils): Your chart states that production on prime and prime farmland must be restored to 100 percent of pre-mining levels. Our program requires non-prime farmland to be restored to 90 percent of the pre-mining level. Why do you do that?

Answer: The North Dakota law requires 100 percent of productivity for all of our reclaimed lands, even native grassland.

6. Kansas Program Requirements, Experience, and Results Marlene Spence, Kansas Department of Health and Environment, Surface Mining Section, Pittburg, Kansas.

No questions.

7. Public Concerns about Technical Aspects of State and Federal Prime Farmland Programs Dr. Richard Stout, Knox College, Galesburg, Illinois.

State Question #I (variability due to Rainfall): ***Have you*** considered rainfall variability in your data analysis?

Answer: I tried but I determined that I would need rainfall data for each field for each year of testing.This was too much to incorporate into the analysis, so instead I tried to use some data provided by Dr. Keply at the Illinois Department of Agriculture and he sent me some data on ideal years, average years, and drought years.The problem with this is that State-wide precipitation data would not be representative of the actual precipitation conditions of the fields being tested. I tried using this data but it did not work. The end result was that I was not able to account for precipitation in the study.

State Question #2 (Availability of Yield Data when Crops Fail): Did you have data for a crop field that was planted but did not make its yield goal? When we have looked at this in Indiana, if a field does not make yield in a particular year we don't know about it because the data is not submitted. Is tbis type of data available in Illinois?

Answer: In this data set, I did not try to account for those cases. I do know that in past years a paper record has been kept but I have not been able to locate any electronic record.

Interactive Discussion with all Speakers for Session 1

Consultant Observation (Variability in Farmer Expertise): Dr. Stout, I have been involved in prime farmland reclamation for about 18 years, growing crops on both prime and non-prime farmland soils, and I have seen intense study of prime farmland soils up to the time the soils are replaced and then I don't see too much. One of the things I have observed is that there is a big difference in the expertise of the farmers growing crops on these lands. I have

one farmer that only gets one or two successful crops over a period of 5 years while another farmer on a similar property obtains good yields every year. It all appears to be in the expertise of the individual farmer. They may actually use similar techniques but one farmer is better at using those techniques than the other. One farmer that grows corn on reclaimed land puts different varieties of corn in different hoppers of his planter in order to compensate for seasonal moisture stress. Purdue University has tried to quantify some of these things through a bulletin they put out called ID 152 and it tries to quantify these differences in farming practices. This is an aspect that needs to be brought into any evaluation of restoration effectiveness on reclaimed crop lands.

Another observation for OSM would be that in Pike County, Indiana, where the population is 12,000 we have experienced a net loss of prime farmland acres due to surface coal mining. That should be considered as an off-site impact in its oversight process. The resulting social/economic impact in loss of agricultural activity should have been prevented by SMCRA. It is hard to get an industrial business to come into the area because there is no infrastructure.

OSM Question ***(Variability in Farmer Expertise):*** Could we have the different states address their experience with the variability of expertise of people farming reclaimed crop land areas?

North Dakota Response: In North Dakota, we have the mining companies contract with farmers to come back on the land and farm that parcel of land. It has been our experience that the mining companies oversee this operation fairly closely. The end result is that those farmers that are good managers obtain bond release and those that aren't don't.

Indiana ***Response:*** In general, most of the coal operators have professional farmers tbat have the expertise to manage these lands well. Naturally some are better than others. For the most part, a very conscientious effort is being made to do everything possible to achieve successful bond release. Although we have good data on years where we achieved successful yields, we have no data on why certain crop years failed.

Illinois *Response:* Early in our program, a number of the operators attempted to have their own farm management programs. After several years, most of them decided they were better miners than farmers. They then shifted over to using tenant farmers. In two of our counties, I meet almost monthly with land owners where the land is leased by private land owners. These land owners continually complain that our standards for bond release are too high. Even though the reclaimed lands are out producing what these farmers had been able to produce before mining they are not achieving success. I don't tell them, but I feel that in many cases the farmers were not doing a very good job farming prior to the mining disturbance. There is a wide variety of pre- and post-mining management of these lands.

Kentucky Response: Most of the large operators do their own farming. The smaller operators seem to be better off using the land owner or hiring a contractor to do the work.

Kansas Response: In the case where the farmer is also the land owner, we see a high level of stewardship because they are interested in getting the land back and being able to use it. They are also able to get the coal company to provide funds for required fertilizer and other amendments. If the land owner hires a tenant farmer, then we do not see the same level of stewardship. The tenant farmer usually has his own land and takes care of it first and the coal companies land second.

The economics of mining coal in the Midwest is such that the coal companies have financial problems such that the reclamation and restoration of soil productivity suffers. Some of the operators are lucky to get their soils replaced let alone be able to afford to do the revegetation studies necessary to prove productivity success. If they have a vegetative ground cover established and are not receiving violations, then we see their level of effort to prove productivity fall off.

State Question ***(Adequacy of SMCRA in Prime Farmland Restoration):*** We have had SMCRA for 20 years now and we have had mining on prime farmland for at least that long. I would like to ask the panel if they believe that SMCRA has provided adequately for the restoration of prime farmland following mining? If there does need to be a change to SMCRA, what change would you recommend?

Kansas Response: *If* SMCRA is implemented correctly, I don't believe any changes need to be made. I was very interested in the survey utilized by Indiana and would be very interested in conducting a similar landowner survey in Kansas and find out what Kansas farmers feel about the productivity of these reclaimed lands.

Kentucky Response: Although I don't think I would make any changes, I would like to see more small land owner participation in the process so that they could better understand how the reclamation and restoration process works.

OSM Response: I do think that SMCRA is working, but I also think that we have learned a lot over the last 20 years. Based on the presentations this morning and talks to be given later by researchers in the field, we have seen that better reclamation methods and equipment have been developed. I am also now more hopeful than I was 10 years ago that progress is being made toward a soils based method for determining proof of productivity.

Dr. Stout Response: Compared to the bad old days, there has certainly been a lot of progress and SMCRA has helped a lot. Based on what I heard this morning, I think that Illinois has a pretty good program. I would still like to see the target yield for prime farmlands higher than they are. I think that passing productivity for 3 years out of 10 years is insufficient to satisfy me that the prime farmland has been reclaimed. The only way these types of changes occur are for concerned citizens to be informed and have access to scientific data to determine what levels of policy can be used to bring prime farmland back up to pre-mining levels of productivity.

Illinois Response: Overall, SMCRA has had a very positive influence on reclamation in our State. For the most part, the current laws adequately address the issues. I would like to see more progress toward soil modeling rather than actually raising crops. I think that all of the necessary authority to conduct successful reclamation is already in SMCRA. One area that is overlooked is the exempted prime farmland (either through grandfathering or negative determination) where there is a great deal of difference from state to state on how these lands are being reclaimed.

Indiana Response: I would agree that, if implemented correctly, SMCRA provides adequate reclamation of these lands. I would think that we have improved a lot over the last 20 years. Going to the replacement of soil materials with the truck/shovel method rather than scrapers has really helped. I would agree with Illinois that it would be nice to have a rule that treated exempted prime farmland as high capability crop lands. This would better address the restoration of soil capability for these lands.

North Dakota Response: I would agree with the other states that SMCRA adequately provides for the restoration of prime farmland. With regard to the special handling of prime farmland, we feel that the requirement to replace all of the original soil materials in sequence is overkill based on our successful experience of mixing prime and non-prime soil materials.

Session *2:* **Reclamation and Soil Reconstruction**

1. Compaction Measurement Methods Charles Hooks, Southern Illinois University/University of Illinois Reclamation Research Station, Percy, Illinois.

Academic Question ***(Use of Soil Strength and GPS Data):*** Who has been actually using soil strength measurements to better apply deep tillage or land use changes? Is anyone actually using GPS grid mapping to determine fertility levels?

West/Central Illinois Consultant Answer: We design constant rate cone penetrometers and have been using them in our business both in the mining industry and in the farming sector to detect compaction. We have been trying to predict the location of compacted areas to guide deep ripping efforts. We use GPS methodologies to map our findings in these efforts. We obtain the location coordinates every time we take a penetrometer reading.

Consultant Question ***(Grid Density for Penetrometer Studies):*** What intensity of a grid should we use to obtain accurate penetrometer readings for compaction?

Academic Answer: The actual grid spacing depends upon the variability of compaction levels in the soils being tested. In research applications, you may use a grid spacing as close as one acre. Most research applications, however use a ***five*** acre grid. You may have to use closer grid spacings on natural soils than you would use on a reclaimed mine soil because of the greater variability of compaction levels in natural soils. We would use a statistical analysis of variability in order to be assured that we have reduced the variability to an acceptable level.

2. Reclamation Methods Comparison Robert Dunker, University of Illinois, Urbana/Champaign, Illinois.

Academic Question ***(Best Methods for Reclaiming Prime Farmland):*** Assuming that money was not limiting, what would you do to reclaim prime farmland in order to meet the required production goals that the land owner would want following reclamation7

Academic Answer: I think the key to success of a good reclamation program is: (1) knowing the quality of soil materials you have to work with; and (2) knowing how you can take advantage of the qualities of those soil materials in order to replace them with a method that will reduce compaction, reduce compaction, and reduce compaction! If you can't reduce compaction sufficiently, then we need to look at alternative methods and we will have to look at deep tillage of the reclaimed soils. Deep tillage is becoming a common practice in the reclamation plans of the State of Illinois; however, quality of soils is still the key ingredient to reclaiming prime farmland soils. It is a site specific process. What may work at one mine will not necessarily work at another simply because they do not use the same techniques. The key in Illinois is to take advantage of the high quality of the soil materials and put them back in a manner that will promote and enhance root penetration and soil productivity.

Regulatory Question ***(Regulatory Use of Penetrometer Data):*** Is the cone penetrometer a practical tool to be used in a regulatory sense? Could it be used by the inspector to determine if prime farmland or high capability crop land had been properly reconstructed?

Academic Answer: The answer to that is that the penetrometer is a tool. As a tool it has to be used properly. Our penetrometer data has been collected under relatively controlled conditions. We take our readings in the spring when soils are uniformly moist. A penetrometer is highly sensitive to soil moisture, texture, and other physical soil variables. There needs to be work done to correlate a calibration curve under different soil moisture and texture conditions. However to compare the penetrometer method with taking bulk density cores, we feel that if the penetrometer data is taken at an optimum time, that we have a pretty good idea of what the reclamation treatment will result in over time. We find that bulk density measurements do not correlate nearly as well as penetrometer readings to actual crop yields. The penetrometer method is a quick, nondestructive methodology that will indicate to the operator the compaction variability in his field and whether or not he is likely to need deep tillage to meet his productivity goals.

My personal opinion is that the penetrometer readings, if done properly, could be used to determine whether or not the field would need deep tillage prior to beginning yield measurement for bond release.

Regulatory Question ***(Use of Soil Measurements for Bond Release):*** Concerning the need to prove productivity by growing crops, how far away is the science of compaction identification where you may not have to grow a crop in order to determine that the soils have been adequately reconstructed? To what extent is this science determined by the compaction issue? Are there any other soil factors involved in making this determination? If so, what would those factors be?

Academic Answer: There are still gaps in the data base that need to be filled in. Some of those gaps for Illinois are that we understand some soils in some parts of the State better than others. We need to increase our knowledge of textural and chemical conditions of soils in some parts of the State. One thing about a diagnostic test that could be ground truthed in the field, through comparison with long-term crop yields, is that "if we could determine that soil texture and chemistry are not limiting, then we would feel fairly comfortable about using soil strengths to make a qualitative assessment of good and bad reclamation." The real sticking point will be finding that part of the curve that says we will accept this level of reclamation but not that one. Currently, we can easily identify the low end and the high end of the soil strength curves. It is in the middle of these curves that we need to refine our methods and do additional research in order to fill in the data gaps, especially textural properties that correlate with medium levels of

soil strength and how these relate to crop yield potential. We are seeing some very close relationships in our yield test plots but they need to be field tested over a field with high variability. It may not be that far in the future, but it will take a few more years assuming that research funds are provided to do the work.

Consultant Comment ***(Correlation of Soil Strength with Yield)****:* I would like to tell the audience what we have been seeing on undisturbed farm ground in comparison to what you are finding on mined lands. We see a very close correlation between soil strength values and actual crop yields that tracks very closely with what you are seeing on disturbed mined lands. On undisturbed crop lands you start seeing a yield reduction at about 175 - 225 pounds/square inch (psi) of pressure. At 300 psi there is significant yield loss with soils that have man made compaction. In upland soils, we are finding vehicle traffic puts compaction in the zone of 14 to 16 inches of depth. In the river bottom soils along the Illinois and Mississippi rivers, we find compaction as deep as 30 inches. We have tracked this back to double incorporation of herbicides utilizing large discs. In some cases, we have seen compaction values even higher than what is found on the mine site.

Academic Comment ***(Soils Based Productivity Index):*** ***The*** issue of the use of the penetrometer to develop a soils based productivity index needs to be developed on a regional basis. What we would develop in Illinois may not be applicable for a comparable mining region in Kentucky because their soils are different in terms of soil development and also have differing soil chemistries. We would need to apply such a predictive model within the range of characteristics that the model was developed under. It is probably not feasible to come up with one model that would fit mining regions in such widely separated regions as Texas, Kentucky, and Illinois.

Academic Comment ***(Soils Based Productivity Index):*** Based on our experience at the University of Kentucky, we found in our efforts to develop a soils based productivity model that we had more variation in mining methods than in any thing else. We could develop a model that would work for a specific set of reclamation methods and equipment (i.e., scraper pans, truck/shovel, etc.). The model would not work when you tried to use it for a different set of reclamation methods and equipment. I think that with current reclamation methods being dominated by truck replacement in much of the Midwest, then the models that could be developed may be more likely to work across state lines.

3. Small Mines and Future Techniques Mark Yingling, Black Beauty Coal Co., Evansville, Indiana

State Question ***(Land Owner Education about Regulations):*** Could you describe the efforts that the company initiates to educate landowners about regulatory requirements related to proving productivity and obtaining bond release?

Answer: When we started our POD mining in Illinois, I am not sure that the bond release regulations were completed. Most of our leases were signed before the bond release requirements were known. Since the productivity formula has been completed, we have sent letters and we have sat down with the landowners to inform them that land has to be separated into different capability classes (i.e., prime, high capability, and non-crop land). It is hard for them to understand why they need a target level of 170 bushels of corn/acre when their average yield on a good year would be 120 bushels/acre.

State Question ***(Investigation of Crop Failures):*** I know you use primarily truck/shovel operations with some scraper pans, and you have had fairly good success at meeting the productivity requirement at Cedar Creek Mine, but when we have numerous repeated failures to make productivity, do you have any methods for determining what the problems are?

Answer: We look at fertility first with both macro and micro nutrient levels. Then we look at compaction by digging test pits and look at root penetration. We look for areas that might be holding water and not draining. Once we identify any problems then we try to alleviate them.

4. Surface Mining - Prime Farmland Soils Using Mixed Overburden Eddie Bearden, Texas Utilities, Dallas, Texas

OSM Question ***(Applicability in other Climates)*** : How would rates of precipitation relate to other parts of the country where this type of methodology would be useful'?

Answer: We typically get about 35 - 45 inches of precipitation per year depending on the location of the mines in the state.

State Question ***(Land Use Trends):*** ***Are*** most of your reclaimed areas going back to pasture rather than crop land?

Answer: *Yes.* We do not typically plant to crop land. We are now increasing the amount of land we are planting to forest land.

State Comment ***(Relative Merits of Overburden to Original Soils):*** Your soils seem to be very different from the soils we have in Indiana. Your soils seem to be very similar to your spoil materials, whereas our soils are very different from our spoil material. I don't know if it would be beneficial in our situation to substitute overburden materials for native soil materials.

Answer: In many of our situations, the overburden materials are better plant growth media than our native soils are. It is a site specific situation.

Academic Question ***(Source of Clay Parent Material Related to Weathering):*** Those clay soils that you showed on the slides might be smectitic or montmorillonic clays. Where is the source of the clays for the native soils? Is it possible that the overburden materials you are substituting will weather with time to something similar to the native soils you have now?

Answer: Most of the clays we deal with are montmorillonic although some are smectitic. I really don't know what the ultimate weathering of these overburden materials will be but it would take a very long time for them to weather into a clay pan soil.

OSM Question ***(Plans for Remining):*** Are there any layers of coal below the two seams that you are currently removing?

Answer: *I think* that there probably are but they are not economical to reach.

Academic Question ***(Pasture Bond Release Standard):*** What are your bond release requirements for pasture?

Answer: First we have five years to prove productivity, then we have to meet 90 percent of the yield standard for pasture. We graze the area, determine the animal unit months of forage harvested and convert that to tons/acre. In some areas, we also hay the area and convert that to tons/acre.

Academic Question ***(Bond Release Standard):*** ***You are*** starting with pasture land then you are converting it to prime farmland capability. Don't you get your bond release based on the productivity target yield for the pre-mining pasture condition?

Answer: That is correct. A lot of our land was previously native undeveloped vegetation. It is land that has been grazed and a lot was utilized to grow cotton during the late 1800s and early 1900s. The soil nutrients have been greatly depleted. They quit farming it because it was no longer economical to produce a crop. The erosion was severe. It has since been allowed to go back to native vegetation. After mining, we are either converting it to Bermuda grass pasture or forest land. We are also converting some land to wildlife habitat with mixed hardwoods and native grasses.

Academic Question ***(Bond Release History):*** ***Has any*** of this land that you feel now has prime farmland capability been released from bond and then had crops grown on it? If so, have any of the landowners developed a history of what its potential to produce crops is?

Answer: Some has been released. None, however, has been used to produce row crops. Partially because farmers in this part of the state no longer grow row crops. During my master's thesis I asked a farmer who had farmed some reclaimed land for some time, "If you had the choice between buying non-mined land or mined-land for the same price per acre, which would you buy?" He said that, "He would choose the reclaimed land every time." That is the kind of rating that most of our landowners give the land we reclaim.

5. Reclamation of Ancillary Surface Affected Soils Dean Spindler, Illinois Office of Mines and Minerals, Springfield, Illinois

State Question ***(Comparison to Oil and Gas Regulations):*** Does the Office of Mines and Minerals also regulate oil and gas?

Answer: Another Division in the Department of Natural Resources regulates oil and gas in Illinois.

State Question and Comment ***(Comparison to Oil and Gas Regulations):*** It is the same in Indiana. The requirement for reclamation on these relatively small areas are next to nothing. They put the soil back and grade the surface and apply seed and mulch and then they are done. These are very small areas and may provide a comparison for what we should be doing on small disturbed areas on mine sites. Since both programs are under the Department of Natural Resources and both under Federal regulatory programs, why do we do things differently in one industry over another?

Answer: The big difference is that the coal industry is regulated by the Surface Mining Control and Reclamation Act of 1977 (SMCRA). I am not sure if there is any national legislation covering the environmental impacts of oil and gas development. When it comes to prime farmland under SMCRA "Thou shalt make it crop land in the post-mining landscape, and you need to measure productivity." Whereas in oil and gas you do not have a standard that you have to compare the reclaimed areas to. What we are attempting to do is to find some other way to assure that the requirements of SMCRA are met.

Industry Question ***(Response to New Proposed Regulations):*** What kind of response are you getting from other agencies on this proposal?

Answer: The bulk of this has not gone to the inter-agencies yet. This has been a multi-year discussion with OSM. Although we have had the general support of the Illinois Department of Agriculture and the NRCS on the initial proposals, the final details have not gone back to them yet.

Industry Question ***(Time Frame for Proposed Regulations):*** What is your time frame on enactment?

Answer: I will have to refer that one to OSM as it is currently under their review. We have been working closely with OSM and I expect to have something in place this year.

Industry Question ***(Length of Time to Publish Annual Yield Goal):*** On your adjustment factor for crop yields, how long does it take to come up with that adjustment7 It would seem that the mine operator would not know at the time of harvest whether he had made his yield or not.

Answer: This has caused some problems. It is normally not until around April of the following year before we can tell the operators what the yield data from the preceding fall harvest was. They are usually getting ready to plant for the next year before they find out whether or not they passed the previous year. The reason for this is the county statistics on the county average yields do not come out the until spring of the following year. This is an integral part of the formula that we use in Illinois.

Interactive Discussion with all Speakers for Session 2

OSM Question ***(Rate of Mining):*** Eddie Bearden, do you have a sense for how many acres per year that Texas Utilities mines?

Answer: Texas Utilities mines approximately 2,000 acres per year,

OSM Question ***(Rate of Prime Farmland Creation):*** How many acres of prime farmland would Texas Utilities be creating per year?

Answer: At the Big Brown Mine, it would be about 125 to 150 acres per year. At the Monticello Mine, it would be around 200 acres per year. Also, the soils that are developing from the cross pit or oxidized materials, I fully expect that it will also meet the NRCS criteria for prime farmland soils. NRCS has not yet finalized its work on classifying this as a new soil series.

State Question ***(Adequate Soil Depth Replacement for Prime Farmland):*** In the Illinois coal basin, what should the total thickness of soil horizon be in order to restore grandfathered prime farmland to its original productive capacity? We had proposed in Indiana at one time that 36 inches would be adequate but this did not pass. What depth of soil materials would you think would be adequate?

Answer: I will assume that we are not talking about fragipan soils, which would be a special case. In Illinois we have two mining districts and we have a varied soil replacement requirement from southern Illinois to northern Illinois. It is not uncommon for prime farmland restoration in western Illinois to have a total root zone requirement of five feet. In a situation were we have been covering refuse, we have had as much as a six-foot requirement. In the more common replacement situations, a four-foot root zone would be required in order to restore the pre-mining capability for most crop lands in Illinois and I would think that this would be the same for Indiana as well.

Academic Answer: From a pedologist standpoint, if we are going to return land capability, and we are going to be growing corn in Illinois, corn is a deep rooted crop. From our research, four feet of soil material is going to be necessary to return 100 percent productivity. Is that a combination of rooting media only or is it a combination of rooting media and high quality material below that? I think we need to have the capability to have four feet of rooting volume. If we are only going to have three feet of rooting material, yet the material below that is going to be severely compacted such that it will restrict root penetration, then we have made the decision to restore capability at 75 percent of its potential to produce a corn crop. We need to assess the rooting media, the quality of materials, and we need the total rooting volume that will support nutrient levels, water capability, and root penetration in order to achieve 100 percent productivity. I have a no till planter where I could plant corn in the carpet of this room, but that does not mean that we have restored the capability to produce a crop. We need to have the total rooting volume.

Academic Answer: Certainly in some of this you are relating to situations where the pre-mined soils had root zones shallower than four feet. A lot of the soils in this region of the country have a full rooting depth. Perhaps this conversation relates to the stewardship liability that we have as the current land managers. Concerning the productivity potential of our newly reconstructed soils, one of the methods of reclamation is deep tillage. If we look at the current research results, can the results we are obtaining on reclaimed soils be applied to our troubles with clay pan natural soils? By merely doing some soil mixing, we can significantly improve those natural soils. This type of technology may not be applied next year or in the next five years. But some day, the economics of agriculture may mandate that mixing of natural soils through deep tillage is economically viable. For that reason, we need to not only be thinking about replacing the necessary rooting volume but even if the natural rooting zone was shallow there may be a potential for creating a better soil given current technology.

Industry Answer: From an operations standpoint, we try to put back as much soil everywhere as possible, not just with prime farmland. This gives us a lot of flexibility from a land use standpoint. The answer of how much soil volume to replace is also dependent upon the replacement methods. If you are scraper placing all of your materials rather than using trucks this will limit root penetration. It also depends on the types of crops you intend to grow. Grazing land does not need as much soil depth as alfalfa. We grow a lot of alfalfa and have found as much need for total root depth as in a crop land situation. That is one reason that we try to put back four to five feet of soil materials everywhere. Since we have to handle all of the overburden material anyway, whether we put it on the top or bottom doesn't make that much difference.

*Academic Question (Cost **of Deep Tillage):*** I am interested in how much it costs to deep till. Could the other panelists respond to that?

Industry Answer: *You need* to look at where your compaction problems are occurring. If your compaction zone is within 16 to 18 inches from the surface, you will be needing a different tool than if the material has been scraper placed and the entire root zone is compacted. Breaking up compaction with a chisel plow or a Tiger II will cost about $20 - $30/acre For deeper compaction at the 24 inch depth, you will pay $60 - $100/acre depending upon whether you are hiring it done or you use your own equipment. Depths up to three to four feet could be costing $300 - $400/acre.

Consultant Answer: We contracted three years ago at $400/acre to do the DM II to four feet.

*Consultant Question **(Seasonal Constraints to Penetrometer Use):*** When measuring soil strength using a penetrometer, how many days in an average year have you been able to use this type of equipment?

Academic Answer: *During the* seasonal window we use, assuming similar low ground pressure equipment, we look for recharge and uniform moisture conditions. This could be from early March to the first of June through the middle of June. Another cut off indicator would be when the corn is at the five leaf stage is when the soil starts to dry out. When ever this happens, your accuracy begins to fall off.

*Industry Question **(Prediction of Soil Compaction):*** In predicting soil compaction, has anyone tried to map in advance areas at risk for soil compaction as a means of economizing on remedial work?

Academic Answer: Most of the areas we have looked at in our research were about 10 to 20 acres in size and the operator wanted to know how much variability in compaction existed on the site. We do not have any experience with large fields (i.e., 40-50 acres). Mostly we have done trouble shooting in potential problem areas.

Industry Answer: We have looked at different soil handling techniques and have asked the University of Illinois to look at soils when they are frozen or extremely dry and truck replaced material versus scraper placed. That gives us a subjective assessment of how and when we need to handle our materials.

*Academic Question **(Possibility of Penetrometer Use during Dry Conditions): Have you*** ever looked at a situation where you measured an area when moisture conditions are right and then come back later and reprobe the same area to try to build a working curve for less than ideal moisture conditions? Then you could use a moisture content measurement and the correction curve to adjust for less than ideal conditions.

Academic Answer: Whenever you start getting below field capacity moisture conditions (17 percent soil moisture) and begin to approach 15 percent soil moisture, the soil strength increases logarithmically and we jump from 100 - 200 psi to 500 psi in non-compacted areas to 1500 psi in compacted areas. In this situation, the limits of the penetrometer equipment will not allow you to take measurements at these soil strengths. Our equipment is designed to work up to a maximum soil strength of 1200 psi and is very accurate in the 100 - 500 psi range. The reality is that once moisture drops below field capacity, soil strengths shoot up so fast you can't get accurate readings or even force the probe into the ground.

*Academic Comment (Use **of Hand Penetrometers):*** I am concerned about the use of hand penetrometers. In this situation, you may not be considering the moisture content at the time the data is collected. The problem is that when the soil moisture is at field capacity you can't dig a soil pit very safely, yet that is when these measurements need to be made. I once probed a 60 acre field on a research farm. It had rained two days previously. When the probe reached a 6-inch depth, the soil strength increased and then later decreased as depth increased at what was assumed to be a lower compacted zone. I initially discounted the 6-inch high soil strength area as a product of low soil moisture because of the rain. It later turned out to be a compacted plow zone. I did not know that the field had been in wheat production six to eight years prior to the university acquiring it. The point is that you need to look at the data critically so that you correctly interpret it.

Industry Comment ***(Positive Dialog for Problem Resolution):*** I have been struck with the positive relationship between the industry, academia, and regulators in working through the problems that have been discussed today. I think this type of event is a very positive thing.

Session *3:* Minesoil Management and Stewardship

1. Long Term Effects of Deep Tillage Robert Dunker, University of Illinois, Urbana/Champaign, Illinois

Academic Question ***(Duration of Tillage Effects):*** What does your research indicate as far as how long the effects of deep tillage will last?

Answer: In our 1997 data, we were still seeing the same significant grouping between tillage depths that we saw in 1988. I will point out that these systems are subject to recompaction immediately after tillage. We need to employ a system that utilizes compaction avoidance techniques. High axle loads on these soils can recompact them. Our plots, however, have not shown any significant reconsolidation at the deeper depths. In the management zone in the upper horizons you will see some variability due to typical agricultural management systems. But there is no indication that the compaction that was alleviated below these zones has significantly reconsolidated after 10 years. The productivity levels have remained high over this same period of time.

OSM Question ***(Effects of Deep Tillage):*** Having seen these deep tillage machines operate, it appears that during deep tillage you actually are just creating deep fissures. You still have big chunks of material down there that would have very high soil strength. In this case, the roots would actually be penetrating the cracks between the chunks.

Answer: Depending upon the type of equipment used and the soil moisture conditions at the time of deep tillage, this could be true In heavily compacted mine soils, you will find that the material can break up in big chunks. At this point, them is no indication that the roots would penetrate into such chunks of highly dense material. What you have actually done is add a lot of areas for water and nutrients to become available for roots.

State Question ***(Compaction Mitigation with Truck/Shovel):*** If you were using a truck/shovel subsoil soil replacement system and replaced the topsoil with scrapers, what type of compaction alleviation system would get the job done? It does not seem that you would have to use quite as deep a tillage system when you have used the truck/shovel system of subsoil replacement.

Answer: There is no yes or no answer to that. You need to assess what the effects are. If I were going to use a shallower piece of tillage equipment, then I would want to actually measure the soils to determine that there was no significant compaction zones below the zone of tillage I was using. Truck/shovel operations create lower soil strengths than what is created with scrapers. But depending upon how the truck/shovel operation was actually carried out could change things considerably. Did the trucks drive on the rooting media? What were the moisture conditions? I would want to know the actual compaction results of using a particular method before making a final decision. In theory, you should be able to use a shallower piece of tillage equipment under such a system. In normal agriculture, you have the rule of thumb that you do not want to till any deeper than necessary in order to not disturb natural soil structure. In a mining situation you do not have natural soil structure.

State Question ***(Depth of Deep Tillage for Truck/Shovel):*** What would be the depth that you would typically need to deep till under ideal conditions for a truck/shovel system?

Answer: I don't know that I could give you an answer. I have seen a wide range of compaction in truck/shovel operations. You would really need to know the particulars about a given site and operation before you could say what deep tillage equipment you would want to use.

Consultant Question ***(Bath Tub Effect of Deep Tillage):*** In massive soils, what could you say about the bath tub effect where you would overload shallower depths with too much moisture?

Answer: *If you open these* soils up to large voids then subsoil moisture will tend to move downslope. Lower topographic areas will be in a moisture receiving condition. Just as in natural soils, landscape position will be a factor in the final conditions of the soils.

Academic Question ***(Post-Deep Tillage Traffic):*** What kind of traffic did you have on your research plots after the tillage treatments?

Answer: We did a lot of no till or minimal tillage treatments initially. We tried to use as light a tractor axle load as possible. We took the fluid out of the tractor tires.

2. Soils Based Productivity Evaluation Charles Hooks, Southern Illinois University/University of Illinois Research Station, Percy, Illinois

Academic Question ***(Data Gaps):*** ***Your*** regression equation for the intermediate set was quite different from the rest of your data set. Soil strength was positively correlated with yields. Could you comment on the differences?

Answer: Historically we have seen a negative correlation with soil strength and yield. As soil strengths increase, yield decreases. In the middle soil strength zone, this correlation does not play a major role and even has a slight positive correlation. This is the zone where we are going from a minimum rooting volume to an acceptable rooting volume and a lot of factors play a role. We have hypothesized that we are seeing soil texture differences playing a larger role in this middle zone than does soil strength. This is an area that needs to be more extensively investigated.

3. Mine Soil Classification and Mapping Scott Wiesbrook and Dr. Robert Darmody, University of Illinois, Urbana/Champaign, Illinois

NRCS Question ***(Classification Differences for Glacial and Non-Glacial Soils):*** Do most of the soil series that you have described have a glacial till component? Much of my experience has been in areas that do not have glacial till material. My observations in these areas is that they are highly variable. It concerns me that any attempt at soil classification with these materials will result in trying to make them fit into descriptions that assume more uniformity than what actually exists. In trying to put these reclaimed materials into soil series categories, I can see a lot of variation just based on things that we can see in the field (i.e., like depth or textural family), not even considering all of the factors that are not visually observable in the field. It seems that any attempt at classification would be much more difficult in non-glaciated geology.

Answer: Most of the areas we worked on in Illinois are glaciated. It is fairly easy to identify in the field whether you have Pennsylvanian (non-glaciated) or Pleistocene (glaciated) age materials. In our experience, the more glacial till material that was mixed in with the spoil the courser the soil texture. Glacial till soils tended to be more loamy in texture. Spoil materials, with a high proportion of glacial loess in the mixture especially northern Illinois, tended to produce a fine silty soil.

State Question ***(Classification Concerns About in Place Development of New A Horizon Material):*** Concerning your chart, I noticed you had a criteria of soil replaced or not replaced. What provisions are you going to have for soil A horizons that have developed in place and were not replaced in the reclamation process? As reclaimed soils without replaced topsoil develop an A horizon over time, how will this fit into your system of classification?

Answer: I don't think it matters so much *if* you have an A horizon develop in place. We are classifying them as Orthents. It is expected that they will follow a natural soil aging process and ultimately develop an A horizon and eventually a B horizon. At this point they will no longer be an Orthent and will have to be reclassified as Inseptisols. We have noted the development of A horizons in the field up to a depth of five to six inches. Although this can be recognized in the soil descriptions, I do not think this will make much difference in how these soils function in terms of agricultural uses.

OSM *Question* ***(Productivity Values and Tax Base for New Soils):*** Do you anticipate determining a range of potential productivity values for these soils? Would you expect this classification system to be used by county assessors in determining land values for tax purposes?

Answer: Yes we plan to do this as soon as Charles Hooks gives us the numbers. We do expect that eventually this information will be used by the county tax assessors.

4. Global Positioning Systems (GPS) and Site Specific Management Dr. Richard Barnhisel, University of Kentucky, Lexington, Kentucky

Academic Question ***(Calibration of Equipment):*** How often do you need to calibrate your equipment with actual grain test weights from the trucks?

Answer: From the yield monitor point of view, the most critical part of using a yield monitor for measurement of grain is calibration. I have a plot combine and we do not have the same mechanism that you would have in a large combine. We built a clean grain elevator in order to simulate the clean grain. That has not changed over time. In a standard combine, where the length of the chain increases with time you need to make adjustments by adjusting the chain at the bottom of the elevator and not the top. Farmers tend to go the other way. If you change it at the top you will mess up the calibration. It takes about five loads in order to get the AgLeader software yield monitor I use to work correctly. Green Star and MicroTrack only use one load. I have a problem with that because you might not have the same amount of variation from one field to the next. What I do is try to drive as fast as I can with the combine. At about 17 percent moisture in the grain, I can run at about 200 bushels/hour. Then I drive as slow as I can to get the next load. Then I try to get two to three loads at intermediate speeds. The software calculates a regression curve. This allows the monitor to compensate for varying rates of speed with the combine. Calibration is extremely important when using yield monitoring equipment in the field.

5. Illinois Reclaimed Soil Productivity: Restoration Techniques Gene Smout, CONSOL Coal Co., Sesser, Illinois.

State Question ***(Economics of Deep Tillage):*** I realize that in your operation you have shifted to soil replacement with trucks in recent years. From a purely economic point of view, is it economical to go ahead and do the full deep tillage to four feet rather than some type of intermediate tillage on less compacted soils replaced with trucks?

Answer: I don't know if I have the information to answer that question. What I can say is that we did a lot of penetrometer work before coming to the management practices that we have now. We looked at determining soil strengths pre-tillage. We did have wheel spoil at several of our mines and some truck haulage at others. We knew that we had soils that had been moved under a wide variety of circumstances including dry, wet, and frozen. We thought maybe we could use the penetrometer to save some money by using it to identify those areas where we would benefit from deep tillage Ultimately, we got our costs down in terms of tillage equipment to the point that deeper tillage was cheaper in many cases than intermediate tillage At that time, we decided to deep till all of our acreage so we would not have to worry about productivity. We felt that tillage less than 32 inches deep was less than adequate. Rather than worry about which equipment to use where, we can now apply one treatment to everything and don't worry about it.

State Question ***(Economics of Deep Tillage):*** Yesterday a question was asked about the cost of deep tillage with the DM II and a figure of $400/acre was an estimate. Would you find that to be a reasonable estimate of the cost?

Answer: I would think that would be accurate for some of the early stages of our work when we were leasing equipment and having contractors come in and do the work. Now by using our own equipment and manpower we are well under that figure.

OSM Question ***(Row Spacing for Deep Tillage):*** What is the distance between furrows with the deep tillage equipment that you use now?

Answer: The sweep is 44 inches wide and we are running on ***54*** inch centers. The right track of the dozer has to be up on the previous ripped rim. This leaves a V from the bottom of the plow of uncompacted material as the plow

moves through the earth. On 54 inch centers, those V's overlap and leave a very small cone of compacted material between passes. Under ideal conditions that small cone will cleave off at the bottom as well. We feel that we are getting the best effect that we can from this type of application.

Academic Question ***(Duration of Settling on Reclaimed Areas):*** How long does differential settling continue on a remined area? How long would someone who wants to build a big shopping center have to wait to ensure that their foundations would be stable?

Answer: I don't have the answer to that one. Differential settling lasts for some time. It is a diminishing activity. Depending upon the type of overburden that you have, we will still see some pockets form five to six years after reclamation is completed.

6. Land Use and Value after Reclamation William R Phelps, ARK Land Co., St. Louis, Missouri.

State Question ***(Quantity of Permanent Program Crop Land Sold):*** Could you give us a ball park figure of how many acres of crop land that you have sold that has successfully demonstrated proof of productivity and completed the bond release process in Illinois?

Answer: We have not sold any of our best reclaimed crop land. My impression is that the value of crop land will be based on the actual crop yield that it is producing rather than what reclamation standard applied at the time of release.

State Question ***(Speculation on Future Prime Farmland Sales):*** ***Since you*** do not have any actual experience with selling significant quantities of crop land to farmers and most of your current sales emphasize the hunting aspects where soil quality is not really in question, could you speculate on what will happen when you actually start trying to sell reclaimed prime farmland as crop land to farmers?

Answer: I think you will see a lot of partnerships where a hunter and farmer will team up to buy the properties. I don't know if reclaimed prime farmland wiII ever achieve the original prime farmland values of undisturbed prime farmland. I think that people still have a stigma about mined land that would cause them to undervalue the reclaimed prime farmland. A lot of its value will depend upon the field configuration, the field size, its proximity to water, and the amount of non tillable acres that go with it. Many of these factors will overshadow factors related to soil capability.

State Question ***(Value of Subsided Agricultural Land):*** In Illinois, we like to think that land that has received mitigation after subsidence from underground coal mines is as productive after mitigation as it was before subsidence. Do you find that land owners still have the perception that it is of lesser value because it has been subsided?

Answer: Yes I do. The problem is that 70 percent of your buyers are from the local area and think of it as the Jones farm or the Smith farm. Most of the sales are in 100 to 200 acre lots. Is it the right size for a son or daughter to build a house on. With subsidence, you have limited the places on a tract of land that you can build a house and this does have a bearing on the market.

OSM Comment ***(Incorporating Post-mining Land Values into Reclamation Planning):*** I would like to see people involved with land sales get involved with the mine operator and reclamation planner so that the initial mine and reclamation plan could incorporate post-mining land values.

Answer: In order to maximize the post-mining land value, the reclamation plan should place the crop land next to water; put trees around the edge of the crop land so that the hunters can eventually set up their deer stands in the trees and hunt the area. Land values are based on what we know about how land is used now so these things should be set up the way they are perceived to be most valuable in terms of undisturbed land.

Interactive Discussion with all Speakers for Session 3

State Question ***(Acreage of Land that can be Deep Tilled per Year):*** How many acres can you deep till per year considering the seasonal window of opportunity for doing that?

Answer: *Our* budgeting considers between 600 - 700 acres per year as a normal season. The best year we ever had at CONSOL was about 750 acres in an ideal year.

State Question ***(Effects of Excessive Rainfall):*** ***Have you*** had a situation where, because of excessive rainfall, you decided it was not worth it to deep till in a particular year?

Answer: We usually stop some time in September or October because of the rain. It is usually more a consideration of what will happen to the areas that have already been deep tilled than the acres yet to be tilled. It becomes very difficult to get back on the area to get it ready for cropping.

State Question ***(Timing for Deep Tillage):*** How do make your decisions on when to begin deep tillage and when do you end deep tillage for a given year?

Answer: That comes with experience. Based on digging soil pits and determining if the stand of alfalfa is a strong or weak stand If you have had a vigorous stand of alfalfa on the area for three years, I am fairly confident that by the 1st of July we will be ready to go. But even then we dig a few soil pits and test the soil conditions. We normally reserve the right to stop the tillage contractor at any time or in any place if we don't think the soil moisture conditions are correct.

State Question ***(Land Value Related to Bond Release)*** : We find that our land acres under bond continue to climb. Do you carry land values on your books any differently for land that has been bond released as opposed to acres still under bond? Is there a point at which it becomes more economic to obtain bond release rather than leaving it under bond?

Answer: We try to carry the actual market value of the land on the books. We can actually market these lands before they are released and reserve the right to finish the bond release process. Prime farmland is harder to do than woodland because for woodland all you have to do is count trees.

Question ***(Compaction Mitigation with Deep Rooted Plants):*** ***Are there any native*** plant species that are particularly aggressive in dry situations in terms of penetrating the compacted soils other than the alfalfa and clovers that we already know about for the purpose of mitigating the compaction?

Answer: I would suggest that we wait for the next glacier. Clark Ashby has done some work with this at Southern Illinois University at Carbondale looking at woody species that have aggressive tap roots that could provide some mitigation of compaction. Normally for legumes you are looking at sweet clover or alfalfa. Clark Ashby has also looked at some of the deep rooting warm season grasses. But my point earlier is the time factor in terms of how long are you going to hold reclamation bonds on these areas waiting for them to meet the performance standards.

Answer: We have had a study in Kentucky where we looked at black locust trees, alfalfa, soybeans, fescue, and sweet clover. We found that black locust, alfalfa, and sweet clover were the best at loosening up the soil. On the black locust trees, we planted them very thick and brush hogged them every year. After two years we plowed up the areas and we did see a benefit to all three of these species as compared to continuous corn. Fescue and a wheat rotation was intermediate in effects. We also found an additive effect of ripping and cross ripping in combination with planting of deep rooted species.

State Question ***(Effects of Prime Farmland Reclamation on Tree Growth):*** One of the purposes of SMCRA is to restore the pre-mining land uses and soil capability. Is 48 inches of soil material necessary in all cases to restore pre-mining levels of soil capability for prime farmland soils in the Illinois basin? If prime farmland soils under SMCRA are replaced with the minimum soil depths and minimal compaction, is that a deterrent to tree growth?

Academic Answer: It is necessary to restore a minimum of 48 inches of soil material to restore prime farmland soil capability. I would answer the second question by saying that improper reclamation of prime farmland soils is detrimental to growing trees. Improper reclamation of prime farmland soils in a row crop application is also detrimental to trees. If you have a highly productive soil for crop land uses you will also have a highly productive soil for forest uses.

Industry Answer: The deeper we rip our soils at our mines, the farmers at our mines say that the productivity is better with the deeper ripped soils. They handle drought better and we have better crop success on these areas. Deep tillage at 40 inches is better than tillage at 36 inches. Our yield data would support this.

Academic Answer: In Kentucky, we have studied the effects of soil depths in a prime farmland situation over several years. If you are only going to grow wheat, about 18 inches of soil materials will produce the quality that you need. If you are going to produce soybeans or alfalfa you may only need two to three feet of soil materials to produce the quality you need. Three feet of soil material was not enough to grow corn productively even when the spoil material under the replaced soils was good material. We only looked at soil depths up to four feet, but at that depth we were able to get the crop production necessary to obtain bond release.

Academic Answer: Some of the soils that you mentioned have a significant rooting problem in their natural subsoil. Whether or not three feet of replaced soil materials would meet productivity levels, I don't have any data on that. However, looking at yield response of corn to depth of rooting media replacement for tillage alleviation, we are still on the curve going up in terms of soil depth. There is a considerable advantage to crop yield between three and four feet of soil depth related to rooting volume.

State Answer: I would take a simplistic approach. We have to grow corn in Illinois and corn is a deep rooted crop. I think that we need four feet of soil material. As far as the effects of soil depths related to tree growth, I would see that more as a compaction problem rather than a soil depth problem.

Consultant Comment: I would like to make a comment on the growth of trees. I have not seen where minimally graded soils pose a detrimental factor to trees as apposed to minimally graded spoils.

Session 4: **Subsidence**

1. Characteristics of Subsidence from Abandoned and Active Undergound Coal Mines in the Illinois Coal Basin
   Robert Bauer, Illinois State Geological Survey, Champaign, Illinois

*Academic Question **(Evidence for Sag Subsidence):*** If you are a land owner, with a farm that has a lot of wet bottomland, with a series of drainage ditches because you need to provide adequate drainage for crop production, and you suspect that there is sag type subsidence because the property has been underground mined, what evidence can you use to prove that you have sag subsidence as apposed to poor maintenance of your drainage ditches?

Answer: We have natural depressions on the Illinois landscape that have the same characteristics as sag subsidence. First, there may be some historical information or even aerial photography that would show that there was no depression features previous to mining. We will then map the sag features and place that over the mine map to see if it fits over the production panel. You can't look at an aerial photograph and look at every sag or depression feature you have on the landscape because we have a lot of them that are naturally there from past glacial actions.

*OSM Question **(Evidence of Subsidence):*** How can you tell if the features are actually caused by underground subsidence?

Answer: The sags are fairly large. They are usually hundreds of feet across with a maximum of two to four feet of downward movement. We do not find that normal soil settling will create a sag like this. I have been to farmers fields where the farmer points out 12 subsidence events. Upon investigation of the mine map, I will find that only three of them have been underground mined. The rest of them were natural depressions from when the glaciers were here.

2. ***Coal*** Mine Subsidence/A Regulatory Perspective Dan Barkley, Illinois Department of Natural Resources, Springfield, Illinois

State Question (Biggest Subsidence&litigation Challenges): What is the biggest challenge for subsidence mitigation from a regulatory perspective?

Answer: I think the biggest challenge is dealing with the surface owners that have subsidence problems. It can be very difficult in dealing with what they believe they have coming to them in terms of subsidence mitigation compensation. The contrast is between what the regulations require and their perception of the high standards that they have. In general, I think that mitigation has gone very well in the State. There are very few problems. Sometimes in the flatter areas we will have more problems than in rolling terrain where we have drainage. I have yet to see something that the companies have not been able to achieve in terms of mitigation.

State Question ***(Effects of Energy Policy Act):*** What is your impression of the positive or negative effects that have occurred with the new regulations under the Energy Policy Act?

Answer: There are some very positive things that has come out of the Energy Policy Act. There are some things that I think will need work in the actual implementation of the Act. The goals of the regulations were appropriate. Some of the mechanics to achieve those goals can be an implementation problem that we will have to work out over the next few years. We have been successful in this program in the past and I think we will have similar success in the future.

Academic Question ***(Coal Production Trends): You started your*** presentation with slides of the production of coal over the past few years, do you have any idea of what coal production is going to be doing over the next 10 years especially concerning increased long wall mining?

Answer: Although I have heard a lot of speculation, the problem we are dealing with is the Clean Air Act and what it has done to our higher sulfur coal. I expect the trend to continue toward underground mining. In the long run, once the dust settles from the clean air legislation, and every one gets on the same playing field, I think that Illinois coal production will begin to rise again. I think that long wall coal production will be a major part of that.

Academic Question ***(Evidence of Subsidence):*** What evidence does a home owner or landowner have to show that damage is a result of subsidence rather than poor structural design or natural sinks on their property?

Answer: With structures, planned subsidence mines are required to do pre-subsidence surveys. We feel that it is best to do those surveys within a short period of time prior to the actual mining. These surveys are the basis for our determining damage from mine subsidence. With land damage, it is a little more complicated. We will take pre-mining contours of the land and project post-subsidence contours in all permits that do long wall mining and high extraction retreat mining. They are expected to delineate where drainage problems are expected to occur. Then they must describe how they are going to mitigate these drainage problems. We have a feel for where we are going to have problems based on this mapping prior to the mining taking place. It is very uncommon for the mine to respond that the drainage is not their problem. Usually mitigation works out well between the land owner and the company.

For abandoned mines, the mine subsidence insurance fund is a private entity. They are regulated by the state, in the sense that it is a legislative act that created them, but they investigate on their own and no state agency goes out to investigate these claims. They have their own experts that monitor based on the types of damage and they monitor over time to see if they can pick up any downward trends in terms of movement. The state abandoned mine land program would only get involved if there is a public safety issue.

3. Impacts of Mine Subsidence on Ground Water Colin Booth, Northern Illinois University, Dekalb, Illinois

State Question ***(Destination of Ground Water): You*** indicated on the Saline County Site that there was recovery because it was cut off from its recharge. That water is going some place. Where is this water going?

Answer: First, the water level in the affected area is dropping. You have the same amount of water filling up a larger fracture space so that the water level drops. Outside of that area you may have some potential for recharge water flowing in but it will only flow in if there are permeable pathways. In the Jefferson county case, there seemed to be continuous pathways for that water to get into the affected aquifer. I think that is what you will see in most cases with reasonably productive aquifers. In the Saline county case, where you had a very poor tight aquifer, it may take 15 years for that to recover. The continued activity of the mining itself is blocking off that flow path as well.

State Question ***(Time Frame for Taking Background Water Data):*** Concerning the water replacement requirement of the regulations, what would be the appropriate time, for a long wall/ high extraction retreat mining operation that may affect a well or spring in terms of the time frame, to get good ambient background water quality data. Would it be best to obtain this information one year in advance of the long wall operation or five years or ten years.

Answer: Looking at the sites we have investigated, you start to see the effect of mining maybe a few weeks in advance of the actual mine face approaching. If you had no mining at all at the site, you should be getting some pretty good ambient water levels over the previous year which should give you the seasonal variation. At the first site I discussed, the initial water levels in the sandstone water aquifer were around 60 to 65 feet below ground and were probably already depressed by 20 feet or so because of mining of the earlier panels nearby. Ideally we should have been taking water levels probably two years in advance.

State Question ***(Time Frame for Taking Background Water Data):*** What problems would you see with taking water data five to ten years in advance of the mining operation?

Answer: The potential problem you would get in that situation would be if something else had happened after the data had been collected but before mining begins. If you have a representative natural water level and it was not taken in a drought year, providing something else has not happened, that should be the representative ambient level. I would be a little concerned about the addition of a pumping well starting up near by or changes in the hydrologic regime due to adjacent mining. You need to look at each site individually to see if there is any intervening stresses taking place.

OSM *Question* ***(Water Treatment Costs):*** You made a statement that on one of the aquifers the dissolved solids in the water was treatable. How much would it cost to treat this water?

Answer: I think the top line treatment systems can treat water up to about 3,000 milligrams per liter. I really don't know what the costs would be.

4. Reclamation of Agricultural Land After Planned Coal Mine Subsidence Dr. Robert Darmody, University of Illinois, Urbana/Champaign, Illinois

Consultant Question ***(Remapping):*** Do you see any effort in the future to remap these subsided soils?

Answer: I think the easiest way to handle that would be for the Natural Resources Conservation Service to use a spot symbol. Most of these very wet areas are around two acres or less. That is about as much detail as you can show on a soils map anyway. What they have done in some counties is to dash out the mine panel where they can show up on a topographic map. Generally, I would not vote for a new soils series but call them wet spots within a given soil series. The soil series should behave fairly uniformly with the exception of that low wet area.

Public Question ***(Damage to Houses):*** ***You talked*** about raising these houses to prevent structural damage. I saw a horror story from Pennsylvania recently of 33 houses splitting half in two from long wall mining. Does most long wall mining take place in rural areas or in residential areas where there would be more houses?

Answer: I can tell you what I have seen. If the coal companies are required to repair or mitigate damage, they are not going to mine where the costs are too high.

Answer: The Pennsylvania law is different than the law in Illinois concerning subsidence damage. They have provisions that are based on the age of the structures while in Illinois the age of the structure is not a factor.

Question ***(Diffences Between Corn and Soybeans):*** You showed that the corn was lower than soybeans, is this from the compaction with equipment?

Answer: ***One*** place where corn is different from soybeans is that corn is a determinate crop. There is a very small window of opportunity where everything has to be right in order for the yield to be maximum. If things are off during the two week period when it is silking things will not turn out like they should. Soybeans are indeterminate, they grow throughout the year and can take advantage of good and bad weather. So you are really seeing a difference in physiology. In most cases, this is due to water. On sites that have been mitigated, the ones that were bad were just not mitigated well enough.

OSM Question ***(Tiling of Wet Areas)*** : Have you seen any cases where the mitigation included tiling of the wet areas to lower the water table?

Answer: Generally, water control in Southern Illinois, because of the clay pans, is on a surface drainage ditch basis. One of the problems with mine subsidence is that if you do have drain tiles, they will run backwards as the area subsides and will make the situation worse. The area I have worked in is not suitable for tiling. Tiling could work if you had the right soils.

Interactive Discussion with all Speakers for Session 4

State Question ***(Correlation Between Subsidence and Depth of Mining):*** We have a lot of citizens that call us in Southern Illinois where the coal is quite shallow (withing 30 feet of the surface). After a heavy rain over the weekend we need to check the telephone recorder to see who called. Do you see any correlation between depth of coal and subsidence?

Answer: We usually tell people from this ares that if the coal is deeper than 200 feet we really don't expect to see much pit subsidence.

Answer: We have seen one where the subsidence was from 300 feet, but its not the depth that controls the subsidence but how much and what type of rock is above the coal. The thing that develops the pit subsidence is that a roof fall develops up through a shale type material and then it intersects the glacial material and soil. This then falls into the void.In the case where we had the mine that was 300 feet deep, we only had about 20 feet of roof rock with the rest being looser materials. In the cases where we have a limestone layer above the coal that is about two feet thick, the roof fall does not go past the limestone. We had one town in Illinois where we had pit subsidence in half of the town but not in the other half. When we drilled the sites, we found that where the pit subsidence was occurring, there was no limestone above the mine. Where there was no subsidence there was a one foot limestone layer above the mine. This is why it is hard to make a general rule correlating overburden depth with frequency of subsidence.