REDUCING THE MANAGEMENT VARIABLE IN ASSESSING RECLAMATION SUCCESS

A Research Proposal Submitted to the Lignite Research Council of the North Dakota Industrial Commission

Principal Investigator
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Industrial Commission Funding Requested

$16,118

Lignite Industry Match Requested

$16,118

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ABSTRACT

The depth of soil replacement required on stripmined land in North Dakota was reduced by the Public Service Commission following public hearings in 1986. The amount the soil depth was reduced depended on the quality of the underlying spoil material. These decreases in soil depth requirements will not apply after the end of 1998. Two years of data have given support to the idea that the current regulations are as good as the previous regulations in achieving productive reclaimed land. The data, however, are highly variable. In this additional year of study we will measure yields on land farmed by four or more growers who have land on both undisturbed and reclaimed land. This will reduce some of the variability due to management practices. Regression equations of yield versus soil depth including analysis of covariance should tell whether current requirements are sufficient. Assuming they are sufficient, the continuation of the current requirements should keep reclamation costs low compared to the cost of increased soil depths. Total cost of the project is $32,236.

PROJECT SUMMARY

In 1986 regulations were adopted by the Reclamation Division of the Public Service Commission to reduce the depth of soil required for reclamation of cropland. The new requirements were based on properties of the spoil material. A sunset clause was added to these new regulations that requires their reevaluation after ten years. A two-year extension of these regulations has recently been approved by the North Dakota Public Service Commission.

The purpose of this study is to evaluate the yields from land that was reclaimed under the current regulations and compare them to yields from undisturbed sites and sites reclaimed under the previous regulations. In the previous years of study, data has strongly supported the contention that land reclaimed under current regulations is as productivity as land reclaimed under the previous regulations. The data, however, has been very variable and questions remain concerning its validity. In 1996, we will work with four or more grower/cooperators who farm both reclaimed land and undisturbed land. We will then sample these fields for yield. This procedure should reduce the variability due to management such as planting date, fertilizer and pesticide applications. Evaluation of these yield data should allow us to determine if these soil depths are sufficient for maximum potential yields to occur. Yields will be regressed against soil depth. These regressions will be used to determine if the current soil depth requirements have successfully produced yields equal to or better than undisturbed land. Analysis of covariance will be used to separate out some of the management effects.

Assuming that this research provides the information necessary to continue the current regulations, the lignite industry will save close to a million dollars a year in reclamation costs.

PROJECT DESCRIPTION

Introduction

Data from years of previous research on the depth of topsoil and subsoil required to reclaim land following stripmining were compiled and published by Doll et al. in 1984. They drew conclusions on the amount of topsoil and subsoil needed and made recommendations for reducing the depth of soil required based on the properties of the spoil material. These recommendations contained a range for the depth of soil to be replaced. Following public hearings, the Public Service Commission adopted these recommendations using the lesser depth of the range given. In addition, more soil is required if the saturation percentage is greater than 95% for spoil with an SAR of 12-20.

The amount of suitable plant growth material required is given in section 69-05.2-04 of the North Dakota Rules Governing Reclamation of Surface-Mined Land as follows:

Table 1. Suitable Plant Growth Material Redistribution Thickness.

Spoil Properties			Total Redistribution Thickness	
Texture	Sodium Adsorption Ratio (SAR)	Saturation Percentage (SP)	(Topsoil Plus Subsoil) Average in Inches	(Centimeters)
Medium*	< 12	***	24	(61)
Coarse**	< 12	***	36	(91)
***	12-20	< 95	36	(91)
***	12-20	> 95	42	(107)
***	> 10	***	48	(122)

*Loam or finer.

** Sandy loam or coarser.

***Not applicable.

Further, it is stated that these requirements are effective only for those areas disturbed prior to the year 1997. In other words, starting in 1997 requirements will revert to the deeper depths of suitable plant growth material. If it can be proven that the current soil depth requirements are adequate, then extending the current rules will be justified. A two-year extension of the current rules is pending.

Objectives

1. Measure wheat yields from cropland on reclaimed and undisturbed land.
2. Develop regression equations comparing yields with depth of topsoil.
3. Determine whether current rules require sufficient soil replacement to achieve productivity equal to or better than before mining.

Methodology

At least four grower/cooperators who farm both reclaimed land and undisturbed land will be asked to participate. Since these lands at each mine are under the control of one person, management should be the same on reclaimed and undisturbed sites. This should help reduce the variability in factors such as planting date, fertilizer applications, seeding rates, and pesticide applications. In addition, it should help reduce the variability in climatic factors such as precipitation since the sites at each mine should be fairly close together geographically.

Fields from each grower/cooperator will be chosen to represent each of the categories given in Table 1 whenever possible. Additional fields reclaimed under the older regulations with deeper soil depth requirements will also be selected. Within each field four or more sites will be located for sampling. The soils at each site will be characterized for topsoil depth and subsoil depth. Selected soil samples, in foot increments, will be taken to a depth of five feet and will be characterized for chemical and physical properties. Particle size will be measured using the hydrometer method (Day, 1965). A glass electrode will be used to measure pH (Peech, 1965). Soluble salts will be determined on saturation extracts (Bauer and Wilcox, 1965). Soluble Ca, Mg and Na will be determined quantitatively using atomic absorption spectrophotometry.

Undisturbed cropland fields will be selected as close as possible to the reclaimed fields. Regression equations will be developed which compare wheat yields to depth of soil replacement from each grower/cooperator. All of the data from all of the grower/cooperators will be compiled into one data set and the influence of which regulations are used and the influence of soil depth can be sorted out using analysis of covariance. Undisturbed soils will be compared to reclaimed soils. Soils reclaimed under the previous regulations will be compared to those under the current regulations. Evaluation and recommendations will be made on whether the current soil replacement requirements are adequate.

Anticipated Results

Previous and ongoing research of the LRRC and other organizations indicates that the current soil replacement requirements are adequate to produce yields equal to or

better than before mining. It is anticipated that there will be no relationship between soil depth and wheat yields for soil depths greater than those now required. This would show that current requirements are adequate. The current one-year project should "firm-up" the data already produced by decreasing the large variability in the data. A comprehensive report from the three years of data gathered in this study will be completed. Recommendations will be made on whether current regulations for soil depth replacement on mined land should be continued.

Facilities, Resources and Technologies

The research will be conducted by the staff of the LRRC. We have adequate vehicles and equipment for the research. This includes a hydraulic probe for soil cores which is mounted on a pickup. We have vehicles for transportation and hand tools for harvesting small plots. At our office site in Mandan we have several PC computers hooked up to a software server on which all necessary statistical analyses can be done. Laboratories are well equipped for the kind of analyses described in this proposal.

Environmental and Economic Impacts

During the course of the study the environmental and economic impacts will be very minor. The wheat harvest from each site will total $1m^2$ or less and will be accomplished by walking into each field and hand harvesting each site. Soil sampling will be conducted when no growing crop is in the field.

Ultimately, the impact of this project on the environment will be to reassure the companies, the PSC and farmers and ranchers that the land is being reclaimed to a productive potential equal to or better than it was before mining. The economic benefit

will be that the current reduced depths of soil replacement can be allowed to remain in effect past 1996. Assuming current regulations reduce topsoil respread depths by one foot, about 2.1 million yards of soil will not have to be handled by scrapers each year. This amounts to an annual savings of almost a million dollars for the lignite industry in the state.

STANDARDS OF SUCCESS

The project will be considered successful if the data allow us to determine if the soil replacement requirements are sufficient to ensure that the productivity of reclaimed land is equal to or better than the productivity of undisturbed land (and land reclaimed under the previous regulations).

BACKGROUND

The first experiments in North Dakota on vegetative reestablishment compared the replacement of 2 inches of topsoil with chemical amendments (Sandoval et al., 1973; Power et al., 1974; and Power et al., 1975). These experiments showed that 2 inches of topsoil on sodic spoil produced much higher yields than the application of gypsum. Different depths of topsoil were studied in an experiment initiated in 1972 (Ries et al., 1978). Yields increased with increasing depth of topsoil up to the deepest depth of 12 inches. Yield trends indicated that maximum yields had not yet been reached.

When a nonsodic sandy loam topsoil was replaced on moderately sodic clay loam spoil, yields on 0.15, 0.30 or 0.60 m of topsoil were higher than on only 0.05 m (Halvorson, et al., 1987). Yields on 0.60 m of topsoil were generally no better than on 0.30 m. In this case, deeper depths of topsoil did not increase yields because the clay loam spoil was not as drought prone as the sandy loam topsoil and therefore, as the depth of topsoil increased, the ability of the profile to continuously supply water to the growing crop decreased.

In a subsoil wedge experiment in which the combined topsoil-subsoil thickness was increased from 0 to 2.10 m over highly sodic spoil with a sodium adsorption ratio

(SAR) of 25, highest yields of all crops occurred when about 0.20 m of topsoil (a mixture of A and B horizons) was placed over 0.55 to 1.10 m of subsoil (C horizon) (Power et al., 1981). Data from 15 wedge plots in Montana, Wyoming, and North Dakota showed that the depth of soil required for maximum production was dependent on spoil characteristics (Barth and Martin, 1984). Maximum production was achieved on these plots when replaced soil depths were 0.71 m on sodic spoil, 0 m on soil-like spoil, and 0.50 m on generic spoil (i.e., spoil lacking distinguishing traits such as sodicity).

As a result of these and other studies, regulations were instituted in North Dakota that required the replacement of 5 feet of topsoil and subsoil. If less than 5 feet of suitable plant growth material (SPGM) was available, then proportionally less was required to be replaced. Research continued in the study of SPGM depth requirements, but now focused on whether 5 feet was more than necessary.

In particular, a study of SPGM requirements on nonsaline, nonsodic spoil compared the productivity of 0.23, 0.46 and 0.69 m of topsoil replaced over loamy sand spoil with and without subsoil, over clay loam spoil, or over silty clay loam spoil (Halvorson et al., 1986). At least 0.69 m of topsoil plus subsoil was required to achieve highest yields on nonsodic, nonsaline, loamy sand spoil, but 0.46 to 0.69 m of topsoil was sufficient for highest yields on clay loam and silty clay loam nonsaline, nonsodic spoil.

The research studies given above and others conducted in North Dakota on SPGM replacement depths were summarized by Doll et al. (1984). In addition, they came to the conclusion that the amount of subsoil needed to restore productivity on reclaimed land is dependent on the chemical and physical characteristics of the underlying spoil.

They developed suggested guidelines for soil replacement based on spoil properties. The parameters they determined to be of importance were sodium adsorption ratio (SAR), texture and electrical conductivity (EC). These recommendations contained a range for the depth of soil to be replaced. Following public hearings the Public Service Commission adopted these recommendations using the lesser depth of the range given and eliminated the EC requirement. In addition, more soil is required if the saturation percentage is greater than 95% for spoil with an SAR of 12-20. These requirements are given in Table 1. A sunset clause was added to these regulations so that starting in 1997 the regulations will revert to the deeper depths of suitable plant growth material. A two-year extension of the current rules is pending.

A two-year study was initiated to determine if current regulations reclaimed the land as well as the regulations prior to 1987. In 1994 lands reclaimed under the current regulations had wheat yields equal to those under the previous regulations. Yields were extremely variable within fields and between fields. Much of this difference appeared to be due to differences in management between the growers. On land reclaimed under the current regulations yields increased with soil replacement depth, but with an R^2=.07. Therefore, soil replacement depth only accounted for 7% of the variability in the data. In 1995 there was no significant difference between the yields on land reclaimed under the current regulations and regulations prior to 1986. Depth of soil replacement did not significantly influence yields. Again in 1995, variability in the data was very large and this made it difficult to interpret the data.

QUALIFICATIONS

The LRRC has been conducting research on the reclamation of mined lands since 1981. The staff is well acquainted with this subject and have published widely in this area. The principal investigator, Gary Halvorson, has conducted research in mined-land reclamation for 16 years. Dr. Halvorson has been involved in numerous projects studying the depth of soil replacement necessary for reclamation of stripmined land in North Dakota. A more detailed listing of his qualifications and pertinent references is given as an appendix to this proposal.

VALUE TO NORTH DAKOTA

Successful completion of this study will show whether the current soil replacement depths are adequate for successful reclamation in North Dakota. This should reassure companies, government officials, and farmers and ranchers that the land is being reclaimed to equal to or better productivity. If the results show that current standards are inadequate, then the data should provide enough information to change the standards in order to get adequate reclamation.

Assuming that this study does show that current soil replacement depths are adequate, recommendations will be made to make the current requirements permanent. As compared to the earlier requirements for a deeper depth of soil, cost savings for the lignite industry will be continued. Cost savings are estimated to be about a million dollars a year.

MANAGEMENT AND TIMETABLE

This project will be managed to ensure the timely completion of the various aspects of the project. This includes selecting the sites, harvesting the wheat, taking soil samples and analyzing them for chemical and physical properties, statistically analyzing the data and presenting the data in reports to the industrial commission and industry. The various aspects of the study will be completed as given in the following timetable.

	1996									1997	
Tasks	A	M	J	J	A	S	O	N	D	J	F
Plan with Cooperators	X	X									
Select Sites		X	X	X							
Harvest					X						
Soil Samples						X					
Data Analysis						X	X	X	X	X	
Reports				X				X		X	X

Budget		
Item	**Industrial Commission**	**Lignite Companies**
Salary		
Scientist (2.5 mo.)	$ 5,209	$ 5,209
Technician (3 mo.)	3,750	3,750
Temporary Help	500	500
Fringe Benefits		
Full time (.27)	2,419	2,419
Temporary (.01)	5	5
Total Salaries	**$11,883**	**$11,883**
Operating		
Supplies	1,000	1,000
Repair and Main.	200	200
Total Direct Costs	**$13,083**	**$13,083**
Indirect Costs (.232)	**$ 3,035**	**$ 3,035**
Total Cost	**$16,118**	**$16,118**
Total Project Cost $32,236		

TAX LIABILITY

As part of NDSU, the LRRC does not pay taxes.

Appendix A.

LITERATURE CITED

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Appendix B.

GARY A. HALVORSON
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CURRENT EMPLOYMENT

Currently employed as Interim Superintendent/Soil Scientist by North Dakota State University at the Land Reclamation Research Center, Mandan, ND.

PREVIOUS EMPLOYMENT AND EXPERIENCE

Developmental leave: Six months of developmental leave working with Dr. Jerry Jurinak at Utah State University; January 1, 1987 to June 30, 1987.

Fertility status of potato fields: Two months evaluating the fertility status of irrigated potato fields in eastern Oregon.

Research fellowship to the Soviet Union: Research fellowship to the Timiryazov Agricultural Academy in Moscow, USSR; February 1978 through November 1978.

Ph.D-cadmium and zinc chemistry: Ph. D in soil chemistry completed in 1979 at Oregon State University. Thesis title was "*Extraction and plant availability of cadmium and zinc in a Willamette sandy loam soil.*"

MS - Land application of municipal waste: MS degree in soil chemistry completed in 1975 at Oregon State University. Thesis title was "*Movement of elemental constituents in Sagehill loamy sand treated with municipal waste.*"

Graduate study - Geology: Completed one semester of graduate study in geology at the University of Colorado in the fall of 1971.

BA - Chemistry: Bachelor of Arts degree was obtained in chemistry from St. Olaf College in 1971; minor area of study was Russian.

RESEARCH PROJECTS

Reclamation of mined lands: Research has included reclamation of prime and nonprime agricultural land; fertility requirements of reclaimed cropland and pasture for N, P, and Zn; depth requirements for topsoil and subsoil on reclaimed land on salt-affected and nonsaline, nonsodic spoil; and the spatial variability of regraded spoil chemical and physical properties.

Brine disposal pits: A grant from the North Dakota Water Resources Research Institute was used to study salt contamination of groundwater and agricultural land from buried brine disposal pits.

Reclamation of a saltwater blowout site: The saltwater blowout of an oil well drilling site caused extensive damage to soils and vegetation.

Topsoil depth requirements: A grant was obtained from the Falkirk Mining Company to study topsoil and subsoil replacement depth requirements on spoil material which is neither saline nor sodic. This research resulted in a change in the regulations on subsoil depth requirements.

Disposal of municipal wastes: Research at Oregon State University centered on the disposal of municipal refuse and sewage sludge on agricultural land and its effect on plant growth and contamination of the groundwater.

Appendix C.

PERTINENT LRRC PUBLICATIONS

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April 26, 1996

Mr. Clifford Porter
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Bismarck, ND 58502-2277

Dear Clifford:

Please find enclosed 35 copies of our research project entitled "*Reducing the management variable in assessing reclamation success.*" The $100 application fee is in process and should arrive shortly. I talked to Dr. Todd this morning and between the two of us we will guarantee that all of the work in this proposal will be completed. Dr. Todd plans for us to get together in the near future to discuss this and any other questions you may have.

Sincerely,

Gary Halvorson

Gary A. Halvorson
Director

GAH/ks

Enclosures

NORTH DAKOTA STATE UNIVERSITY

APPLICATION TRANSMITTAL

SPONSOR ORGANIZATION: Industrial Commission & Lignite Companies

PROJECT TITLE: Reducing the Management Variable in Assessing Reclamation

PRINCIPAL INVESTIGATOR: Gary Halvorson

DEPARTMENT: Land Reclamation Research Center

PROJECT BUDGET: $32,236.00

AUTHORIZED UNIVERSITY REPRESENTATIVE: William K. Perrizo, Ph.D

Title: Interim Dean, Research Administration

Address: NDSU, P.O. Box 5790
Fargo, North Dakota 58105-5790

Phone: (701) 231-7033

Signature: William Perrizo

Date: 4-29-96