THE IMPACT OF RECLAMATION ON ACCEPTABLE STRIP MINING ROYALTY PAYMENTS*

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INTRODUCTION

Rapid increases in energy prices, federal policies of energy independence and further projections of energy shortages are encouraging development of sources of energy such as strip mining for coal. A key issue faced by the owner of surface and sub-surface (mineral) rights to land is determination of the price or fee (royalty) that should be extracted from a miner who wants access to the subsurface resource. This is a crucial problem because productivity and income potential of the surface resource may be altered during the mining process. Although extracting coal through strip mining is an obvious example of this phenomenon, the same issue is confronted in surface extraction of other minerals or in placement of easements or restrictions on land use options available to surface property-right owners.

The particular mode of accessing the subsurface resource will influence not only cost to the miner, but also the future income stream of the surface owner. For example, strip mining with no attempt to reclaim the surface will lower costs to the miner, but will also lower the future income stream of the surface right holder — thus encouraging the surface right owner to extract a higher price for interfering with his use of the surface resource. In contrast, reclamation will usually increase the miner's direct cost, but reduce income forgone by the surface right owner. Thus, the owner need not extract as high a royalty to compensate for the interference with his surface activity.

In essence, a key issue faced by the surface resource owner is determining the loss or cost resulting from interference with use of his surface right. This determination will specify the minimum price he must extract to allow access to the subsurface resource. For the miner who desires access to the subsurface right, the issue is the maximum price that can be paid for reclamation and the right to mine without impairing his profit. A further issue of importance is the impact of different reclamation practices on the maximum royalty acceptable to the surface owner.

In reality, royalty value is composed primarily of two parts — intrinsic value of the mineral and value of reduced surface production due to mining. The following conceptual model develops a method to analyze the value of reduced surface production, but does not attempt to measure the intrinsic value of the mineral. As a consequence, the conceptual model and the resulting example generate minimum royalty values for the land owner that are typically less than current market prices. The difference, of course, depends on the value of the particular mineral (gold, coal, limestone, etc.) and relative economic conditions.

A CONCEPTUAL MODEL

Two firms are assumed: one owns both surface and subsurface property rights, and the other wants to extract subsurface resources. Each firm operates in a competitive market where prices of inputs and products are exogeneously determined. The owner may be a farmer or rancher who produces and sells

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agricultural commodities as his source of income or someone who sells recreation services, forest products or other surface services. In this example, the owner is assumed to be a farmer. The miner extracts and sells the subsurface resource to generate income. In addition, he produces a second product that influences the future income stream of the owner — the quality and productivity of the land surface after mining. Both firms maximize profits independently.

The Farmer

The minimum price (royalty) the farmer should accept to allow the miner to interfere with his cultivation of the surface is the income that will be foregone during and after the mining process. The farmer's future income stream from a particular tract of non-mined land can be defined as:

$$I = \sum_{t=1}^{\infty} \frac{\sum_{j=1}^{w} Q_j^t Y_j^t - \sum_{i=1}^{s} P_i^t X_i^t}{(1+r)^t} \qquad (1)$$

where

I = net present value of income during the planning horizon
Q_j^t = price of agricultural commodities in time t
P_i^t = price of agricultural inputs in time t
Y_j^t = agricultural outputs in time t
X_i^t = agricultural inputs in time t and
r = rate of discount.

The production function representing agricultural production on non-mined land is specified as:

$$Y^t = f(X_i^t, R) \qquad (2)$$

where

X_i^t = conventional management and inputs and
R = quality characteristics of non-mined land.

The rate of discount is defined as:

$$r = r^{\rho} + r^{\alpha} - r^{\propto} \qquad (3)$$

where

r^{ρ} = a pure time preference for money
r^{α} = risk premium associated with traditional agricultural production
$r^{\propto}$ = expected rate of annual land value appreciation.[1]

If the subsurface resource is mined and the surface altered during the mining process, the farmer's income is reduced through reduced productivity during the mining and reclamation period. The actual level and timing of loss depends upon the mining and reclamation process used. This reduced productivity can be reflected in lower income by substituting the production relationship for reclaimed land in equation (1). In general, the production function for reclaimed land would be specified as:

$$Y^{t*} = f(X_i^{t*}, R^*) \qquad (4)$$

where

Y^{t*} = agricultural output on reclaimed land in time t (may be zero during mining, and different commodities may be produced after mining)
X_i^{t*} = agricultural inputs to be used on reclaimed land in time t and
R^* = quality characteristics of the land immediately after mining.

Furthermore, the farmer may associate a higher risk with producing agricultural crops on reclaimed land. Thus, the discount rate included in (1) for farming reclaimed land would be defined as:

$$r = r^{\rho} + r^{\beta} - r^{\delta} \qquad (5)$$

where

r^{β} = higher risk premium associated with producing on reclaimed land and
r^{δ} = expected rate of annual land value appreciation.

By substituting relationships (4) and (5), and (2) and (3), respectively, in equation (1), an income stream for farming reclaimed land can be generated. If I represents the future income stream (using equation (1)) from farming the tract of land with no mining, and I* the future income stream from farming on reclaimed land, the minimum royalty the farmer would accept for the right to mine is defined as:

$$L_{min} = I - I^* \qquad (6)$$

The Miner

The maximum price (royalty) a miner can pay to acquire access to the subsurface resource is the difference between his potential income from the sale of the coal and his total expenses (including a normal profit), excluding the royalty payments.

[1] Asset appreciation is assumed to substitute in part for annual revenue from using an asset. Therefore, the rate used to discount annual cash income is reduced by the rate of land appreciation to reflect substitution of capital gain for cash income.

Expenses incurred during mining and reclamation vary with different techniques and equipment complements. Draglines, shovels and scraper-dozer complements have different operating costs per ton depending upon whether they are involved in the mining operation or reclamation. Draglines generally have low (relative to shovels and scraper-dozers) costs per ton during mining but higher costs per ton when certain reclamation operations are performed. Conversely, scraper-dozer complements have high (relative to draglines and shovels) costs per ton for mining functions but lower costs per ton for various reclamation practices. Therefore, the maximum royalty a miner can pay (L_{max}) will vary among mining and reclamation methods and can be expressed as:

$$L_{max} = \sum_{t=1}^{z} \frac{P_c^t C^t - \sum_{n=1}^{s} P_m^t Z_m^t}{(1 + v)^t} \qquad (7)$$

where

P_c^t = price of coal in time t
C^t = coal output in time t
P_m^t = price of coal mining and reclamation inputs in time t *excluding* price of the right to access of the subsurface resource
Z_m^t = coal mining and reclamation inputs in time t *excluding* right to the subsurface resource
v = rate of discount (possibly composed of time preference, risk, asset appreciation of inputs, and/or other factors unique to the industry).

The mining process generates two outputs, coal and reclaimed land with particular quality characteristics. These outputs are influenced by the mining and reclamation procedures used and can be specified as:

$$C^t = f(E_m^t, D_m^t) \qquad (8)$$

(coal production function)

$$R^* = f(E_m^t, F_m^t) \qquad (9)$$

(reclaimed land production function)

where

E_m^t = inputs used to produce coal and reclaim land in time t
F_m^t = inputs unique to the reclamation process in time t
D_m^t = inputs unique to the coal production process in time t.

Scrapers, dozers, draglines and shovels are examples of E_m^t inputs because they can be used to mine coal as well as to reclaim land. Draglines and shovels can judiciously remove and replace overburden while dozers and scrapers can level and relocate spoil piles. Unique inputs of reclamation (F_m^t) include seed, fertilizers and traditional farming equipment. Alternatively, certain inputs such as front-end loaders and augers used to mine coal are generally not used in reclamation.

Finally, state and federal laws specify a minimum quality of the reclaimed land, or

$$R^* \geq \overline{R}. \qquad (10)$$

Notice that the quality of reclaimed land ($R^* = f(E_m^t, F_m^t)$), an output for the miner, becomes an input in the farmer's crop production function. $\overline{R}$ is one of the key constraints for the individual decision maker, but it is a *decision variable* in the public policy arena. In fact, one possible application of this conceptual model is to determine private costs of various levels of $\overline{R}$ as an input into the policy decision concerning reclamation laws.

This conceptual model requires a complete specification of the cost and revenue functions for both miner and farmer, and empirical relationships for production functions must be estimated. Response data necessary to empirically estimate these relationships are sketchy and very limited.[2] An alternative approach, based on the same concepts, is to use budgets rather than continuous production functions to determine the difference in royalties a miner can pay (or that a farmer would require) based on different reclamation practices.

AN ILLUSTRATIVE EXAMPLE[3]

A simple example will be used to illustrate the impact of different reclamation practices on royalty payments and land values. Results will indicate the minium royalty the farmer should be willing to accept, maximum royalty the miner can pay, and the difference (if one exists) which represents a cost someone must bear.

[2]An intensive search was performed to find useful secondary data to estimate response functions. See [3] in the references section for further information.

[3]Results contained in this example are synthesized from actual conditions and are based on the most reliable information available concerning costs, prices and reclamation and management practices. Caution should be used in further extrapolation of these results.

Assumptions

The land profile is characterized by 40 feet of both toxic and non-toxic shale—eight feet of glacial till and loess as soil parent material, and five feet of the A horizon topsoil and B horizon soil. The following four mining and reclamation methods are considered:

(1) Invert overburden, then leave toxic material on surface with no agricultural production possible.
(2) Invert burden, then place nontoxic material on surface with limited agricultural production possible.
(3) Remove the top two and one-half feet of soil from surface before mining and spread on reclaimed land. Agricultural production is increased over method (2) above.
(4) Remove the top five feet of soil from surface before mining and spread on reclaimed land. Agricultural production reaches pre-mined levels after the fifth year of production after mining terminates.

A five year span is assumed to be the minimum time frame for the soil to stabilize after being disturbed.[4] The land disturbed is assumed to have high productivity (100 bushels per acre of corn, 40 bushels per acre of wheat). In addition, two post mining moisture characteristics are considered—low moisture holding capacity and no moisture holding problem. A major problem associated with reclamation is compaction, which reduces moisture holding capacity and restricts root growth. Corn and wheat are the two crops analyzed; corn because of its wide adaptability as a row crop and wheat for its superior quality during the early portion of reclamation.[5] Two cropping rotations are considered, a wheat-wheat-wheat-corn-corn rotation and continuous wheat.

The farmer is assumed to own both surface and mineral rights in fee simple. For the miner, a small dragline is assumed to be used as the primary stripper. All overburden is moved with the dragline in projections where soil is not replaced. Wheel tractor scrapers are used to move soil in operations requiring replacement of soil on top of other spoils. Scraper one-way hauling distance is 1400 feet. Owning and operating costs for the dragline are estimated at $.1444 per bank cubic yard (BCY). Scrapers can perform soil replacement operations for $.30 per BCY. All other operations and costs are assumed constant among methods.

Impact on the Farmer

The farmer's estimated returns to land per acre for various rotation practices and the two post-mining soil moisture scenarios are shown in Table 1. With no moisture holding problem on a wheat-wheat-wheat-corn-corn rotation and a reclamation practice of replacing five feet of soil, production and income approach original land potential. A reclamation practice of replacing two and one-half feet of soil has returns to land of only about 80 percent of the original land and reclamation practice of five feet of soil. When no soil replacement is performed during reclamation but a nontoxic surface is left, returns to land are reduced by 40 percent. Land values are correspondingly lower.

Under a wheat-wheat-wheat-corn-corn rotation with low moisture holding capacity soil after mining, production is reduced dramatically except for the reclamation practice involving replacement of five feet of soil.[6] Reduced water holding capacity results in "normal" production during wet years, but low production during normal or dry years. Reclamation with two and one-half feet of soil reduces returns to land by 65 percent compared to pre-mining conditions, and reclamation without soil replacement (leaving a non-toxic surface) reduces returns by about 88 percent.

With no soil replacement but a nontoxic surface, negative net returns are indicated in all cases during the first and second years in agricultural production. The farmer is not recovering variable costs and would be better off not to produce. However, it is assumed that the soil must go through tillage cycles to improve pore space, tilth and build up organic matter if no topsoil is replaced. The farmer must sustain these losses in order to attain positive net returns during later time periods.

Miners have indicated that a decrease in yield often occurs during the second year of production on reclaimed land. Data and experiments do not show conclusively why these yield decreases occur; however, nitrogen immobilization by microbes may occur

[4] Actually, soil conditions will never stabilize, but after five years the change is assumed to be gradual and for practical purposes non-measurable.

[5] Reclamation practices by industry as well as agronomic research by universities and private firms provide evidence that row crop-small grain (especially wheat) rotations are excellent tillage practices for reclaimed land.

[6] Five feet of soil is assumed to be sufficient to prevent water holding problems due to compaction from mining and reclamation. Topsoil texture and type, slope and drainage after reclamation are all assumed to be similar to pre-mined conditions. It may be possible to reclaim land to higher productivity with tiles, terraces and other soil improvement methods, particularly on certain land types. Presently, however, empirical studies reveal only very isolated cases of mined land being higher in productivity than unmined land.

TABLE 1. RETURN ABOVE VARIABLE COST PER ACRE FOR LAND WITH HIGH PRE-MINED PRODUCTIVITY BEFORE AND AFTER MINING UNDER VARIOUS ROTATIONS AND RECLAMATION PRACTICES

Rotation Practices	Years 1[a]	2	3	4	5	6[b]	Proportion of Pre-mined Productivity After Mining[c]
	dollars per acre						percent
Non-Mined Land							
Continuous Corn	$98.83	98.83	98.83	98.83	98.83	98.83	--
Continuous Wheat	87.30	87.30	87.30	87.30	87.30	87.30	--
Mined Land							
Wheat-Wheat-Wheat-Corn-Corn (No moisture holding problem)							
No topsoil-Toxic Surface	0	0	0	0	0	0	0
No topsoil-Nontoxic Surface	0	(11.70)	(27.20)	12.30	14.84	55.34	60
2 1/2 feet of soil	0	22.80	23.30	42.30	48.34	79.59	80.5
5 feet of soil	0	37.30	47.80	54.80	70.59	98.84	100
Wheat-Wheat-Wheat-Corn-Corn (Low moisture holding capacity)							
No topsoil-Toxic Surface	0	0	0	0	0	0	0
No topsoil-Nontoxic Surface	0	(11.70)	(27.20)	12.30	(52.66)[d]	(17.16)[d]	12.3
2 1/2 feet of soil	0	22.80	23.30	42.30	3.34	34.59	35
5 feet of soil	0	37.30	47.80	54.80	70.59	98.84	100
Continuous Wheat (No moisture holding problem)							
No topsoil-Toxic Surface	0	0	0	0	0	0	0
No topsoil-Nontoxic Surface	0	(11.70)	(27.20)	12.30	31.05	49.80	57
2 1/2 feet of soil	0	22.80	23.30	42.30	64.80	72.30	82.8
5 feet of soil	0	37.30	47.80	54.80	71.05	87.30	100

[a]Land is assumed not to be in production for one year during the mining process.

[b]After the fifth year back in production, land is assumed to maintain the fifth year's return into infinity.

[c]These percentages were derived through the budgeting process which includes the best production response data available from university personnel (Iowa State University, Western Illinois University and the University of Florida), industry (Utah International, Amax Coal Co. and Peabody Coal Co.), and other individuals involved in both private and public reclamation projects.

[d]Losses occur because rotation shifts from wheat to corn during remaining years.

while the previous crop residue is decomposing, decreasing nitrogen availability for second year crop production. This occurrence presumably could be eliminated with proper management.

Table 2 summarizes land values for the various reclamation scenarios of Table 1. These values were calculated as the discounted net revenue stream from farming (net returns to land) for the different mining-reclamation-rotation practices. Maintaining land in production and not mining has a higher value to the owner for any given discount rate than any mining-reclamation-rotation practice. This is because no agricultural production occurs during the year of mining and lower returns are obtained during the rehabilitation period.

The difference between net present value without mining and net present value with mining under any rotation—reclamation practice represents economic loss to the farmer. He must recover at least this value in royalties to allow mining to take place. Using the conceptual model outlined earlier and an eight percent discount rate, unmined continuous corn land has a value of $1223 per acre (I). Land reclaimed with two and a half feet of soil with no moisture

TABLE 2. NET PRESENT VALUE OF INFINITE INCOME STREAMS (LAND VALUES) FROM NON-MINED LAND AND LAND RECLAIMED UNDER VARIOUS RECLAMATION PLANS, CROP ROTATIONS AND DISCOUNT RATES

Reclamation and Rotation Practice	Discount Rate (%) 6	8	10	12	14
	dollars per acre				
Non-Mined					
Continuous Corn	1,631	1,223	978	815	699
Continuous Wheat	1,455	1,091	873	728	624
Mined					
Wheat-Wheat-Wheat-Corn-Corn (No moisture holding problem)					
No topsoil-Toxic Surface	0	0	0	0	0
No topsoil-Nontoxic Surface	677	458	331	249	193
2 1/2 feet of soil	1,098	777	588	464	378
5 feet of soil	1,394	995	759	604	495
Wheat-Wheat-Wheat-Corn-Corn (Low moisture holding capacity)					
No topsoil-Toxic Surface	0	0	0	0	0
No topsoil-Nontoxic Surface	(214)	(162)	(130)	(108)	(93)
2 1/2 feet of soil	507	366	282	227	188
5 feet of soil	1,394	995	759	604	495
Continuous Wheat (No moisture holding problem)					
No topsoil-Toxic Surface	0	0	0	0	0
No topsoil-Nontoxic Surface	620	422	307	232	181
2 1/2 feet of soil	1,022	728	557	440	360
5 feet of soil	1,257	901	690	552	454

holding problem is worth \$777 per acre (I*). Therefore, minimum royalty acceptable to the farmer (L_{min}) is \$446, i.e., $L_{min} = \$1223 - 777 = \$446$. The farmer must have \$446 per acre to cover the value of lost production while mining and of lower production during and after rehabilitation.

Growing crops on reclaimed land is generally riskier than unmined land. If the farmer assigns an additional risk premium of four percent to farming on reclaimed land (an increase from eight to 12 percent in the above example) reclaimed land value (I*) decreases from \$777 to \$464. L_{min} then increases from \$446 to \$759 (\$1223 − 464). Table 3 shows various L_{min} values under different reclamation practices and discount rates (to show sensitivity) with no additional risk premium for farming mined compared to unmined land. Table 4 shows L_{min} values when mined land has a four percent risk premium compared to unmined land.

Data in Table 2 assume loss of one cropping season with crop production beginning in the second crop season after mining. If land is out of production for more than one season, values of reclaimed land would be less and royalty payments necessarily higher. For example, leaving land out of production two years instead of one results in approximately a five percent decrease in land value when a six percent discount rate is used and a 12 percent decrease in value when a 14 percent discount rate is used. The farmer's required royalty payments would increase by similar amounts.

TABLE 3. MINIMUM ROYALTY ACCEPTABLE (L_{min}) BY THE FARMER UNDER VARIOUS RECLAMATION PLANS, CROP ROTATIONS AND DISCOUNT RATES (NO RISK PREMIUM FOR FARMING RECLAIMED LAND) WITH CONTINUOUS CORN AS INITIAL PRE-MINED CROP

Reclamation and Rotation Practice	Discount Rate (%)				
	6	8	10	12	14
	------------dollars per acre------------				
Wheat-Wheat-Wheat-Corn-Corn (No moisture holding problem)					
No topsoil-Toxic Surface	1631	1223	978	815	699
No topsoil-Nontoxic Surface	954	756	647	566	506
2 1/2 feet of soil	533	446	390	351	321
5 feet of soil	237	228	219	211	204
Wheat-Wheat-Wheat-Corn-Corn (Low moisture holding capacity)					
No topsoil-Toxic Surface	1631	1223	978	815	699
No topsoil-Nontoxic Surface	1845	1385	1108	923	792
2 1/2 feet of soil	1124	857	696	588	511
5 feet of soil	237	228	219	211	204
Continuous Wheat (No moisture holding problem)					
No topsoil-Toxic Surface	1631	1223	978	815	699
No topsoil-Nontoxic Surface	1011	801	671	583	518
2 1/2 feet of soil	609	495	421	375	339
5 feet of soil	374	322	288	263	245

TABLE 4. MINIMUM ROYALTY ACCEPTABLE (L_{min}) BY THE FARMER UNDER VARIOUS RECLAMATION PLANS AND DISCOUNT RATES (ASSUMING A FOUR PERCENT RISK PREMIUM FOR FARMING RECLAIMED LAND) WITH CONTINUOUS CORN AS THE INITIAL PRE-MINED CROP

Reclamation Practice	Discount Rates		
	Pre-mining-6%; After reclamation-10%	Pre-mining-8% After Reclamation-12%	Pre-mining-10% After reclamation-14%
	------------dollars per acre------------		
Wheat-Wheat-Wheat-Corn-Corn (No moisture holding problem)			
No topsoil-Toxic Surface	1631	1223	978
No topsoil-Nontoxic Surface	1300	974	785
2 1/2 feet of soil	1043	759	600
5 feet of soil	872	619	483
Wheat-Wheat-Wheat-Corn-Corn (Low moisture holding capacity)			
No topsoil-Toxic Surface	1631	1223	978
No topsoil-Nontoxic Surface	1761	1331	1071
2 1/2 feet of soil	1343	996	790
5 feet of soil	872	619	483

Impact on the Miner

As mined land is reclaimed to higher levels of productivity, post-mining value increases and, therefore, the amount of royalties required by the farmer decreases. Reclaiming land to higher productivity levels, however, results in increased costs to the miner. By analyzing incremental changes in cost to reclaim land to higher productivity levels, changes in the miner's ability to pay royalties can be determined. In the following discussion only the incremental cost changes and incremental ability to pay will be evaluated, not the total amount of royalties the miner could pay.

Table 5 shows additional cost incurred to replace soil with scrapers and dragline cost savings with soil replacement. It is assumed that no additional costs are incurred by the miner to invert the overburden and leave nontoxic soil on the surface.[7] The soil replacement operation, therefore, is of primary concern in determining increased costs of reclamation and the miner's ability to pay royalties.

If the miner places two and one half feet of soil on the surface, net increase in cost to the miner is \$628 per acre (Table 5). If we assume royalties paid in one lump sum and, therefore, do not require discounting and a normal profit margin, maximum royalty (L_{max}) is then decreased by \$628 compared to the royalty with no soil replacement. Ability of the miner to pay royalties decreases as soil replace-

[7]This is not an unrealistic assumption in most areas of the United States. By judiciously placing overburden with a dragline, a nontoxic surface can be obtained without much difficulty by using horizon C loess.

TABLE 5. CHANGE IN MINING COSTS DUE TO VARIOUS RECLAMATION PRACTICES

Reclamation-Rotation Practices	Dragline cost saved by miner	Added cost to spread topsoil by miner	Net increase in cost to miner (L_{max})
	-----------------dollars per acre--------		
Wheat-Wheat-Wheat-Corn-Corn (No moisture holding problem)			
No topsoil-Toxic Surface	0	0	0
No topsoil-Nontoxic Surface	0	0	0
2 1/2 feet of soil	582	1,210	628
5 feet of soil	1,164	2,420	1,256[a]

[a]$1,256 per acre is a conservative figure when compared to recent estimates based on reclaiming land to its original condition. Estimates in this table are, however, logically consistent and reliable when intermediate stages of reclamation (nontoxic, toxic, 2½ feet, 5 feet, etc.) are performed.

ment operations increase his costs. With five feet of soil replaced by the miner, maximum royalties decrease by $1,256 per acre.

When soil replacement operations are performed, royalty required by the farmer (L_{min}) decreases as indicated earlier. The L_{min} for the farmer with no topsoil, nontoxic land is $974 per acre (Table 4). With two and one-half feet of soil, L_{min} is $759 per acre, so a net reduction in required royalties of $215 per acre ($974-759) occurs with the addition of two and one-half feet of soil. The miner's ability to pay (L_{max}) is reduced by $628 per acre if he changes from no soil replacement to two and one-half feet of soil. The net difference of $413 ($628-$215) represents additional cost the miner or consumer must bear.[8] Table 6 shows various values for "net cost" (increased private cost of reclamation minus the private income benefit) for different reclamation practices.

TABLE 6. NET DIFFERENCE BETWEEN THE CHANGE IN MINIMUM ROYALTY THE FARMER IS WILLING TO ACCEPT (L_{min}) AND THE CHANGE IN MAXIMUM ROYALTY THE MINER CAN PAY (L_{max})[a]

Wheat-Wheat-Wheat-Corn-Corn (No moisutre holding problem)	Discount Rate (%) 6	8	10	12	14
No topsoil-Nontoxic Surface to:	---------------dollars per acre----------				
2 1/2 feet of soil	207	318	371	413	443
5 feet of soil	960	1038	1085	1116	1139

[a]Formula used: $\Delta L_{max} - \Delta L_{min}$ = Net Difference.

CONCLUSIONS

The analysis illustrates that good agricultural land, even when reclaimed to a high productivity level, does not have a discounted income stream approaching the value of non-mined land. Further, as productivity is increased to a higher level through better reclamation, increased costs of reclamation more than offset the incremental revenue from farming the land. Reclamation past the no topsoil-nontoxic stage, therefore, is economically inefficient if only private costs and benefits are considered.[9]

An additional issue faced with higher reclamation levels is who will absorb the net difference between the change in minimum royalty the farmer is willing to accept and change in the maximum the miner can pay (difference between changes in L_{min} and L_{max}). In the absence of reclamation laws, the miner would probably reclaim to a nontoxic surface and pay the farmer his minimum acceptable royalty for this reclamation practice. Most state reclamation laws, however, require at least partial soil replacement. With two and one-half feet of soil replaced, the difference between minimum royalty acceptable to the farmer and *increased* cost to the miner is a net cost of $413 per acre for the no moisture holding problem scenario.

This cost must be absorbed in part (in the short run) by the farmer or miner (resulting in a loss or at least lower profit margins) or by consumers through higher prices for energy. The long-run result is that consumers will pay for reclamation. Furthermore, since net cost of reclamation (increased costs of reclamation minus increased agricultural productivity from reclamation) increases with the reclamation effort, consumers will have to pay a higher subsidy for higher levels of reclamation. Although the numerical results are only illustrative, they do provide further insight into economic costs that must be quantified and absorbed in the public policy decision as to the acceptable level of reclamation.

[8]This represents the no moisture holding problem scenario and any other scenario would have correspondingly higher net differences.

[9]The authors are cognizant of the argument that the social discount rate is lower than the private rate; consequently, if a lower rate were used, the net difference ($L_{max} - L_{min}$) would be reduced. This analysis, however, assumes a conceptual model of private individuals acting independently. To argue that *private* individuals lower their discount rate to *social* levels is inconsistent with the profit maximization assumption. It may be that a lower social rate *should* be used to reconcile the net difference, but this is part of the policy question, not of negotiations between private individuals.

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