United States Department of the Interior
Geological Survey

ECONOMIC ANALYSIS OF MAXIMUM ECONOMIC RECOVERY OF FEDERAL COAL

by

William Watson and Richard Bernknopf

1979

Open-File Report 79-1142

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards.

Executive Summary

The proposed Federal coal management regulations (Federal Register Monday, March 19, 1979, part III pp. 16800 - 16845) require maximum economic recovery (MER) of Federal coal on all new Federal coal leases. An economic interpretation of the proposed MER rule is that on Federal leases all coal seams whose collective average private costs are equal to or less than price are required to be mined. The intent of the rule is to force more coal to be mined on a given lease, thereby delaying (a) the lateral extension of the land disturbance impacts from surface mining and (b) the beginning of mining in new regions.

The main issue investigated in this report is whether this MER rule or some other MER rule is economically efficient. Maximum economic efficiency or recovery would occur in this situation when extra administration and mining costs for MER are just offset by extra benefits.

Extra administrative costs would be costs of additional core drilling and analysis to determine the seams that are to be removed, and costs of explaining, defending, and possibly modifying the Federal Government's MER decisions. Extra mining costs would be the costs of removing seams that private operators on Federal leases would not otherwise remove on their own part (such seams are referred to as privately uneconomic seams) and extra benefits would be environmental costs and socioeconomic impacts that are avoided because more coal is removed from currently producing tracts instead of through lateral extensions of mining activity.

Examples of benefits that could derive from mines that are deeper and have slower rate of lateral extension are fewer disturbed acres, fewer acres partially reclaimed to the standards of the Surface Mining Control and Reclamation Act, fewer environmental disamenities from railroad tracks, haul roads, and power lines, and fewer boomtown cycles.

Analysis is undertaken for the currently proposed rule (MER option 3) and two other alternatives:

- mine all seams that have marginal private costs less than or equal to price (MER option 1)
- mine all seams that have marginal social costs less than or equal to price (MER option 2)

The analysis provides estimates of extra administrative and mining costs to society and a qualitative description of the environmental benefits that could result from the alternative MER rules.

The significant results of the empirical analysis are as follows:

- Extra administrative costs to the Federal Government and mining companies under MER options 2 and 3 (compared to MER option 1) are estimated to be $150,000 a year and $1.5 million per year, respectively.
- Under MER option 3 assuming Federal leasing commences during 1980, removal of privately uneconomic seams could be required on about 25% of the Federal coal to be stripped in the year 1985. This could increase mining costs by $113 million per year by 1985 in comparison with MER option 1.

- Assuming 356 million tons of Federal coal are stripped in 1985, the application of MER option 3 would result in 456 fewer acres being disturbed in 1985. This would amount to about a 9 percent reduction in acreage disturbed under Federal leases in 1985.
- Under MER option 3, additional costs of mining deeper seams do not appear to be justified by benefits. A comparison of benefits (jointly considered) with extra costs indicates that unreasonable values would probably have to be assigned to environmental and socioeconomic impacts to justify the mining of deeper seams under MER option 3.
- There are likely to be few cases if any where mining of additional seams under MER option 2 could be economically justified. Analysis indicates that any candidate seams must be close to already being privately economic. But in this situation, a correct determination of when additional seams should be removed would be very sensitive to small changes in coal prices and mining costs, indicating that "fine tuning" under MER option 2 may be a practical impossibility.

A distinguishing feature of MER option 3 is that it would automatically require removal of privately uneconomic seams on Federal leases anytime that rents on privately economic seams are adequate to finance the removal of privately uneconomic seams. Under MER option 3 there would be no attempt to determine the situations when benefits might (or might not) reasonably be expected to exceed costs. The analysis in this report indicates that MER

option 3 could be a relatively costly way of reducing external environmental and socioeconomic costs. Therefore, it is concluded that MER option 3 is likely not to be an economically efficient policy.

MER option 2 would require mining of privately uneconomic seams only when there was a reasonable expectation that benefits might exceed additional mining costs. On the basis of the analysis in this report, it would appear that this might happen very infrequently in the next 20 to 30 year period. Thus MER option 2 might for all practical purposes lead to the same outcome for mining as MER option 1. However, MER option 2 compared to option 1 would have additional administrative costs--on the order of $150,000 a year. In addition, the analysis indicates that a correct economic determination to mine additional seams under MER option 2 would probably be sensitive to changes on the order of $1 to $2 in coal prices and mining costs. It is unlikely that the Federal Government could predict coal prices and mining costs to within $1 to $2 because of changing conditions in the coal market and in technology for mining coal over the extended lifetime of a typical mining operation. Therefore Government decisions could just as easily be wrong as right and thus "fine tuning" under MER option 2 may be a practical impossibility.

Economic Analysis of Maximum Economic Recovery of Federal Coal

The Department of Interior recently proposed regulations that specify the conditions under which Federal coal can be leased and mined (Federal Register, Monday, March 19, 1979, Part III, pp. 16800-16845). One of the requirements for operators mining Federal coal is that they achieve "maximum economic recovery" (MER) of coal on Federal leases. In the proposed rules, MER is defined to be the "amounts of coal that can be recovered by prudent mining practices from all seams that are collectively profitable to be mined on any tract evaluated for a lease sale at the time of the MER determination. Social and environmental costs shall be considered in determining profitability." A brief restatement of this proposed MER rule is that on Federal leases all seams (or portions of the deposit) will be mined that collectively have an average cost equal to or less than price.

It may appear that this rule is rather harsh from the viewpoint of economic efficiency. In competitive markets where all costs are reflected in market transactions, it is well known that maximum economic efficiency would occur when coal is mined to the point where marginal private cost is equal to or less than price. Compared to a marginal private cost rule the proposed average cost requirement would result in a larger amount of coal mined on a given tract and also in higher total mining costs for a given amount of coal mined, all other things held constant. Could this average rule ever be consistent with maximum economic efficiency? The answer on general grounds is that it could be because all the costs of mining coal may not be absorbed by producers or operators on Federal leases in the absence of an MER requirement.

The proposed Federal coal leasing rules (other than MER) impose a number of conditions designed to reduce environmental costs and socioeconomic impacts, for example, the screening out of lands unsuitable for leasing, the resource trade-off decisions made during the Bureau of Land Management's land use planning, tract ranking and selection, the setting of lease stipulations, Office of Mining approval of the mining plan, and regulations deriving from the Surface Mining and Reclamation Act. These rules have the effect of internalizing some of the external environmental and socioeconomic costs that could occur when coal is mined on Federal leases.[1/] But even after application of these rules some external costs could remain. These could take the form of external environmental and socioeconomic impacts that might occur when mining operations are extended laterally. Therefore, it could be economically efficient from a social viewpoint to mine more coal on a given lease and delay the lateral extension of mining activity and its relocation to another region. Maximum economic efficiency or recovery in this situation would occur when extra administrative and mining costs of MER are just offset by extra benefits.[2/] Extra administrative costs would

---

1/ External costs are internalized when they are perceived by producers as part of production costs. Internalization of costs makes costs higher overall. In competitive markets all or part of these higher costs are passed onto consumers in the form of higher prices, thereby also making all or part of external costs internal to consumers.

2/ All impacts from mining additional seams may not be beneficial. Harmful impacts could occur to underground aquifers and to surface hydrology. Another class of disbenefit could occur if mining of additional seams delays the relocation of mining activity to regions where workers and other resources are underemployed. In this report, empirical analysis of such disbenefits is not undertaken. At a later point, implications of leaving out these disbenefits are discussed.

be costs of additional core drilling and analysis needed to determine the seams that are to be removed, and costs of explaining, defending, and possibly modifying MER decisions. Extra mining costs would be the costs of removing seams that private operators on Federal leases would not otherwise remove on their own part, and extra benefits would be environmental costs and socioeconomic impacts that are avoided because more coal is removed from currently producing tracts instead of through lateral extensions of mining activity.

For a given level of coal production, the following are examples of benefits that could derive from a slower rate of lateral extension:

(1) The cumulative number of acres disturbed by any given year would be smaller.

(2) At any one time, there would be fewer acres that were only partially reclaimed to the standards of the Surface Mining Control and Reclamation Act.

(3) The reduced lateral spread of mining activity would reduce any visual disamenities or environmental costs associated with extra miles of railroad tracks, power lines, and haul roads.

(4) Because mines remove more coal per acre, mining operations in any given region would last longer. This could delay the movement of mining activity to new regions and thereby delay the next cycle of "boomtown" social costs (over and and above those covered by taxes on mining operations).

It is clear that the currently proposed MER average cost rule works in the right direction. More coal on a given Federal lease would be removed and the lateral extension of mining activity would be delayed. However it may not be the best rule. If the extra costs are larger than the extra benefits for removing additional beds under the average cost rule, then a marginal private cost rule (mine all seams that have marginal private costs less than or equal to price) would be better, or in other words, less costly to society for a given amount of coal mined. In a sense, average cost and marginal cost rules for MER are extremes. The average cost rule pushes very hard toward removal of additional seams; the marginal private cost rule doesn't push at all. Something in between the two that attempts an explicit balancing of costs and benefits (mine all seams that have marginal <u>social</u> costs less than or equal to price) would seem on balance to provide the most straightforward approach to the problem of maximum economic recovery or efficiency.

The purpose of this paper is to provide an empirical analysis of three alternative MER rules. There are four sections to the analysis:

- a brief description of the parts of the Federal coal management program that involve or are related to MER,

- a listing of the alternative MER rules (marginal private cost, marginal social cost, and average cost) and a discussion of the qualitative implications of choosing each rule,[3/]
- a presentation of estimated costs for mining additional seams and for administering MER under the average cost and marginal social cost MER rules using the marginal private cost MER rule as a baseline, and
- a description of environmental and socioeconomic benefits from mining more coal on a given tract and a comparison of these benefits with the additional costs for the average cost and the marginal social cost MER rules.

The general terms of reference for this report are as follows:

(1) The analysis focuses solely on MER alternatives for surface mineable coal beds. Analysis of MER determinations for underground coal beds is not included because for thick Western underground deposits, MER is mainly a post lease economic-engineering consideration.

(2) In this report, the phrase "removal of privately uneconomic coal" means removal by private operators of Federal coal that is regarded by private operators to be uneconomic. Coal is

---

3/ The alternative MER rules analyzed in this report were originally drafted by personnel in the Assistant Secretary's Office for Policy, Budget, and Administration (PBA) of the Department of the Interior. An "options" paper has been prepared by PBA on these alternative MER rules for use by the Secretary of the Interior in making his decisions in June 1979, on the proposed Federal Coal Management Program.

uneconomic from a private viewpoint when its private mining costs are higher than the private mining costs for other available coal, everything else held constant.

(3) Unless otherwise indicated, costs and benefits for a private marginal cost MER rule are the baseline. Thus "additional" costs and benefits of the average cost and marginal social cost MER rules are their costs and benefits minus costs and benefits of the baseline.

(4) The representative cases analyzed in this analysis are just that. These cases may not necessarily coincide with actual mining operations, rather they are meant to be the average of the situations where privately uneconomic seams could be required to be mined under the average cost MER rule.

1. The MER Process

Procedures for leasing of Federal coal are provided in the Federal Register (Mon., March 19, 1979, Part III, pp. 16800-16845). The requirement for maximum economic recovery is intermixed with a number of other requirements in these regulations and its application is somewhat complex.

There are four stages where estimates of coal recovery need to be made. Each of the four steps allows a more detailed estimate of recoverable coal, based on the more detailed information available at that step in the leasing process. Different MER rules would have different impacts

at each stage. Generally, the MER rules that could involve mining of additional seams on a given tract--such as the average cost and marginal social cost MER rules--would necessitate additional data and more careful evaluations. The four steps are:

(1) Tract delineation. The delineation of a tract will take into consideration what coal is economically recoverable or could be made to be recoverable if Federal bonuses were to be reduced under the average cost and marginal social cost rules for MER.

(2) Tract ranking and selection. The amount of coal recoverable from a tract and the cost of recovery will be important in ranking tracts, and in determining how many tracts are to be selected for leasing in order to meet regional production goals. Under an average cost or marginal social cost MER rule, when privately uneconomic seams are required to be mined on selected tracts, recovery costs per ton on those tracts would be relatively high (compared to tracts where removal of privately uneconomic seams is not required). This could change tract rankings and the leasing schedule for meeting production goals.

(3) Pre-lease mineral evaluation. The purpose of this stage is to estimate a coal resource economic value (CREV). CREV is an estimate of after-tax net present value or the economic rent (in present value terms) on the seams that are to be

mined. The CREV, together with other information, is given to the Bureau of Land Management for use in the determination of a minimum acceptable value for the lease under consideration.

(4) Post-lease mine plan approval. The Federal Coal Leasing Amendment Act of 1976 requires an MER determination before the issuance of a lease as well as before approval of a mining plan. Section 3 of the Act states:

> Prior to issuance of a lease, the Secretary shall evaluate and compare the effects of recovering coal by deep mining, by surface mining, and by any other method to determine which method or methods or sequence of methods achieves the maximum economic recovery of the coal within the proposed leasing tract. This evaluation and comparison by the Secretary shall be in writing but shall not prohibit the issuance of a lease; however, no mining operating plan shall be approved which is not found to achieve the maximum economic recovery of the coal within the tract.

Under current practice, the area mining supervisor determines pre-lease what mining method best yields maximum economic recovery. This is not a detailed determination, seam-by-seam, based on extensive economic analysis. It does involve a general examination of the tract and evaluation based on standard practices to estimate which methods are appropriate. Prior to mining plan approval, the mining supervisor evaluates

the proposed plan in light of maximum economic recovery, specifying modifications where necessary. Under the average cost and marginal social cost MER rules, at the mine plan approval stage there could be some modification in the determination of the seams that are to be removed, based on the more detailed information contained in the mining plan.

2. Alternative Definitions for Maximum Economic Recovery (MER)

Three alternative MER definitions are analyzed in this report. The first definition is a marginal private cost rule, definition 2 is a marginal social cost rule, and definition 3 is an average private cost rule.[4/]

Option 1 (Marginal Private Cost). Maximum economic recovery would have the goal of maximizing the net present value of the coal extracted from a Federal lease. This would mean that after safety factors are taken into account, all portions of the coal deposit within a Federal lease should be

---

4/ The MER alternative currently preferred by the Department of Interior is a slight variation of MER option 3 defined in this report. Depending upon the source, the wording used to define the currently preferred alternative changes a bit but the meanings are equivalent. According to the Draft Environmental Statement Federal Coal Management Program (Dec. 1978 p. 3-41), MER is to be "calculated in a way that all coal seams which are collectively profitable must be mined, taking into consideration social and environmental costs." In "Coal Management Proposed Rulemaking" (Federal Register, Mon. March 19, 1979, Part III, p. 16811) MER "means the amounts of coal that can be recovered by prudent mining practices from all seams that are collectively profitable to be mined on any tract evaluated for a lease sale at the time of the MER determination. Social and environmental costs shall be considered in determining profitability." The main difference between this report's MER option 3 definition and the currently preferred alternative is the dropping of the phrase "taking into consideration social and environmental costs." It is not clear what meaning or operational significance (if any) that phrase has.

mined that have a private incremental cost of recovery (including reclamation costs) less than or equal to the market value of the coal.

Option 2 (Marginal Social Cost). Maximum economic recovery would have the goal of maximizing the net present value of the coal extracted from a Federal lease. Normally this would mean that after safety factors are taken into account, all portions of the coal deposit should be extracted that have an incremental cost of recovery (including reclamation costs) less than or equal to the market value of the coal. But when there are substantial social and environmental costs and benefits that are not otherwise considered in the private decisions of the mining company or the Federal coal management program and when consideration of those additional costs and benefits might reasonably be expected to alter the decision as to what coal should be removed, the Federal land manager may, at his discretion, require that those costs and benefits be considered and that all portions of the deposit be mined for which the marginal social benefits are greater than or equal to the marginal social costs of recovery.

Option 3 (Average Private Cost). Maximum economic recovery is defined as the extraction of those portions of the coal from a Federal lease after safety factors are taken into account, that collectively have an average cost of recovery less than or equal to the market value of the coal.

MER options 2 and 3 differ from option 1 in an important way. With implementation of MER options 2 or 3, operators on Federal leases could be required to mine coal seams that would be uneconomic from a private viewpoint. There are two implications of this difference.

One implication is that under options 2 and 3, when privately uneconomic seams are to be removed, a pre-lease announcement of the seams to be removed should be made so that potential lessees can bid an appropriate amount. Otherwise, unless notified, potential lessees are likely to assume that only privately economic seams are to be removed. They would tend to bid too high and then withdraw their bids when they discover, after the lease sale, that removal of privately uneconomic seams is required. Although the currently proposed regulations, which would implement a variation of MER option 3, do not explicitly state that seams to be removed are to be announced when an MER determination requires removal of privately uneconomic seams, the Department of Interior intends to provide this information prior to a lease sale.

A second impact, comparing options 2 and 3 with option 1, is on the size of the CREV. Under MER option 1 operators would attempt to select the most economic coal for extraction and therefore after tax net present value would be equal to or very close to its maximum value. However, if the Federal Government applied an MER definition such as options 2 or 3 that required removal of privately uneconomic coal, the CREV would be reduced.[5/] Operators, of course, will not remove this coal unless

---

5/ By definition, under MER option 3 the lowest value that the CREV could reach is zero. This would occur when the collective cost for mining all seams (including a normal rate of return on investment) exactly equals revenues from selling the coal. In principle, under MER option 2 the CREV could go negative. If additional benefits were large, removing additional coal could have large costs and achieve a maximum net benefit. If these extra costs exceeded after tax net present value on privately economic seams, then a mining operation that included removal of both privately economic and uneconomic seams would have a negative CREV. In effect, the Federal Government in this case would be providing on outright subsidy for mining of additional seams. However, as a practical matter, the lower limit on the CREV would probably be zero if MER option 2 is adopted by the Department of Interior.

they have financial incentive. For the MER definitions that require removal of privately uneconomic coal, the Federal Government would provide an appropriate financial offset in the form of a reduced bonus. This happens automatically under the proposed rules: when privately uneconomic coal seams are designated, their higher costs lower the U.S. Geological Survey's estimate of CREV and thus the Bureau of Land Management's estimate of a minimum acceptable value. In effect, the Federal Government would be using rent on coal seams that are economic from a private viewpoint to finance (through bonus reductions overall) the mining of coal that is privately uneconomic.[6/]

Adoption of each MER definition as the preferred alternative has certain qualitative implications. Choosing option 1 would be appropriate if adequate mitigation of environmental and socioeconomic impacts were almost always provided by the surface reclamation and Federal coal

---

6/ Since the higher costs for privately uneconomic coal are financed out of reduced Federal bonuses, prices and quantities demanded will be unaffected by MER considerations, other things held constant. From a resource efficiency viewpoint, this could be undesirable. For MER to fully internalize any remaining external environmental and socioeconomic costs, coal prices should be higher to reflect or internalize those costs to coal users. By subsidizing MER, the Federal Government could be keeping coal prices too low and coal demands too high. On the other hand, if the Federal Government did not subsidize MER, there could be substantial shifts into non-Federal coal where MER does not apply. If non-Federal coal seams are thinner and mining costs higher, both resource costs and disturbed acres could be higher than in the current Federal subsidy situation. The problem here is that Federal subsidy for MER is probably not economically efficient and probably neither is application of unsubsidized MER to Federal coal alone. One is left with having to choose between two inefficient policies. On the basis of limited observations, the current Federal subsidy policy would appear to be the better option.

management regulations (other than MER). It is worth noting that other parts of the Federal coal management program do work in the direction of mitigating some of the same kinds of environmental and socioeconomic impacts as would be lessened by MER. For example, surface mining reclamation regulations make mining of new tracts more costly because reclamation of disturbed land is required. This gives incentive to mine more coal on an already disturbed tract in order to avoid reclamation costs on new tracts. Boomtown external costs are mitigated by using severance taxes and the share of Federal royalties and bonuses going to States to purchase social infrastructure such as hospitals, schools, etc. MER by delaying the movement of mining operations to new regions could also mitigate boomtown external costs by reducing the frequency of boomtown cycles. However, in the case of MER the benefit is likely to accrue decades into the future and so it must be appropriately discounted when compared to the extra mining costs incurred in the near term. The point here is that private mining decisions already constrained by Federal regulations (other than MER) could be more or less aligned with socially desirable outcomes. Thus an economically efficient outcome would be to allow operators to pursue constrained private objectives, as MER option 1 does.

A different justification for MER option 1 would be to argue that there may be some cases where mining seams that are slightly uneconomic from a private viewpoint could provide some net benefits (environmental and socioeconomic benefits exceed extra mining costs) but that benefits are likely to be less than the costs of administering MER in those cases.

The second definition is a "fine tuning" option. Choosing this definition would be appropriate if there are some cases when the benefits of mining privately uneconomic seams might resonably be expected to exceed extra costs. While this option would not require an analytical balancing of benefits and costs, there would be an attempt to make an explicit judgment as to whether or not benefits might reasonably be expected to exceed costs. Presumably the judgment would incorporate the best qualitative evaluations of appropriate experts within the Department of Interior.

Choosing option 3 would be appropriate if the environmental and socioeconomic costs that remain after the application of reclamation and coal management regulations (other than MER) were consistently so substantial that extra MER mining and administrative costs seldom if ever exceeded the additional environmental and socioeconomic benefits achieved by mining additional seams. It is important to note that this option does not require a determination that benefits exceed costs. Instead, rents on Federal coal would automatically be used to finance removal of privately uneconomic seams when it is determined that such seams have total mining costs that would not exceed the after tax net present value on the privately economic seams.

The question of which MER option is the "best" one boils down to several empirical questions: What are the extra costs of administering MER options 2 and 3? How often would removal of additional coal be

required under MER options 2 and 3? What are the costs of removal in those cases? How do these costs compare with benefits? These are the topics that are taken up in the remaining sections of this report.

3. Analysis of Costs for Alternative MER Definitions

This section contains estimates of the additional costs to the Federal Government and the mining companies for MER options 2 and 3, taking MER option 1 as the baseline. There are four parts to the analysis of this section:

(1) estimates of additional Federal administrative cost,

(2) estimates of additional administrative costs to mining companies,

(3) estimates of additional mining costs, acres disturbed, and lateral spread for MER options 3 and 1,

(4) estimates of a cost schedule (additional costs per acre not disturbed) for mining a hypothetical privately uneconomic seam at varying depths below a privately economic seam.

3A. Additional Administrative Costs

Additional administrative costs to the Federal Government would occur both before and after lease sales. The estimates of extra pre-lease costs assume that an average of 10 tracts[7/] per year would be evaluated by Federal analysts when the Federal coal leasing program is fully implemented and underway. The possibility that privately uneconomic

---

7/ A tract covers four sections or 2560 acres.

coal seams could be required to be mined would make the evaluation process more complicated than it would be under MER option 1. Additional personnel (such as physical scientists, engineers, and financial analysts) and additional drilling would be needed to identify privately uneconomic seams on Federal tracts and to determine whether their mining costs could be financed without driving the CREV for an entire mining operation to a negative value.

The costs to the Federal Government for additional personnel and drilling under MER option 3 at three stages (tract delineation, tract ranking and selection, and pre-lease mineral evaluation) are estimated as follows:

(1) Pre-lease mineral evaluation will require again as many personnel, per tract evaluated, as are now used by the U.S. Geological Survey in making tract evaluations for short-term leases.[8/]

(2) Tract delineation will require a slight increase in personnel, estimated to be one-tenth of the requirement at the pre-lease mineral evaluation stage.

(3) Tract ranking and selection will require a moderate increase in personnel, estimated to be one-half of the requirement at the pre-lease mineral evaluation stage.

8/ Based upon analysis and data provided by Ray Cheeseman (U.S. Geological Survey memorandum, April 23, 1979).

(4) To evaluate less familiar, privately uneconomic seams, it will be necessary to drill one extra hole on each tract to obtain cores for privately uneconomic seams. The cost of a drill hole to strippable depths is estimated to be $10,600 per hole.[9/]

After a lease sale, additional administrative costs to the Federal Government could be incurred: (1) because determinations under MER option 3 are likely to be challenged by mining companies based on the more detailed information they obtain on the lease when preparing the mining and reclamation plan; (2) because the Federal Government would probably have to more diligently enforce the mining of privately unprofitable seams; and (3) because coal prices and costs of mining could change over the life of a mine and hence the MER determination might have to be periodically recomputed based on changing conditions. It is estimated that extra personnel for dealing with these problems would be one-half of the requirement at the pre-lease mineral evaluation stage.

Under MER option 3, mining of additional seams is automatic anytime rents on privately economic seams are adequate to finance removal of privately uneconomic seams. In comparison, under MER option 2 mining of additional seams is required only when there is a reasonable expectation that benefits will exceed costs. Therefore under MER option 2, there are likely to be many tracts that can be put aside

---

9/ Based upon analysis and data provided by Ray Cheeseman (U.S. Geological Survey memorandum, April 23, 1979).

as not requiring detailed analysis, based on preliminary information that the costs of mining privately uneconomic seams are likely to be very high. To reflect this, additional personnel and drilling costs for MER option 2 are assumed to be one-tenth of the requirements for MER option 3 in all categories.

Summing over all categories, additional administrative costs to the Federal Government under MER option 3 are estimated to be $823,500. Whereas under MER option 2, additional administrative costs to the Federal Government are estimated to be $82,350 (see total, panel A, Table 1).

Prospective lessees would also incur extra administrative costs under either MER option 2 or 3. If privately uneconomic beds are required to be removed, operators planning to bid on Federal leases would have to evaluate mining costs for those beds and adjust their bids accordingly. This could involve the hiring of consultants and could require extra drilling under exploratory licenses by private operators on Federal tracts. The evaluation and personnel requirements would be similar to Federal analysis and requirements at the pre-lease mineral evaluation stage. However, each private company would have to undertake its own evaluation for each tract of interest. This could result in more than a single evaluation per tract whereas in the Federal case more tracts may be evaluated but only one evaluation per tract is required. On this basis it is assumed that evaluation

costs to private mining companies are twice the Federal personnel costs at the pre-lease mineral evaluation stage. Thus additional administrative costs to mining companies are estimated as $700,000 per year under MER option 3 and $70,000 per year under MER option 2 (panel B, Table 1).

Summing over all categories, the additional public and private administrative costs are estimated to be about $1.5 million per year for MER option 3 and about $150,000 per year for MER option 2.

3B. Mining costs, acres disturbed, and lateral spread under MER option 3 and 1.

The next set of estimates to be discussed are total mining costs, acres disturbed, and lateral spread under MER options 1 and 3. The analysis involves the following steps:

(1) Representative coal configurations in specific coal areas are identified where privately uneconomic seams would be expected to be mined under MER option 3.

(2) Average and marginal costs per ton for coal mined in the identified coal areas are estimated (a) assuming the removal of privately economic seams only (MER option 1) and (b) assuming the removal of both privately economic seams and privately uneconomic seams (MER option 3).

(3) An estimate of the amount of coal which could be surface mined in 1985 from each of the specific coal areas is provided

Table 1. Additional annual administrative costs for MER options 2 and 3 beyond costs alternatively incurred under MER option 1 (1978 $)

	MER Option 2	MER Option 3
A. Federal Administrative Costs		
Tract Delineation		
Personnel	$1,750	$17,500
Tract Ranking and Selection		
Personnel	$17,500	$175,000
Pre-lease Mineral Evaluation		
Drilling	$10,000	$106,000
Personnel[a]	$35,000	$350,000
Post-lease		
Personnel	$17,500	$175,000
Total Costs to the Federal Government	$82,350	$823,500
B. Pre-lease Administrative Costs to Mining Companies		
Pre-lease Mineral Evaluation by Prospective Lessees	$70,000	$700,000
Total, Public and Private	$152,350	$1,523,500

[a]Estimated as 7 additional professional employees at $50,000 per person per year. Cost per employee includes salary, fringe benefits, secretarial and computer support, office, supplies, and incidentals.

assuming full implementation of the Federal coal leasing program starting in 1980.

(4) Average costs per ton under MER option 1 and under MER option 3 are applied to total tons produced in 1985 in the identified areas to estimate total mining costs in 1985 in the identified areas under MER options 1 and 3.

(5) Technical equations are applied to estimate acres disturbed and extent of lateral spread under MER options 1 and 3.

The analysis uses the simplifying assumptions of uniform horizontal coal beds and uniform overburden and interburden. A similar analysis could be applied to dipping seams, variable width seams, variable width interburden and overburden, and thin rider seams above the principal seams. These cases would probably be encountered in actual applications of MER to specific coal leases, but the analysis in this report is meant to be illustrative. Further, the actual numerical values used to describe coal geology (for example, seam thickness, overburden, and interburden) do not reflect high degrees of certainty. Data on coal beds and associated rocks were gathered within a time frame too short for detailed measurement. However, the data are adequate for estimating cost differences for representative cases, but it should be noted that these cases and costs may not necesarily coincide with actual mining operations and actual costs.

Three representative coal configurations for strippable Federal coal in specific areas of the West have been identified where privately uneconomic seams would be expected to be mined under MER option 3 (see Table 2). For these areas, estimated after tax net present value for representative mines in each region was estimated to be positive when both privately economic and privately uneconomic seams are required to be mined. Other areas where Federal coal will be stripped in the near term were also analyzed but it was found that (a) either no other strippable seams existed (for example, below the Wyodak coal seam) or (b) no other seams were close enough to privately economic seams to be framed under MER option 3 (for example "Bed 79" below "Bed 80" in the vicinity of Hanna, Wyoming).

For each of the representative areas, selling prices f.o.b. at the mine, and mining costs per ton for the main economic seams were obtained from sources within the U.S. Geological Survey (see Table 3). In the case of the privately uneconomic seams--where mining cost estimates could not be obtained from U.S. Geological Survey sources--average mining costs per ton were estimated by running the Bonner and Moore surface mining simulation model.[10/]

10/ Description and documentation of the Bonner and Moore model are provided in A Coal Production Cost and Discounted Cash Flow Simulation Model (Robert Kalter Associates, Dec. 15, 1977).

Table 2. Three representative coal configurations where privately uneconomic seams could be mined under MER option 3[a]

1. Northeast Powder River Basin, Wyoming[b]

Overburden on the average equals 125 feet
Anderson Coal seam (economic) has an average thickness of 40 feet
Interburden on the average equals 115 feet
Canyon coal seam (economic) has an average thickness of 40 feet
Interburden on the average equals 40 feet
Unnamed coal seam (privately uneconomic) has an average thickness of 10 feet

2. Yampa Area, Vicinity of Steamboat Springs, Colorado[b]

Overburden on the average equals 20 feet
Lennox coal seam (economic) has an average thickness of 5 feet
Interburden on the average equals 30 feet
Wadge coal seam (economic) has an average thickness of 12 feet
Interburden on the average equals 75 feet
Wolf Creek coal seam (privately uneconomic) has an average thickness of 10 feet

3. San Juan Area, Northwest New Mexico[b]

Overburden on the average equals 45 feet
Coal seam 1 (economic) has an average thickness of 6 feet
Interburden on the average equals 25 feet
Coal seam 2 (economic) has an average thickness of 13 feet
Interburden on the average equals 30 feet
Coal seam 3 (privately uneconomic) has an average thickness of 4 feet

[a]Spacing and width of overburden, coal, and interburden in these representative areas were compiled from U.S. Geological Survey coal resource maps and information provided by U.S. Geological Survey area mining supervisors. These cases may not necessarily coincide with actual mining operations, rather they are meant to be the average of the situations where privately uneconomic seams could be mined under MER option 3.

[b]Overburden, coal seam, interburden, and so on are in order starting from the surface and going to deeper depths.

Table 3. Selling Price f.o.b., Average Mining Cost,[a] and Marginal Mining Cost[b] for MER options 1 and 3 (1978 $/Ton)[c]

	MER Option 1	MER Option 3
Northeast Powder River Basin		
Selling Price f.o.b.	$ 6.75	$ 6.75
Average Mining Cost/Ton	$ 4.60	$ 5.14
Marginal Mining Cost/Ton	$ 4.60	$ 9.10
Yampa Area		
Selling Price f.o.b.	$16.50	$16.50
Average Mining Cost/Ton	$ 8.90	$12.40
Marginal Mining Cost/Ton	$ 8.90	$18.50
San Juan Area		
Selling Price f.o.b.	$ 8.00	$ 8.00
Average Mining Cost/Ton	$ 3.40	$ 4.20
Marginal Mining Cost/Ton	$ 3.40	$ 7.80

[a] Average and marginal mining cost includes annualized capital costs, operation and maintenance costs, and a 12 percent rate of return on investment. Income and severance taxes and royalties are not included in the values reported in this table because the desired estimates are to be average and marginal resource costs. However, income and severance taxes and royalties are reflected in the calculation of after tax net present value which is the basis for determining which seams are privately economic and privately uneconomic.

[b] For MER option 1 marginal mining costs are the same as average mining costs. For MER option 3 marginal mining costs are the additional costs of mining privately uneconomic seams divided by additional tons in those seams.

[c] F.o.b. selling price estimates were obtained from the U.S. Geological Survey, Resource Evaluation Unit, Denver, Colorado. Estimates for average mining costs for mining of principal seams (except for the San Juan area) were obtained from U.S. Geological Survey regional offices. Average mining costs for the main economic seams in the San Juan area were estimated by multiplying its selling price by the average ratio of mining cost to selling price for the other formations.

The Bonner and Moore model was run separately for each seam in each configuration with appropriate input data for each seam.[11] A truck and shovel operation was simulated throughout since this appears, on the basis of cost comparisons with (a) draglines and (b) a truck and front-end loader operation, to be the most economic method for multiple bed stripping. Costs for each seam were added together to determine the combination of seams that would provide the largest estimate for after tax net present value, thereby identifying seams that satisfied the conditions for MER option 1. Other seams were then added to these privately economic seams until such point that the after tax net present value was driven to a negative value, or no other seams were available. Once the appropriate seams were identified, the next step was to estimate average and marginal mining costs per ton under MER options 1 and 3 for the three specific areas of interest. These cost estimates are reported in Table 3.[12]

11/ Input data for each seam consisted of thickness of overburden, coal, and interburden, length of haul roads, the width of the panel being stripped, and mine size. Mine size for the main seam in the Northeast Powder River Basin was set at 5 million tons per year. In the Yampa and San Juan formations, the mine size for the main seam was set at 2.8 million tons. These representative sizes were taken from Premanent Regulatory Program of the Surface Mining Control and Reclamation Act of 1977 (U.S. Department of Interior, Sept. 1978, Table 2, p. 32). A mine production life of 20 years preceded by 3 years for mine development was assumed for all three representative cases.

12/ Additional details on methods and a listing of equations used in these calculations are provided in Appendix I.

Estimates for tons of coal to be strip mined by 1985 from the three areas where MER option 3 would require the mining of privately uneconomic seams are provided in Table 4. The total, 89 million tons, is 25% of the 356 million tons that are estimated to be stripped on all Western Federal lands in 1985. Out of this 89 million tons, about 17.3 million tons or about 5% of all stripped Western Federal coal would actually be recovered in 1985 from privately uneconomic seams under MER option 3. Applying average mining costs per ton to these production estimates gives the estimates of total resource costs shown in Table 5 for MER options 1 and 3.

The two other sets of estimates in Table 5 are acres disturbed and miles of lateral extension of mining activity. These are calculated using "technical" equations:

(1) Acres disturbed equals production divided by the product of tons of coal per acre-foot and the combined thickness of coal seams. As shown by the estimates, fewer acres are disturbed in any one year under MER option 3 compared with option 1.

(2) Miles of lateral extension after 20 years of continuous mining at the indicated annual production rates equals acres disturbed in 1985 times 20 divided by 640 acres per square mile. This provides an estimate of lateral spread in miles assuming the mining operation is moving along with a one-mile-wide cut.

It should be be noted, however, that differences in acres disturbed and lateral spread in miles are transitional differences. For example, in the Yampa area, it is estimated that there are 563.5 million tons

Table 4. Estimated Production in 1985 of Surface Mined Coal from areas where MER Option 3 would require the mining of privately uneconomic seams (millions of tons)[a]

	MER Option 1	MER Option 3[b]
Northeast Powder River Basin	28	28
Yampa Area	18	18
San Juan Area	43	43

[a] Production is estimated as the fraction of total production of Western surface mined coal times total production in 1985. Fractions by formation were estimated by U.S. Geological Survey personnel. Total production in 1985 (356 million tons) was taken from Permanent Regulatory Program of the Surface Mining Control and Reclamation Act of 1977 (U.S. Department of Interior, September 1978, Table 20, p. 118).

[b] It is assumed that operators do not shift to non-Federal coal when MER option 3 is implemented. This, of course, may not be a valid assumption. The implication for the analysis if operators do in fact shift are discussed at a later point.

Table 5. Costs and acreage disturbed for surface mining of Federal coal in areas where MER option 3 could force the mining of privately uneconomic seams, 1985 production.

	Northeast Powder River Basin	Yampa	San Juan
Production in 1985 (million tons)	28	18	43
Tons of Coal per Acre-foot	1770	1820	1800
Combined Thickness of Coal Seams (feet)			
MER Option 1	80	17	19
MER Option 3	90	27	23
Acres Disturbed in 1985			
MER Option 1	198	582	1257
MER Option 3	176	366	1039
Miles of Lateral Extension after 20 Years of Continuous Mining at Indicated Production			
MER Option 1	6.2	18.2	39.3
MER Option 3	5.5	11.4	32.5
Mining Resource Costs in 1985[a] (million of 1978 $)			
MER Option 1	129	160	146
MER Option 3	144	223	181

[a] Resource costs for mining of coal are the sum of annualized capital costs, operation and maintenance costs and a 12 percent rate of return on investment.

of recoverable coal under MER option 3 and 354.8 million tons of recoverable coal under MER option 1. If coal production is assumed to grow at 2% per year starting in 1981 at 16.3 million tons, then mining activity in the Yampa area will last 26 years under MER option 3 and 18 years under MER option 1. But when mining operations cease, the same number of disturbed acres (11,470 acres) and the same number of miles of lateral spread (18 miles) would be involved under either option. The only difference is that the rate of impact is slower under MER option 3. This point will be further elaborated a a later point when the benefits of MER option 3 are compared with its costs.

3C. Cost tradeoffs for a hypothetical seam

The analysis of the previous sub-section provided costs for mining additional seams under MER option 3. The coal configurations for that analysis were representative (a) of actual coal occurrences in the Western U.S. on Federal lands and (b) of coal seams that are likely to be strip mined in the near term. In all cases, it was found that the marginal costs per ton of mining privately uneconomic seams were substantially larger than the marginal costs of mining only privately economic seams, for example $4.60 vs. $9.10 per ton in the Northeast Powder River Basin, $8.90 vs. $18.50 per ton in the Yampa area, and $3.40 vs. $7.80 per ton in the San Juan area (see Table 3).

Because the costs for the privately uneconomic seams are substantially larger than costs for the privately economic seams, it may be difficult

to argue that additional benefits (to be discussed below) outweigh additional costs of mining privately uneconomic seams in the case of the Northeast Powder River Basin, the Yampa area, and the San Juan area. Also it must be remembered that MER option 3 would automatically require the removal of privately uneconomic seams in all three cases; there is no possibility of invoking MER option 3 for any separate coal configuration where additional mining costs could be relatively low. However under MER option 2 this is possible. Nonetheless, for the three cases that were analyzed above, it is unlikely that any separate situation from among the three, as they are represented, would provide positive net benefits if privately uneconomic seams were required to be mined under MER option 2.

When it comes to "fine tuning" under MER option 2, the above analysis may not be adequate. Since the representative cases are averages of a possibly wide range of coal configurations, they may be "averaging out" the cases that would be of primary interest, given the fact that MER option 2 is to be applied selectively. In other words, there could be situations inside the representative cases where costs of mining privately uneconomic seams may be low enough so that positive net benefits would occur if such seams and only such seams were required to be removed.

The purpose of this sub-section is to provide analysis that can be used as a basis for determining whether or not there are likely to be coal configurations where there is a reasonable expectation that positive

net benefits would result under application of MER option 2 (that is, when removal of privately uneconomic seams is to be required only in a few selected cases). It is useful to mention that the analysis undertaken in doing this is, in a sense, the inverse of the analysis carried out above. Above, the analysis identified seams in the real world and estimated costs. Here, the procedure is, instead, to posit some hypothetical seams, calculate costs for those seams, and then ask: What types of hypothetical coal configurations have relatively low costs for mining privately uneconomic seams and therefore may be plausible candidates for invoking MER option 2? Is it likely that such coal configurations exist in the real world?

The example coal configuration which has been chosen as a basis for this analysis is "Bed 80" in the vicinity of Hanna, Wyoming. The seam and overburden thickness for Bed 80, a privately economic coal seam, are close to the average conditions for strippable coal on Western Federal lands. Overburden averages 70 feet, coal in Bed 80 is 30 feet thick on the average, and there are 1840 tons of coal per acre-foot on the average in Bed 80.

The Bonner and Moore model was run to simulate the strip mining of Bed 80 and a hypothetical coal seam of three alternative thicknesses (10 feet, 20 feet, and 80 feet) at varying depths below Bed 80.[13/] The results

---

13/ A mine size of 5 million tons per year for the main bed was assumed. Mine production life was assumed to be 20 years.

are displayed in Figure 1, and are explained below. The explanation of the derivation of the schedules in Figure 1 uses the 10 foot seam as an example but is generally applicable to the schedules for the other two alternative seams.

For interburden of less than 13 feet, it was found that the after tax net present value for a property including Bed 80 and the hypothetical 10-foot seam would be higher if both were mined simultaneously compared to the case when only Bed 80 is mined. Thus in the 13 feet or less range of interburden, operators would have enough incentive on their own part to mine both beds. Between 13 and 70 feet of interburden, the after tax net present value was found to be less than that which could be achieved by mining only Bed 80. Therefore, operators on their own part would not have adequate incentive to mine a second-10 foot coal seam when the interburden is in this range unless the Federal Government were willing to provide enough financial incentive in these cases (by reducing the minimum acceptable bonus bid). Beyond 70 feet of interburden, mining costs for the 10 foot seam are large enough to render the after tax net present value less than zero for both beds. Thus beyond 70 feet, even if Federal Government could capture all of the economic rent on Bed 80, it could not finance removal of the 10-foot seam.

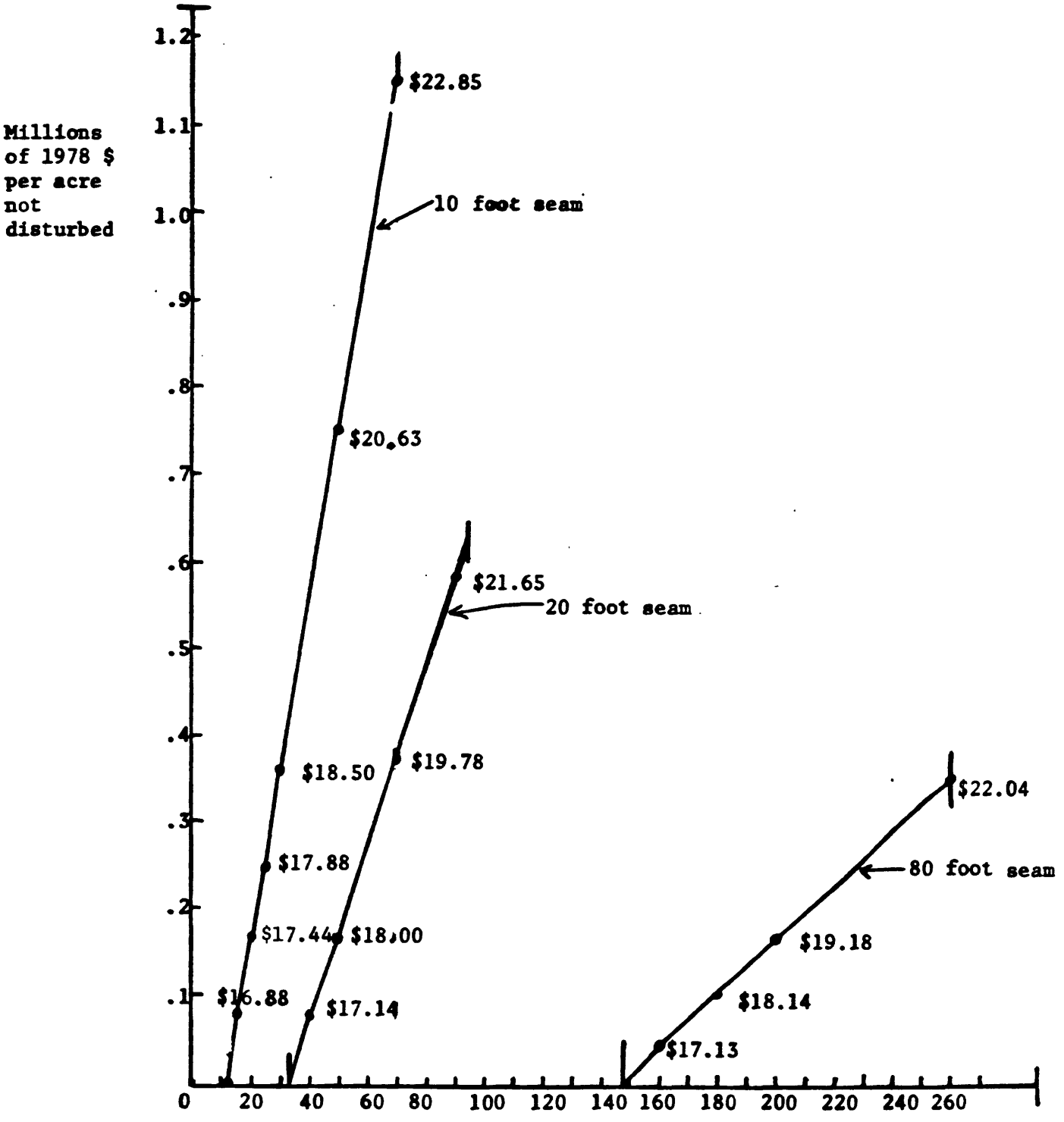
In terms of MER option 2, the area of interest is when the 10 foot seam lies between 13 and 70 feet below Bed 80. For this range, the incremental costs of mining the 10 foot seam are divided by the difference in acres not disturbed when the two beds rather than just Bed 80 are mined. The

schedule obtained is shown in Figure 1, and is labelled "10 foot seam." The "20 foot seam" and "80 foot seam" schedules also shown in Figure 1, were obtained in a similar fashion. The interburden thickness within which MER option 2 would apply extends from 32 feet to 94 for the 20 foot seam, and from 148 feet to 258 feet for the 80 foot seam.

The additional data provided in Figure 1 (the dollar figures attached to the schedules) are estimates of selling prices needed to make removal of the second seam privately economic. The interpretation of these prices is provided as follows. The selling price for Bed 80 is currently about $16.50 per ton. If there were a second 10 foot bed, 15 feet below Bed 80, then a private operator would not remove the second bed on his own part if the selling price remained at $16.50 per ton. However, if the selling price rose to $16.88 per ton or mining costs dropped by an equally compensating amount, then the operator would find that removal of the second bed would be privately economic.

For purposes of illustration, it is assumed in Figure 1 that the only environmental benefit of removing the second seam is a savings in acres disturbed. However there could be other environmental benefits (a slight annual decrease in lateral extension of haul roads and utility lines, fewer partially reclaimed acres, and extended time to mine out one area) so any conclusion drawn on the basis of Figure 1 as it stands should be slightly modified to account for these other considerations. For example, assume it is determined that in one specific area there is a second 20 foot seam, 40 feet below Bed 80 (or a seam like Bed 80). To economically justify the taking of that second bed, the Federal

Figure 1. Costs per acre not disturbed for a hypothetical second seam, below Bed 80, Hanna, Wyo.[a]



[a]Selling price for Bed 80 is assumed to be $16.50 per ton. Dollar figures attached to each schedule are selling prices that would make removal of the second seam profitable from a private viewpoint.

Government would have to be willing to assign an environmental benefit of $75,000 per acre not disturbed or if it were willing to assign a benefit of only $10,000 per acre not disturbed then the balance ($3.7 million a year) would then have to be assigned to the other benefit categories.

Insofar as MER option 2 is concerned these are several significant things about Figure 1:

(1) The three schedules are relatively steep. Even in the "best" case of an 80 foot seam, if removal of the 80 foot seam were close to being privately economic (say from 150 to 164 feet below Bed 80), a benefit between $6,500 and $50,000 per acre not disturbed would have to be assigned to economically justify its removal.

(2) The real world occurrences of a 30 foot seam with a second 80 foot seam below it (or a similar favorable configuration) are probably few if any. Therefore, the tradeoffs from applying MER option 2 are more likely to be similar to the "10 foot" and "20 foot" schedules.

(3) Assume the Federal Government is willing to assign a benefit of $10,000 per acre not disturbed, that this is the only benefit, and that a case is found where there is a second 20 foot seam 33 feet below Bed 80 (that is, <u>one foot</u> beyond the depth at which removal of the second seam would otherwise be privately economic). Then according to the "20 foot" schedule in Figure 1, there would be economic justification for invoking MER option 2 and requiring that the second seam be mined. However, a rise in the price of coal by a few cents above $16.50 would make the lower seam profitable

from a private viewpoint. Also a fall in the price of coal by a few cents would make the benefit-cost tradeoff for removing the second seam unfavorable. However the Federal Government is not likely to be able to accurately forecast cost and price within $1 to $2 because of changing market conditions and changing technology over the life of the mining activity. Therefore in the case where the Federal Government invokes MER option 2 and the price rises (or is higher than estimated by the Federal Government), the correct action will have been taken from a social viewpoint but in fact it is unnecessary for the Government to intervene because private operators would mine the second seam on their own part. In the case where the Federal Government invokes MER option 2 and the price falls or is lower than estimated by the Federal Government, the wrong action from a social viewpoint would have been taken.

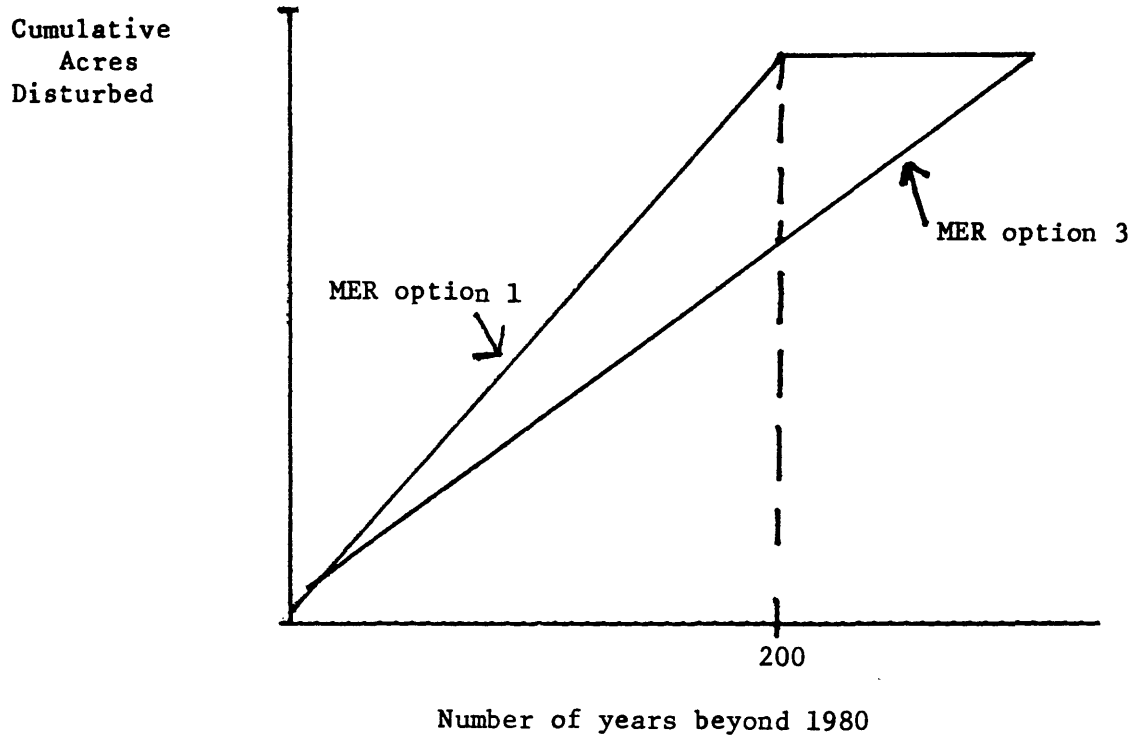
These calculations indicate that it may not be desirable or even possible for the Federal government to specify exactly what seams of coal should be mined.

4. Benefits of MER Options 2 and 3

For a given level of coal production, the following are examples of benefits that could derive from mines that are deeper and have a slower rate of lateral extension:

(1) The cumulative number of acres disturbed by any given year could be smaller. The number of acres disturbed is likely to be smaller for quite some time but could ultimately catch up. This is demonstrated by Figure 2.

Figure 2. Cumulative acres disturbed under MER options 3 and 1 assuming privately uneconomic seams are required to be mined under MER option 3 in some proportion of cases.



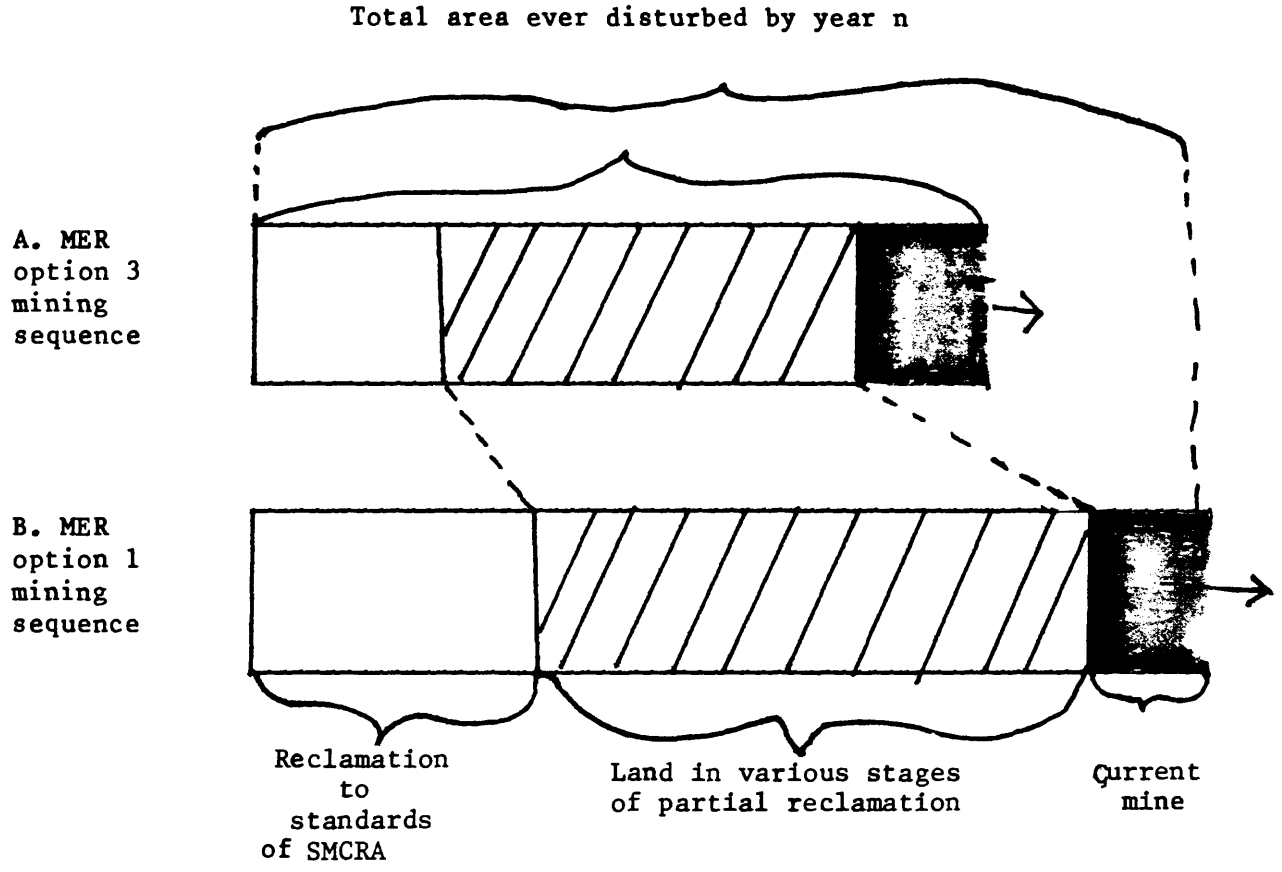
For a given level of coal production, less land is disturbed each year under MER option 3 (assuming mining of privately uneconomic seams) than is disturbed under MER option 1, and the cumulative path for MER option 3 lies below the path for MER option 1. Eventually, though, all privately economic coal is mined and mining ceases under MER option 1 (say 200 years from now). In contrast, mining under MER option 3 continues since both privately economic and the privately uneconomic coal would still remain after 200 years. Mining under MER option 3 would stop after all the areas that contained privately economic coal under MER option 1 were mined, all other things held constant. At that point, the cumulative number of acres disturbed would be the same under both options. Thus a generous categorization of disturbance benefits under MER option 3 is to say that in "year t we would spend an additional d dollars (extra mining costs) to save an additional y acres from being disturbed for about 200 years."

(2) At any one time, there would be fewer acres that were only partially reclaimed to the standards of the Surface Mining Control and Reclamation Act (SMCRA). After coal is stripped, the land would be reclaimed, usually with some lag and through a series of staged reclamation activities. When mining spreads laterally at a relatively rapid rate, reclamation probably follows at a comparable pace on already stripped acreage. However, because it takes time for vegetation to grow on reclaimed land, the

reclaimed land of a mine that is spreading laterally at a fast rate would contain more acres that were only partially reclaimed to the standards of SMCRA. These impacts are illustrated in Figure 3 where it is assumed that the same amount of coal per year is being mined under either MER options 1 or 3. Under MER option 3, less area would be stripped each year to mine a given amount of coal in comparison to MER option 1. Thus the total area ever disturbed under MER option 3 is drawn as a smaller area than the area ever disturbed under MER option 1. Under MER option 1 by year n, there would be a larger amount of land in various stages of partial reclamation because of the difference in the rate of lateral spread, and the "average" appearance of the land at any point in time should be more appealing under MER option 3. Eventually (as indicated above) the same number of acres could be disturbed and reclaimed so that the final appearance of the land under MER option 3 would be the same as under MER option 1.

(3) The reduced lateral extension of mines could reduce any visual disamenities or environmental costs associated with extra miles of railroad tracks, power lines and haul roads. The costs of constructing the utility lines, roads, and railraod spurs would be internal to the mining company since these costs would be reflected in the power and transportation rates charged to or absorbed by the mining company. This would give incentive to the mining company to mine additional seams and thereby delay the lateral spread of its operation.

Figure 3. A comparison of areas disturbed and reclaimed by mining equal amounts of coal under MER options 3 and 1 for a case where MER option 3 requires removal of more seams than MER option 1

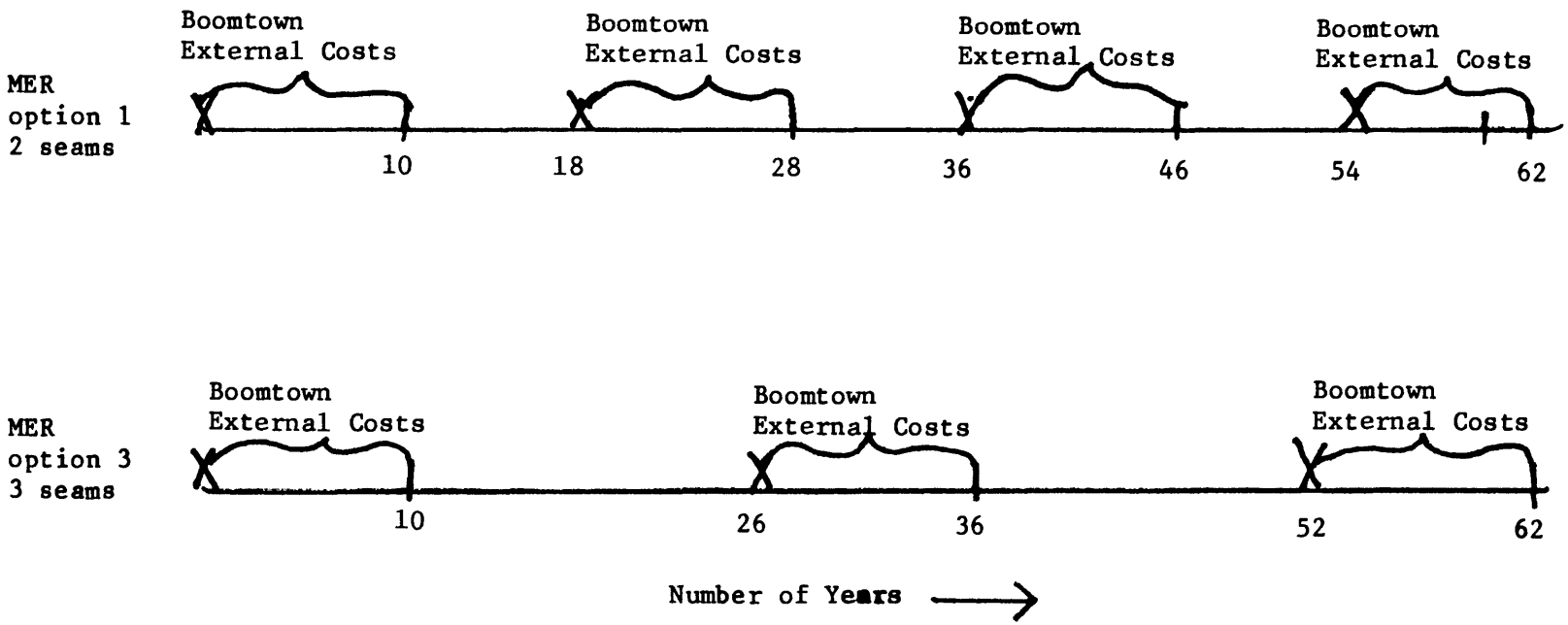


Nonetheless there could be external costs associated with extra miles of railroad tracks, power lines and haul roads that would not ordinarily be reflected in the decisions of mining companies. As in the case of cumulative number of of acres disturbed, the cumulative miles of spread under MER option 3 could catch up with the cumulative lateral spread under MER option 1. Thus a generous characterization of these benefits would be "in year t we spend d dollars (extra mining costs) to avoid an additional x disamenities from an additional y miles of railroad tracks, haul roads, and power lines for about 200 years."

(4) Because mines remove more coal per acre, mine life would be increased thereby reducing any social costs (over and above those covered by taxes on mining operations) associated with closing down all the mined-out operations in one area and moving them to another community. When mining operations enter a new region, a typical sequence of events is that new workers and their families overload existing infrastructure (such as schools, hospitals, sewer systems, etc.) and there is a deterioration in social services. Eventually, but with a lag, additional infrastructure is constructed and personnel hired so that social services return to "normal" levels. Major sources of funding for rebuilding social services are severance taxes, property and income taxes, and Federal coal

royalities and bonuses shared with States. To the extent that mining companies pay higher taxes to rebuild social services or pay higher wages to compensate workers for lower levels of services, some of these "boomtown" external costs are internalized in decisions to open mines in new areas. That is, mining companies would have some incentive to extend mine life to save on taxes and wages. Nonetheless some external costs related to the boomtown cycle could still remain, for example, the transitional deterioration in social services available to long-time residents of a community between the time when the "boom" begins and the new infrastructure catches social services up to normal levels. An illustration of a sequence of boomtown cycles is provided in Figure 4. This example uses coal in the Yampa area as a basis for determining how often mining operations have to be moved to new regions. Earlier it was indicated that coal reserves in the Yampa area could support mining operations growing at 2 percent a year from a base of 16.3 million tons for a period of 26 years under MER option 3 and 18 years under MER option 1. In Figure 4, everytime 26 or 18 years go by it is assumed that mining operations move to a new "Yampa" and start up again at the same rate and level. In each case, boomtown external costs occur for a period of 10 years, this being the

Figure 4. Boomtown external costs under MER option 3 and MER option 1. The length of time for mining in an area is based upon estimated coal reserves in the Yampa area.



X indicates the movement of mining operations into a new area.

assumed length of time required for social services to return to normal levels. As indicated in Figure 4, over a period of years there would be fewer boomtown cycles and associated external costs under MER option 3 in comparison with MER option 1.

5. Cost/Benefit Comparisions and Implications

The purpose of this section is (1) to make comparisons of additional mining costs with benefits, primarily for MER option 3, and (2) to provide some overall conclusions with respect to the economic efficiency of MER options 2 and 3.

The cost and benefit comparisons for MER option 3 are drawn, for the most part, from earlier tables and discussion. They start with simple comparisons of extra mining costs with individual categories of benefits and end with a comparison of all benefits, jointly, with extra mining costs.

The benefits that are compared with additional mining costs are (a) fewer disturbed acres; (b) fewer disamenities associated with fewer miles of railroad tracks, haul roads, and utility lines; and (c) fewer boomtown external costs. There is no easy way to determine the difference in partially reclaimed acres under MER options 3 and 1 and so that benefit is not compared with additional mining costs. But since it is closely related to having fewer disturbed acres one could think of this benefit as being included in that benefit category.

The first set of comparisons is shown in Table 6:

- By 1985, the costs under MER option 3 of strip mining Western coal on Federal lands could be $113 million per year more than under MER option 1.
- In 1985 under MER option 3, 456 fewer acres would be disturbed than under MER option 1. Altogether about 5000 acres would be disturbed in the West in 1985 under MER option 1 assuming 356 million tons of coal are strip mined.[14/] Thus under MER option 3 there would be about a 9 percent reduction in disturbed average.
- Assuming for the moment that acres not disturbed are the only benefit of deeper mining, then the cost per acre not disturbed of achieving these benefits in 1985 is estimated to range from $161,000 per acre to $682,000 per acre under MER option 3, depending upon coal area.
- Assuming alternatively that disamenities from additional haul roads, railroad tracks, and power lines, (associated with lateral spread) are the only benefit of deeper mining then the cost per mile of spread saved of achieving these benefits in 1985 is estimated to range from $103 million per mile to $441 million per mile under MER option 3, depending upon coal area.

An additional comparison is to match additional mining costs against the savings in boomtown external costs. This is accomplished by setting up the proper stream of discounted mining costs and boomtown external costs

---

14/ The estimate of total disturbed acres assumes an average coal thickness of 40 feet and an average coal density of 1800 tons per acre-foot.

Table 6. Comparison of additional mining costs with additional environmental benefits, MER option 3 in comparison to MER option 1, 1985 production.

	Northeast Powder River Basin	Yampa Area	San Juan Area
Million ton of coal produced in 1985	28	18	43
Fewer acres disturbed in 1985	22	216	218
Fewer miles of lateral extension in 1985 (miles)[a]	.034	.337	.341
Increased mining costs in 1985 (millions of 1978 $)	$15	$63	$35
Change in cost per change in acres disturbed (1978 $/acre)	$682,000	$292,000	$161,000
Change in cost per change in miles of lateral extension (millions of 1978 $/mile)	$441	$187	$103

[a]Change in lateral extension assuming a constant one-mile-wide cut.

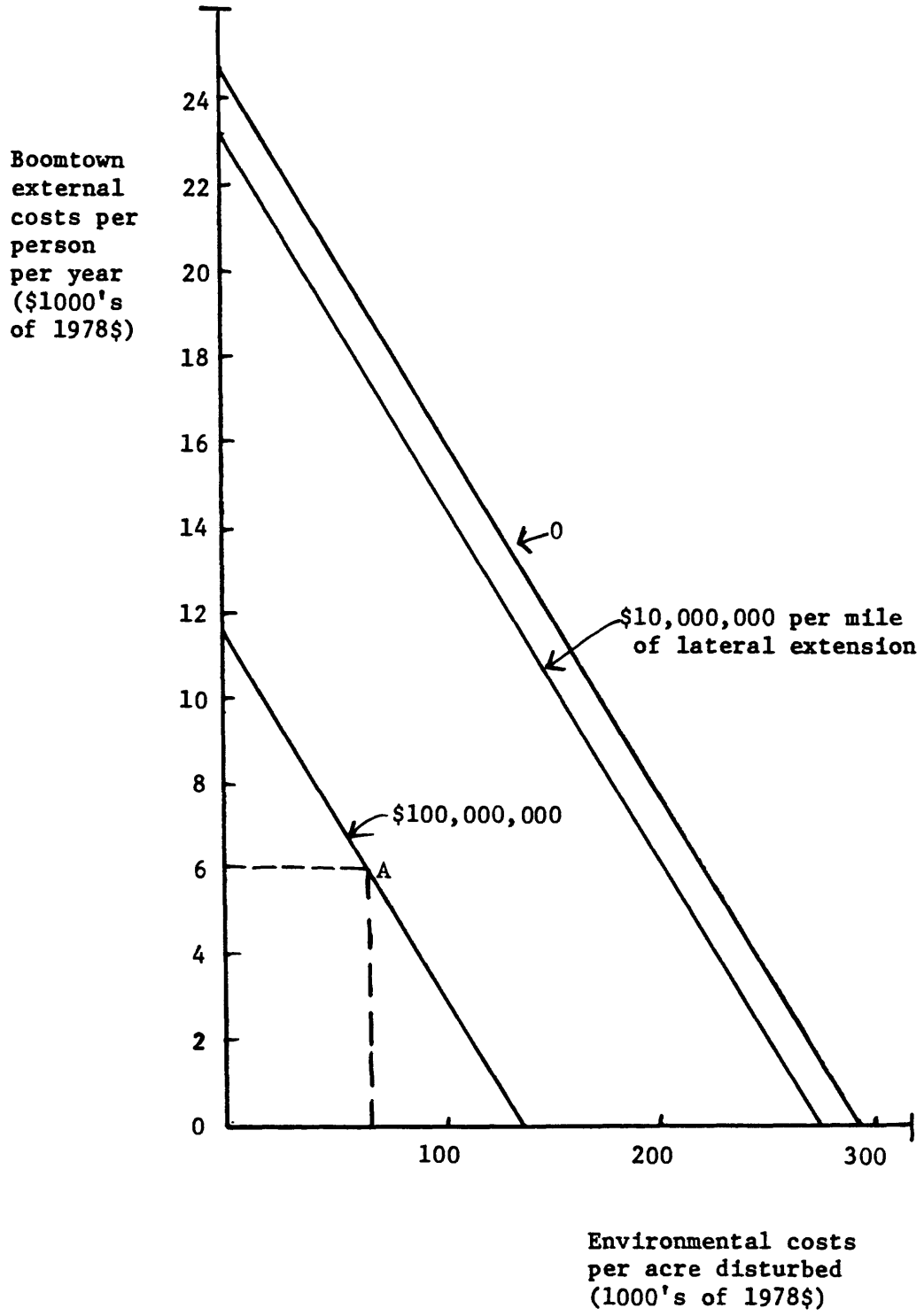
for the two mining sequences shown in Figure 4.[15/] For this purpose, it is assumed that 50,000 people would incur boomtown external costs during each boomtown cycle of 10 years. The variable which is being solved for is the external cost per person per year that would make the costs of the MER option 3 mining sequence equal to the costs of the MER option 1 mining sequence, where the only costs being considered (again momentarily) are mining costs and boomtown external costs. The value that makes the two sequences equal is $24,600 per person per year. Below this value, the MER option 1 sequence would be less costly, and above this value the MER option 3 sequence would be less costly. In other words, if the only impact of mining deeper seams is to reduce the number of boomtown cycles, then for MER option 3 to be less costly than MER option 1 (for Yampa coal) boomtown external costs have to be more than $24,600 per person per each year externalities exist.

The comparison of benefits jointly with costs for MER option 3 is accomplished by deriving an equation for which the discounted costs for MER option 3 equal the discounted costs for MER option 1. In this exercise four categories of costs are included: mining costs, environmental costs for disturbed acres, environmental costs for miles of lateral extension, and boomtown external costs. The latter three

---

15/ Equations are provided in Appendix II. The "planning horizon" for the computations are 62 years as indicated in Figure 4. Due to discounting, a longer horizon has a very small impact on any of the calculated values.

FIGURE 5. Environmental and socioeconomic tradeoffs for MER Option 3.



cost categories are parameterized so that tradeoffs among environmental and socioeconomic costs can be displayed. The Yampa area was chosen for example calculations because it should provide a relatively favorable situation for MER option 3. It has the shortest expected production life of any of the three coal configurations (Northeast Powder River Basin, Yampa, and San Juan) where MER option 3 would require mining of deeper seams and it has only modestly higher additional mining costs per disturbed acre and mile of lateral extension in comparison with the San Juan area.

The derived tradeoff equation is provided in Appendix II and plotted in Figure 5. Each schedule shown in Figure 5 is labelled with the assumed value for environmental costs per mile of lateral extension (0, $10,000,000 per mile, $100,000,000 per mile). The points on any given schedule are combinations of (a) boomtown external costs per person per year and (b) environmental costs per acre disturbed for which MER option 3 and MER option 1 mining sequences have equal total discounted costs. All points above and to the right of any schedule show the environmental and socioeconomic "unit" costs for which MER option 3 is less costly than MER option 1.

To illustrate the use of Figure 5 consider this question: Under what conditions could the removal of the third seam in the Yampa area be economically justified? Assume it has been estimated that environmental costs from additional miles of railroad tracks, haul roads, and power lines are at least $100,000,000 per mile. Then the answer becomes: Digging

deeper to remove a third seam is economically justified if environmental costs per acre disturbed are at least $65,000 per acre and if boomtown external costs are at least $6,000 per person per year (point A) or any other combination of unit boomtown costs and environmental costs for disturbed acres that lies above the lowest schedule in Figure 5. In other words, environmental and socioeconomic costs must be very high to economically justify the mining of deeper seams.

The conclusion which can be drawn from Figure 5 is that even when environmental and socioeconomic benefits are jointly considered, it is highly unlikely that the mining of additional seams under MER option 3 can be economically justified.

5.A. Implications and Qualifications

Recall that under MER option 3, mining of privately uneconomic seams on Federal lands would automatically be required anytime it was determined that the extraction of privately uneconomic seams could be financed out of rents on economic seams. The implicit presumption here is that the benefits from a less rapid lateral extension of mining activity always exceed additional costs. But this is not supported by the analysis provided above. Recall, also, that other provisions in the Federal coal management regulations do provide for reduction in external environmental and socioeconomic impacts. On these bases, there is reasonable doubt that the Nation would benefit from adoption of MER option 3.

In principle, MER option 2 is the "correct" rule from the viewpoint of maximizing economic efficiency. Under MER option 2, mining of privately uneconomic seams would be required only when there is a reasonable

expectation that benefits would exceed costs. However there are two practical problems with MER option 2. One problem is that there may be very few, if any, situations where mining of deeper seams under MER option 2 could be economically justified. For the three broad representative coal configurations analyzed in this report, it does not appear that the benefits of mining additional privately uneconomic seams could exceed additional mining costs. Even when hypothetical examples were considered which might favor MER option 2, it was found that the expected environmental and socioeconomic benefits would have to be quite high in order to justify the extraction of privately uneconomic coal.

The second problem with MER option 2 is that mining of deeper seams could probably only be justified when privately uneconomic seams are very close to being privately economic. It is only in such marginal cases that it seams reasonable that additional mining costs would be out weighed by environmental and socioeconomic benefits. But in this situation, it was shown that mining of deeper seams is sensitive to small shifts in mining costs and coal prices. A deviation of $1 to $2 in coal prices or mining costs could switch the mining of an additional seam from being privately uneconomic to being privately economic (in which case there is no need for the Federal Government to intervene) or alternatively, the deviation could make deeper marginal seams uneconomic from a private and a social viewpoint. It is unlikely, that the Federal Government could accurately forecast coal prices and costs to within $1 to $2 because of changing conditions in the coal market and in technology over the life time of a typical mining operation. Thus a strong argument cannot be made that

the Federal Government could in fact be correct in its decisions to require the mining of deeper seams. In other words, marginal determinations under MER option 2 are likely to be very unreliable, because of uncertainty in price and cost predictions.

There are three qualifications to the implications discussed above which should be mentioned:

(1) The first qualification is concerned with impacts on integrated mining plans. MER applies only to Federal coal. There are likely to be many situations in the West due to the "checkerboard" pattern of mineral ownership when operators will include both Federal and non-Federal coal within a logical mining unit. Operators will negotiate separately with the Federal Government and with non-Federal owners. On non-Federal portions, especially private portions, operators and coal owners would attempt to identify privately economic seams and share rents on those seams since this would tend to maximize returns to both parties. In contrast, on Federal portions, under MER options 2 and 3, operators could be required to mine economic seams and privately uneconomic seams. When this happens, equipment requirements and mining sequence may differ considerably between Federal and non-Federal portions. In fact, an integrated mining plan may be more costly. Operators could react by designing separate mines on private portions and on Federal portions. In any case, mining costs are likely to be higher when different numbers of seams are mined in different portions of a logical mining unit, all other things held constant.

Since these higher costs are not reflected in the mining cost estimates presented above, implications drawn from those cost estimates tend to be conservative.

(2) A second qualification is concerned with shifts of mining from Federal coal to non-Federal coal or to other Federal coal without the possibility of privately uneconomic seams. When privately uneconomic seams are required to be removed from Federal tracts, operators may regard this as a very risky proposition. For one thing, less is generally known about the physical characteristics of less familiar privately uneconomic beds. Operators may place very high risk premiums on privately uneconomic beds and condition their bids accordingly. If Federal analysts do not allow for uncertainty in geology and mining costs when they estimate the CREV, it could turn out that few bids on Federal coal would be accepted and operators might turn more towards non-Federal coal. If the non-Federal coal is in thinner seams and more costly, total extra resource costs could be higher and fewer acres saved from disturbance under MER option 3 than is reported above. It is expected that the shifting would be in some proportion less than the 25% of cases to which MER option 3 is estimated to apply.

(3) The third qualification is concerned with environmental benefits of MER. For the coal formations analyzed in this report, privately uneconomic seams in all cases were deeper seams. All of the environmental

impacts from mining deeper privately uneconomic seams may not be beneficial. A deeper mining operation may adversely impact underground aquifers. Also, removal of additional seams which tends to lower the reclaimed land surface could adversely impact surface hydrology. A more complete assessment of MER options 2 and 3 would consider these potential negative impacts as well as the positive environmental impacts discussed above.

All three qualifications tend to make the tradeoffs for MER options 2 and 3 even less favorable and to make the case for MER option 1 more favorable. MER option 3 can immediately be put aside as a poor economic choice.

In the case of MER option 2, it is difficult to make a reasonable case for its adoption on economic grounds. Compared to MER option 1 it does have additional administrative costs (on the order of $150,000 a year). There are likely to be very few instances in the next 20 to 30 year period when benefits could reasonably be expected to exceed additional costs of mining deeper seams under MER option 2. And even if there exist a few cases that can be economically justified, the Federal Government may not be able (a) to identify such cases or (b) may <u>incorrectly</u> order removal of deeper seams because of inability to correctly predict prices and costs to the degree required by the "fine tuning" nature of MER option 2.

Appendix I

Method for Estimating Mining Cost

1. Mines with privately economic seams

A mine with privately economic seams is a mine for which the estimate of after tax net present value (ATNPV) is at its maximum value. ATNPV is equal to discounted revenue (DREV) minus discounted royalties (DR), minus discounted mining costs (DC), minus discounted income and severance taxes (DT):

$$ATNPV = DREV - DR - DC - DT$$

where DREV = (Price per ton x tons)/(D1 x D2)

D1 = ((1/r) (1-(1 + r)**-n))**-1

r = rate of return on investment (.12 in all cases)

n = length of production period (20 years in all cases)

D2 = 1/(1+r)**d

d = length of the development period (3 years in all cases)

DR = royalty rate x DREV

royalty rate = .125

DC = (cost per ton x tons)/(D1 x D2)

DT = t (DREV - DC)

t = effective tax rate (.30 in all cases)[1/]

The procedure is to calculate ATNPV for the major seam and then keep adding seams in all possible orders to find the combination that maximizes ATNPV.

1/ The value .30 is the average of DT/(DREV - DC) as calculated from a series of runs of the Kalter discounted cash flow model (A Coal Production Cost and Discounted Cash Flow Simulation Model, Robert Kalter Associates, Dec. 15, 1977).

Costs for main seams were provided by personnel in U.S. Geological Survey regional offices. Costs for other than main seams are derived by scaling estimated costs obtained from running the Bonner and Moore model. The Bonner and Moore model is run to estimate costs for main seams. Then the ratio of the U.S. Geological Survey estimate to the Bonner and Moore estimate is applied to the Bonner and Moore estimates for other seams.

2. Mines with privately economic seams and privately uneconomic seams

A mine with privately economic seams and privately uneconomic seams is one for which ATNPV $\geq$ 0. The procedure is to identify mines with privately economic seams (as in step 1) and then add additional seams in the order that keeps ATNPV at its largest non-negative value. The discounted mining cost (DC) for each additional seam is estimated by the Bonner and Moore equipment selection model (Robert Kalter Associates, op. cit.).

To estimate average mining costs per ton for a multiple-seam mine, the discounted costs for all privately economic and privately uneconomic seams are added, multiplied by D1 and D2 and divided by tons mined per year:

Average mining cost per ton = (Sum of DC x D1 x D2)/tons

APPENDIX II

Equations for comparing costs and benefits for MER Option 3 (Yampa Coal).

Discounted Mining Costs (millions of 1978$)

$$\text{MER Option 1: } 148 + \sum_{n=1}^{61} \frac{16.6292 \times 8.90 \times (1+g)^n}{(1+r)^n} = 1653.2$$

$$\text{MER Option 3: } 206.2 + \sum_{n=1}^{61} \frac{16.6292 \times 12.40 \times (1+g)^n}{(1+r)^n} = 2303.3$$

g = growth rate of coal production = .02
r = discount rate = .12

Discounted Boomtown External Costs (millions of 1978$)[a]

$$\text{MER Option 1: } \frac{1}{(1+r)^{18}} \sum_{n=1}^{10} \frac{50 \times KB_{10}}{(1+r)^{10}} + \frac{1}{(1+r)^{36}} \sum_{n=1}^{10} \frac{50 \times KB_{10}}{(1+r)^{10}} + \frac{1}{(1+r)^{54}} \sum_{n=1}^{8} \frac{50 \times KB_8}{(1+r)^8} = 42.045KB$$

$$\text{MER Option 3: } \frac{1}{(1+r)^{26}} \sum_{n=1}^{10} \frac{50 \times KB_{10}}{(1+r)^{10}} + \frac{1}{(1+r)^{52}} \sum_{n=1}^{10} \frac{50 \times KB_{10}}{(1+r)^{10}} = 15.61\ KB$$

KB = Boomtown external costs per person per year (1000's of 1978 dollars)

Discounted Costs for Disturbed Acres (millions of 1978$)

$$\text{MER Option 1: } \left[526.9 \times KA + \sum_{n=1}^{61} \frac{16.6292 \times (1+g)^n}{.017 \times 1.820 \times (1+r)^n} \times KA\right] \times 10^{-3} = 5.993KA$$

$$\text{MER Option 3: } \left[331.8 \times KA + \sum_{n=1}^{61} \frac{16.6292 \times (1+g)^n}{.027 \times 1.820 \times (1+r)^n} \times KA\right] \times 10^{-3} = 3.7733KA$$

KA = Environmental costs per acre disturbed (1000's of 1978$)

Discounted Costs for Miles of Lateral Extension (millions of 1978$)

MER Option 1: (5.993/6.40) x KM = .009364KM

MER Option 3: (3.7733/640) x KM = .005896KM

KM = Environmental costs per mile of lateral extension (1000's of 1978$)

Equation for which MER Option 3 costs = MER Option 1 Costs

$$26.435KB = 650.1 - 2.2197KA - .003468KM$$

[a]The initial boomtown external costs under MER options 3 and 1 are equal and therefore cancel each other in any comparison.