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The law and economics of reclamation bonds

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Abstract

It is becoming a standard practice for governments to require mining operations to post reclamation bonds. Yet, there have been few theoretical treatments examining the rationale for bonding mechanisms, and even fewer empirical treatments of the effectiveness of bonding. This paper addresses some of these holes in the literature. It begins by examining the rationale underlying reclamation bonds, and discusses the strengths and weaknesses of bonding as a tool for enforcing reclamation requirements. The role of bonding mechanisms is to help enforce standards, not necessarily yield efficient outcomes, and these mechanisms are best viewed as a complement to — not a substitute for — liability rules. The paper also examines the effectiveness of bonding by drawing on evidence from hardrock mining on public lands in the western United States. © 2001 Elsevier Science Ltd. All rights reserved.

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The use of bonding mechanisms to ensure site reclamation is pervasive in the mining industry worldwide, yet there are few theoretical or empirical treatments of bonding issues (Miller, 1998). This is surprising because public policy debates over bonding issues are fraught with unresolved questions: When should reclamation bonds be mandatory? When bonds are required, how effectively do they promote site reclamation? What is the appropriate level of setting bonds — the expected reclamation cost, the worst-case scenario, or some other level? Should the bond amount depend on the financial strength of the firm? Do the costs of bonding discourage exploration and development?

In this paper, I outline a model for thinking about these questions through the lens of law and economics scholarship (Cooter and Ulen, 2000; Shavell, 1993; Becker and Stigler, 1974). Bonding is a mechanism for enforcing contractual and regulatory provisions (where the term *bond* refers to financial instruments such as surety bonds, performance bonds, fidelity bonds, and letters of credit). In the context of mining operations, a firm posts a bond with the regulator that is released when reclamation is successfully completed. If site reclamation is not completed, the firm forfeits the bond and the proceeds are used to finance reclamation.[1]

If polluters are liable for the harms they cause others, then bonding might be considered unnecessary or even superfluous. Bonding mechanisms, however, have a number of features that make them a complement to — not a substitute for — liability rules.[2] The bond assures that some resources will be available for reclamation if the firm fails to clean up the site. In addition, the bond shifts the burden of proof of a legal dispute from the damaged party to the polluter. In contrast, under a liability rule the burden is on the injured party to bring a suit and demonstrate harm. Once a bond is posted, it is incumbent upon the firm to demonstrate that the cleanup

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[1] Various forms of bonds are used to ensure performance or payment in a number of situations: to ensure that people out on bail appear in court; to subcontractors and laborers that work on construction projects; for projects affecting public health or safety; services that are rife with unscrupulous business practices; and enterprises that require payment of taxes, such as sales or gasoline taxes (Carman, 1997). Environmentalists also advocate bonding as an instrument for regulating activities with uncertain future costs (Perrings, 1989; Costanza and Perrings, 1990), but bonding mechanisms have a number of elements that limit both their scope and their effectiveness (Shogren et al., 1993).

[2] See Shavell (1984) for a discussion of the limits of the deterrent effects of liability rules.

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meets the terms of the agreement before the bond is released.

The use of bonds also transfers some of the risk of default from the public to the private sector. In many cases a third party, such as a surety provider, will assume part of this risk. For a fee, the surety posts the bond on behalf of a firm, agreeing to cover the amount of the bond if the firm defaults. The use of a third party further reduces public exposure by increasing the number of parties potentially liable for the cleanup.[3] Moreover, the third party assumes an enforcement role, which encourages contractual or regulatory compliance (Becker and Stigler, 1974).

The financial incentives and reputation effects inherent in the use of bonding mechanisms and liability rules have a number of attractive features, but these features do not necessarily imply that mandatory bonding is desirable. First, although bonding encourages compliance with reclamation agreements, there is no a priori reason to believe that the benefits of reclamation always exceed the costs. In other words, bonding promotes regulatory compliance, but it in no way suggests that the standard promulgated by the regulations is necessarily efficient. Second, bonding encourages low-cost cleanup because firms are the residual claimant for the difference between the bond amount and the realized cleanup costs. Consequently, firms have the incentive to minimize cleanup costs, as well as to take precautionary actions during the operation phase to facilitate lower cleanup costs.[4] Of course, this is also true of a liability rule facing a solvent agent. Therefore, for an agent that is not a bankruptcy risk, it is not clear why a bonding mechanism is necessary. Third, bonding can effectively utilize reputation effects. Firms need to have a good reputations both with surety providers and with regulators. Similarly, regulators must have the reputation of being fair in the release process, otherwise it will be difficult to attract business.

The analysis in this paper is a starting point for addressing issues germane to reclamation bonds. The following section discusses the basic problem of moral hazard, the particular problems associated with bankruptcy risk, and the principal motivations for using bonding mechanisms. This is followed by an examination of a firm's decision on whether to reclaim a site. The effectiveness of bonding is then evaluated using evidence from hardrock mining on public lands in the western United States.

Moral hazard, default risk, and bonding mechanisms

Although there has been considerable interest in the environmental economics literature concerning the choice of efficient regulatory instruments, there has been relatively little attention paid to regulatory enforcement (Cohen, 1999).[5] Yet, enforcement is costly, and firms have the incentive to cut costs at the expense of environmental quality when enforcement is lax. As a result, the potential efficiency gains from choosing the correct policy instrument may well be overwhelmed either by regulatory enforcement costs or by a firm's disregard for the existing regulations.

The problem of enforcing contracts and regulatory provisions is often framed as a principal–agent problem. In the case of US mining, the environmental standards stipulated in operating permits are often a product of negotiations between the regulatory agency (the principal) and the regulated firm (the agent) where environmental laws provide a baseline negotiations (McElfish et al., 1996, p. 6). If a principal has high costs of monitoring performance, the agent may reduce costs by "shirking" — the standard example of moral hazard. For instance, a regulator can require a firm to implement a given technology and can easily observe whether the firm installs the device. It is more costly, however, for a regulator to monitor whether that device is turned on, used properly, and maintained. Thus, high monitoring costs might lead the regulated firm to shirk, reducing its costs at the expense of environmental quality.

When there is an agreement between the principal and the agent that can be verified by a third-party, assigning liability to the agent effectively addresses the moral hazard problem. For example, it is often easy to observe if vegetation has taken hold at a reclaimed mine site, or to sample water for high concentrations of heavy metals. If monitoring costs are low and the terms of the agreement are clear, it is a straightforward matter for the principal to recover damages by assessing a fine or taking legal action against the shirking agent. In response, the agent is more likely to take the appropriate level of care.

[3] Bonding requirements do not fully transfer risk because the surety is only liable for the face value of the bond, and the realized cost of nonperformance may well be higher than that amount. As a result, these excess costs are absorbed by the public (e.g., the site is not reclaimed, or the cleanup is paid by someone other than the responsible party).

[4] This is problematic if the regulator cannot perfectly monitor reclamation quality. If, however, the firm remains liable for any damages even after the bond is released, moral hazard on the firm side is reduced. Consider the case where a firm does a poor job of mitigating the possibility of acid mine drainage, but the regulator fails to notice and releases the bond. If an acid drainage problem develops, the firm remains liable for the cleanup costs.

[5] An extensive survey article observes that "the great bulk of the literature on the economics of environmental regulation simply assumes that polluters comply with existing directives: they either keep their discharges within the prescribed limitation or, under a fee scheme, report accurately their levels of emissions and pay the required fees" (Cropper and Oates, 1992, p. 695).

Liability rules will not promote compliance if the regulated firm is a bankruptcy risk. Environmental liabilities are debts, and therefore can be discharged in bankruptcy proceedings. In effect, the firm's assets are the upper bound on liability. A firm is said to be "judgment-proof" for liabilities beyond existing assets, and consequently ex post fines or damage awards do not provide adequate deterrence. Thus, the possibility of bankruptcy affects firm incentives and behavior even for a solvent firm, and the judgment-proof problem is considered a central weakness of sole reliance on liability rules (Shavell, 1986). An approach to the judgment-proof problem is to require collateral (such as a bond), thus providing the agent with a direct monetary incentive to comply with the regulations. If the agent fails to perform, the forfeited collateral is used to remedy the performance failure.

A simple equation illustrates the use of bonds as collateral: P is the probability that shirking is detected, β is the amount of bond posted, and R is the regulatory compliance cost, with $E(R)$ being the expected regulatory compliance costs. Then $P\beta$ is the agent's expected cost of shirking. This suggests that the size of the bond should be inversely related to the probability that shirking is detected. If P=1, the amount of the bond posted should be equal to the expected reclamation costs (β=$E(R)$). The probability that shirking is detected is most likely to be close to one if monitoring costs are low. These monitoring costs, in turn, are a function of the number of times a site must be inspected, as well as the ease in which shirking can be detected and demonstrated to a third party. Because of the nature of site reclamation, it might be the case that shirking is easy to detect and therefore the probability of detection is close to one.

The collateral also shifts the burden of proof from the regulator to the firm. That is, if the regulator retains the collateral (for whatever reason), the firm must initiate a court action in order to recover the funds. The illustration does not incorporate the effects of the burden of proof, but presumably it is more costly for the firm to win as a plaintiff than as a defendant. As for the regulator, holding a bond is comparable to having a bird in hand.[6]

[6] Note that a bond is not the same as an insurance policy, although both are instruments of transferring risk. An insurance company calculates premiums to cover expected payments. In contrast, a surety provider issues a bond based on credit principles, and the bond premium covers the underwriting expenses and assumes that there will be no default. If the probability distribution over expected payments is not well defined, then insurers hedge against this uncertainty by charging substantially higher premiums. Surety providers may respond to uncertainty by requiring a higher percentage of the bond amount as a premium, requiring substantial collateral, or simply refusing to underwrite the bond.

Problems with bonding mechanisms

There are several problems associated with bonding mechanisms that limit their applicability (Shogren et al., 1993). First and foremost, bonding is not free — the firm, the regulator, and the surety each incur transaction costs. These transaction costs increase as uncertainty increases or as contracting becomes more complex, as complex contracts are costly to write, interpret, and enforce. For instance, a contract that specifies that "reasonable efforts must be taken to reclaim the site" would be likely to be much more difficult to enforce than one that specified bright-line rules for reclaiming drill holes, roads, processing facilities, and the like. As contracting becomes more costly, the effectiveness of the bonding mechanism decreases. Uncertainty is also a primary impediment to the smooth operations of liability rules. Therefore, it is unlikely that the bonding mechanism will be an effective substitute for liability rules.

A second problem is that bonds can impose liquidity constraints on firms. Cash, treasury bonds, certificates of deposit, and other liquid assets are often acceptable forms of collateral, but these instruments can tie up a firm's operating capital. This liquidity constraint becomes more binding as the deposit amount increases. One way to mitigate the liquidity constraint is by involving a third party, for instance, a surety. For a fee, a surety agrees to cover the amount of the bond if the agent fails to fulfill its obligation, which also transfers a portion of the default risk from the public to the surety provider (there is not necessarily a transfer of funds that the landowner holds in trust; instead, the surety assumes a legal obligation to provide funds if the firm reneges on its agreement). The use of a surety reduces, but does not eliminate, liquidity constraints. The firm must pay an annual premium, and the bond amount is also a liability on the firm's balance sheet that adversely affects the firm's credit.[7]

Although collateral reduces the firm's moral hazard, it also introduces moral hazard on the side of the regulator. A wealth-maximizing regulator may have the incentive to retain the bond whether or not reclamation is performed. This is a potentially serious defect of the bonding mechanism. If, however, the operating permit specifies reclamation requirements that can be verified by a third-party at a low cost, the firm should be able to successfully challenge the regulator's decision. Moreover, it would be difficult for a state with a poor reputation to attract capital to its jurisdiction, and surety pro-

[7] The premium is often one to five percent of the face value of the bond, though large firms can secure a surety by posting less than one percent, and small firms may face premiums of 15 to 20 percent or higher. For a discussion of liquidity constraints in coal mining see US General Accounting Office (1988).

viders would be less likely to underwrite contracts for operations within that state.[8]

The decision to reclaim or default

Once mining is completed (and probably even before mining is completed) firms choose to reclaim the site or default on the bond. For a solvent firm the decision is independent of whether the firm or the surety posts the bond; if the firm fails to reclaim the site and the surety reimburses the regulator for the amount of the bond, the firm remains liable to the surety for the amount of the bond, and to the landowner for any cleanup expense over and above the amount of the bond. Notice that these costs are approximately the same as those expected under a liability rule, as a defaulting firm would incur legal expenses, and would also be liable for any damages.

Default has other monetary and non-monetary costs. For instance, firms have repeat dealings with surety providers, and surety providers charge higher premiums or refuse to issue policies on behalf of firms with poor credit histories. In addition, regulators often have the authority to block permits for any operator that has a record of noncompliance. Thus, a firm that remains solvent will incur higher future costs in obtaining a surety because of higher premiums and collateral requirements, as well as the cost of being denied access to a given jurisdiction. This can pose a serious limitation for mining firms if the landowner (e.g., the government) is a dominant source of mineral potential. If government agencies were to place a permit block on a firm — thus denying the firm access to other state lands — the amount of land available for exploration and development could be seriously limited.

These characteristics show that the potential costs of default are liability to the surety for amount of the bond (β); liability to the regulator for any additional cleanup costs ($R-\beta$); litigation costs with the surety and/or regulator; costs associated with damaged reputation (C). Given these costs, there are three cases where the firm weighs default against reclamation:

Case 1: $P\beta > R$.
Case 2: $P\beta < R$ and $P(\beta+C) > R$.[9]
Case 3: $P(\beta+C) < R$.

In each case, the expected costs of defaulting are directly related to the probability of being detected. An increase in the probability of being detected increases the likelihood that bond amount encourages reclamation.

In the first two cases the firm definitely chooses to reclaim the site because total expected costs exceed reclamation costs. The expected outcome in the first case is no different than what we would expect under a simple liability rule. The interesting result is that in Case 2. If P is close to one, as would be expected for monitoring reclamation projects, then the firm reclaims the site even though cleanup expenses exceed the bond amount. This suggests that compliance can be induced with bond levels that are below the expected reclamation costs. Specifically, a risk neutral regulator could set a bond amount at $\beta=(R/P)-C$. This result is in stark contrast to Constanza and Perrings (1990), who recommend bonding for the worst-case scenario.

In the third case the reclamation costs exceed the sum of the bond default amount (for which the firm is liable to the surety) and additional costs associated with reputation effects. Even so, the firm's decision is not unambiguously to default. Even if the firm defaults on the bond, it may still be found liable to the landowner for cleanup expenses beyond the amount of the bond. Thus, it is not clear what a firm will do in Case 3 until a number of other variables are quantified — the probability that a landowner sues to recover damages, the probability that the landowner wins the suit, expenses defending these suits, and the expected payments. For a solvent firm, it is likely that site reclamation is the preferable strategy even if realized reclamation costs far exceed the bond amount. This helps to explain why in a number of industries (landfills, underground storage tanks, and oil tankers) firms must have adequate capital reserves in order to operate, but bonds are not required.

The implication of the simple model is that firms with deep pockets are likely to reclaim regardless of the relationship between the bond amount and the realized reclamation costs. This suggests that the firm's financial position should be a factor in determining whether a bond is appropriate. The results also suggest that setting the bond amount at the worst-case scenario would be an extremely risk averse strategy. In fact, the basic intuition suggests that compliance can be induced by setting the bond amount less than the expected reclamation costs.

This, however, is not an unqualified endorsement for setting bonds below expected reclamation costs. There are well-known limitations of reliance on liability rules, as well as marked uncertainties concerning likely reclamation costs, especially at large-scale operations that have the potential to degrade water quality. Moreover, reputation effects only work in games with repeat players. The illustration does show, however, that there are other ways to encourage site reclamation than to increase the bond amount. Well-functioning surety markets and use of permit blocks may add to costs, C, and facilitate site cleanups. If agencies diligently pursue legal actions

[8] Of course, it is possible that this is the preferred outcome for either the regulator or for an anti-mining constituency.

[9] Because $0 \leq P \leq 1$, it follows in Case 1 both that $\beta > R$ and $P(\beta+C) > R$. I thank the referee for clarifying this point.

against delinquent operators, this would tilt the firm's decision towards site reclamation.

Hardrock mining in the Western United States

The legacy of mining in the western United States includes thousands of abandoned mines sites that pose a variety of environmental hazards and safety risks. The possible degradation from heavy metal contamination or acid drainage is of course a continuing concern. In addition, old mine sites often pose public safety hazards, as a number of people meet untimely deaths in abandoned mine shafts each year. In Montana the state has evaluated more than 3000 sites based on their environmental and safety characteristics, and 350 of these sites are on a priority cleanup list. The state of Arizona — currently the leading US producer of hardrock minerals — has surveyed 5890 mine openings, shafts, adits, prospects, and quarried out areas. Of these sites, 118 (2 percent) have possible environmental hazards, and 668 (11 percent) pose public safety hazards (Arizona State Mine Inspector, 1999).

The abandoned mines legacy is attributed both to a lack of concern about potential hazards and an absence of regulation. Attitudes about the public lands, however, have changed. Mining is now governed by an extensive regulatory structure that consists of federal statutes, regulations from federal land agencies, including the Bureau of Land Management (BLM) and the Forest Service, and state statutes and regulations. The relevant federal statutes include the Clean Water Act, the Clean Air Act, National Environmental Policy Act, the Endangered Species Act, and Superfund. These laws are not specifically tailored to mining, but the federal land management agencies each have mining-specific surface management regulations. The agency regulations address both the effects of current operations, as well as financial assurances for site reclamation. State governments also have laws and regulations covering exploration, development, and reclamation. Mandatory bonding is in place to prevent today's mining operations from becoming tomorrow's abandoned mine sites.

Because there is often substantial overlap of federal and state requirements, state and federal agencies have a Memorandum of Understanding that establishes which agency has the primary regulatory responsibilities. In most cases, state agencies have the primary roles for permitting the mine, conducting on-site inspections, and enforcing the permit requirements. This is true even when the rules are issued by Congress or a federal agency, and even when the mining takes place on federal lands. The lead agency negotiates permit provisions with the mine operator using state and federal rules as a baseline for the negotiations. This relationship suggests the principal–agent model is an appropriate way to think about bonding issues.

The operating permit includes a reclamation plan and a reclamation cost estimate, as well as a financial assurance of site reclamation. Reclamation requirements apply whether the operation is a rudimentary surface scratching that can be addressed with a handful of grass seed, or a multi-million dollar cleanup of a mine site that operated for a decade or more. The basic objectives are to minimize public health risks and to allow the land to support other uses when mining is completed (Deisley, 1991). The terms of the permit are quite comprehensive, and include stipulations regarding the reclamation of drill holes, open pits, processing facilities, and roads, as well as requirements for backfilling waste rock disposal, and revegetation.

The monitoring costs for reclamation requirements vary, but in many cases can be expected to be reasonably low. The firm requests the release of the bond, and the regulator has the discretion to withhold the bond if the site is not satisfactorily reclaimed. In response, the mine operator (or the surety) can challenge the decision in court. The court will make its decision based on a comparison of the permit terms and the condition of the site, and the probability that nonperformance is detected is likely to be close to one.

Bonding provisions

In general, there have been two ways to set bond amounts. The first is a per-acre calculation. Second, the bond is set at the expected reclamation costs, which usually includes administrative expenses and a profit margin for a third-party contractor. The BLM regulations illustrate these two cases. The agency caps bond amounts at \$1000 per acre for exploration projects, and \$2000 per acre for development. In contrast, operations using cyanide or with potential for acid drainage are bonded at the expected reclamation cost. These BLM requirements are considered minimum standards, because the western states have their own bonding rules. Montana and Nevada, for instance, require bonding at the expected reclamation costs for all projects.

Table 1 summarizes information about bonded acres and bond amounts for operators in Montana. Notice that the amount of the bond is substantially higher than the amount required by BLM. A recent survey of multinational mining companies found annual surety premiums of 0.37 to 1.5 percent of the face value of the bond (Miller, 1998). The very large mines in Montana (mines with more than 500 acres bonded) have an average bond of over \$20 million, suggesting annual premiums between \$75,000 and \$300,000. In addition, the bond amount is a liability on the firm's balance sheet. It is not clear to what degree this expense affects liquidity of a large firm, but many firms consider this a pure cost (Miller, 1998). If the primary benefit of the bond is

Table 1
Bonded operations in Montana, January 1999[a]

Bonded acres	Number of sites	Average acres bonded	Average bond amount ($)	Average $/acre
0–100	14	27	143,341	5309
101–500	9	277	3,414,425	12,326
>500	6	2048	21,447,009	10,472

[a] Source: Montana Department of Environmental Quality

to shift the burden of proof in potential litigation, this indeed appears to be a steep price to pay.

Firms with limited assets or spotty financial histories pay a premium that is a much higher percentage of the bond amount. Small firms also post a higher percentage of collateral in terms of the bond amount. A 1988 GAO report found that small coal operations posted collateral of 25 percent of the face value of the bond; whereas the amount for large operations was less than 10 percent (US General Accounting Office, 1988, p. 4).

In response to the problem of surety availability, some state governments have bond pools for operations that cannot secure surety bonds privately. Nevada operators that cannot obtain a private surety, for instance, can join the state bond pool, but the costs of joining the pool are higher than obtaining a surety privately (of course, if the firm could obtain a bond privately, it would not have to pay higher rates). To enter the Nevada pool, the operator posts a collateral deposit of 15 percent of the face value of the bond, and pays a 10 percent annual premium. The state allows maximum bonds of $250,000 for exploration, and $1 million for mines.

Table 2 lists characteristics of bond-pool participants in Nevada. Consider the exploration project bonded at $34,000. Based on the information concerning costs of joining the state pool, the firm posted $5100 in collateral, and pays an annual premium of $3400. Assuming a 10 percent opportunity cost on the collateral ($510), the firm pays an annual fee that amounts to almost 12 percent of the bond amount. This is a substantially higher percentage than the 0.37 to 1.5 percent paid by large mines. The state bond pool is one way to address liquidity constraints, and if successful, private bond pools may arise. However, pooling risks among operators that cannot obtain private sureties is likely to introduce an adverse selection problem — that is, only high risk firms will select into the bond pool.[10]

Does hardrock bonding work? Evidence from the Western United States

There have been audits of surface management regulations in the western states by the US General Accounting Office (GAO) and state agencies. The first was a 1986 GAO report revealing a poor record of ensuring reclamation on BLM lands. Even after BLM promulgated its regulations in 1981, the agency only required bonds for operators that had a record of noncompliance. The GAO audit identified 556 operations in ten states and found that only one operator was required to furnish a bond (US General Accounting Office, 1986, p. 29). As a result, there was a low rate of reclaimed sites. A review of 246 inactive or abandoned sites found that 96 sites (39 percent) went unreclaimed.

A GAO examination of the Forest Service program in 1987 showed more promising results. GAO found that the Forest Service required financial guarantees for 214 of the 336 operations evaluated for five national forests in Nevada, Idaho, Montana, and California. (US General Accounting Office, 1987, p. 12). Operations were discontinued at 57 of the 214 sites where the Forest Service required a bond. Of these sites, one had created no disturbance, 28 sites had been reclaimed by the operator,

[10] Miller (1998) discusses the problems of the emergence of insurance markets for reclamation policies.

Table 2
Nevada bond pool participants[a]

Type of activity	Acres disturbed	Bond amount ($)	$/acre
Mineral processing	276	713,212	2584
Reclamation	235	328,942	1399
Exploration	n/a	34,000	n/a
Mineral processing	85	269,195	3167
Mining	38	53,352	1404
Reclamation	95	124,017	1305

[a] Source: Nevada Bureau of Land Management Records

18 were in the process of being reclaimed, and six sites were inactive but not abandoned. Of the remaining four cases, the Forest Service used the proceeds from forfeited bonds to reclaim three sites. The bond amounts were $6000, $400, and $3585. In another case, the Forest Service allowed a guarantee of $9700 to lapse, and was stuck with the cleanup bill (US General Accounting Office, 1987, p. 12).

The success rate was lower at the 19 sites where the Forest Service did not secure financial guarantees. Nine of these sites posed no significant disturbance, in six cases the operators had reclaimed the site even without the bond, and four sites were unreclaimed (US General Accounting Office, 1987, p. 16). The GAO concluded that the financial guarantees, when required, were an effective tool for promoting reclamation.

More recently, the Inspector General of the Department of Agriculture finished an audit of the Forest Service's handling of abandoned mines. The Inspector General found that "the percent of active sites that become problems when abandoned are small, [but] the resulting reclamation costs can be large" (US Department of Agriculture, 1996, p. 32). For the period 1991 to 1994, operators failed to reclaim 295 sites. The Forest Service retained $860,000 in bond forfeitures, and spent $699,000 reclaiming 146 sites. The estimated cost of reclaiming the remaining 149 sites is $1.3 million (US Department of Agriculture, 1996, p. 31). Thus, for the three to four year period, the Forest Service was left with $1.14 million in unfunded liabilities.

Finally, a legislative audit of Montana's mining enforcement, though critical in many areas, found no problems with bond releases (Montana Office of the Legislative Auditor, 1994, p. 20). Table 3 presents information on bonds that were released or forfeited between 1978 and 1996. The information was gathered at the Montana Department of Environmental Quality (DEQ) in January of 1999. Of the 28 operations, 13 had full bond releases, seven partial releases, and eight were forfeited. A number of sites have multiple release dates, either because the initial reclamation was not sufficient, or because of partial release provisions. In some cases bond amounts are reduced in proportion to the completion of on-site reclamation. According to DEQ personnel, the proceeds from the bond (or cash) forfeitures were generally sufficient to reclaim the sites.

The collateral posted for the sites listed in Table 3, however, is relatively small — the largest bonds posted just over $100,000. There are currently ten mines in Montana with bonds in excess of $1 million, including a cyanide operation at the Golden Sunlight mine that has posted a bond of $51.7 million. The effectiveness of bonding at larger sites is less clear, and the preliminary indications present mixed signals. For instance, in Montana, a surety provider recently reimbursed the state for $6.5 million at the Beal Mountain Mine, and $3.8 million at Basin Creek after bankruptcy of the parent company.

Enforcement of other provisions

Miller (1998) finds that reclamation bonds are being used by governments around the world, and the United States' experience suggests that bonding is a reasonably effective means for ensuring reclamation. The widespread use of reclamation bonds and their apparent utility beg the question of why bonding is used for reclamation, but not for other dimensions of environmental protection. Conceivably, regulators could require bonds to guarantee compliance with other environmental regulations (or any regulations), but if such a practice exists, it is certainly not the norm.

Shogren et al. (1993) show why the scope of bonding is limited, and also catalog conditions when bonds are likely to be effective: (1) well-known damage valuation (2) a high probability of detecting environmental damage; (3) a well-defined agreement; (4) few parties; (5) a fixed time horizon; (6) a low bond value; and (7) no irreversible effects. This list is probably more exhaustive than it needs to be. The Coase Theorem, for instance, demonstrates that if there are clear rules (condition 3), few contracting parties (condition 4), and low transaction costs (conditions 1 and 2), the efficient outcome will occur through voluntary exchange.

Interestingly, most of these conditions are in place for ongoing operations (few parties, clear permit provisions, fixed time horizon), yet mine operators are not bonded out for water quality, air quality, and other environmental performance standards. The probable reason is monitoring costs. Most mine sites are infrequently monitored. In 1996, for instance, the Inspector General of the Department of Agriculture reviewed 115 active operations on Forest Service land and found that 69 (60 percent) had not been inspected for more than three years. Of the sites that had been inspected, 25 had been inspected once, 13 twice, and only eight sites had been inspected three times. The Forest Service cited budget constraints, lack of qualified personnel, remoteness of sites, and higher priority work as reasons for the lax inspection record (US Department of Agriculture, 1996, p. 26). Even if there was regular monitoring, however, the purpose of the bond is to guarantee financial assurance if the agent shirks. It is not clear that the state would be in a position to remedy problems at an ongoing operation.

The bonding mechanism has been compared to a deposit-refund system — the agent makes an up-front deposit that is refunded when the principal verifies compliance (Bohm and Russell, 1985). The underlying motivation is the high default risk on the side of the agent. The system will work if the conditions are clear,

Table 3
Bond releases and forfeitures in Montana, 1978–1996[a]

Case #	Minerals	Operation	Acres	Owner	Release/Forfeiture
1	gold, silver, lead, zinc, copper	underground	9	Forest Service	Released $4500
2	gold	placer	2	private	Released $2000
3	gold	placer	4	private	Released $2000
4	gold	placer	23	Forest Service	Released $23,000
5	gold	placer	14	private	Released $1000; Forfeited $14,900
6	gold, silver, copper, lead	open pit, underground	10	BLM	Forfeited $2000
7	gold, silver	placer	12	BLM	Forfeited $6600
8	gold	heap leach			Released $15,000; Retained $12,000
9	iron	open pit	15		Forfeited $2000
10	gold	placer	4	private	Forfeited
11	gold	placer	243		Released $73,182; Retained $25,614; Full Release–12/90
12	gold	placer	15		Forfeited $6000
13	gold, silver, lead, zinc	underground, mill	47	Forest Service	Released $72,000
14	gold	placer	40		Released $8000
15	gold	placer	244		Forfeited $108,375
16		open pit, mill	14		Released $1250
17	gold	placer	16	private	Released $4800
18	gold	placer	60		Released $6825; Retained $3675
19	gold	placer	20		Released $20,000
20	tungsten, molybdenum	underground, mill	15		Released $25,000
21	gold	placer	6	Forest Service	Released $12,000
22	sapphires, gold, silver		162		Released $100,500; Retained $12,000
23	gold	placer	30	private	Released $22,000, 12/82; Released $6812, 5/87; Released $5812, 3/88; Released $1000 9/94
24	gold	placer	23		Forfeited $35,000
25	barite	quarry	35		Released $2000, 12/93 Released $12,250, 5/92
26	gold, silver	underground	10		Released $5950, 7/93; Forfeited $21,950, 6/96
27	gold	underground, cyanide	160		Forfeited $74,299
28	gold	placer	193		Released $6150, 12/91 Forfeited $5865; Released $14,831, 8/93

[a] Source: Montana Department of Environmental Quality.

there are low monitoring costs, and the system does not trigger moral hazard on the side of the principal. Consider the aluminum can recycling programs that are run in some areas. The customer posts a deposit (e.g., five cents in some areas of the US) when she buys a can of soda. The terms of the agreement are clear and easily verified — if she returns the can, the state refunds her five cents. Thus, the deposit averts her temptation to put the can with her other refuse, and it is not likely to impose a major liquidity constraint. In general, the customer is not overly concerned that the state will renege and refuse to reimburse her.

That the deposit-refund system is operable is undeniable — the polluter that tosses a can in the ditch pays by forfeiting the deposit. There is, however, no way to tell if this is an instrument that will deliver socially optimal environmental quality at the lowest possible cost. In fact, it is not clear that the deposit in any way approximates the marginal social damages associated with failing to return the can. This underscores the role of the bonding mechanism as a means to enforce a standard, not to necessarily yield an efficient outcome.

Conclusions

The empirical literature on environmental enforcement shows that monitoring effectively deters regulatory violations (Cohen, 1999), and the theoretical and empirical results from this paper show that bonding is no exception. Bonding is a market-based enforcement mechanism that relies on financial incentives and reputation effects to deliver site reclamation at the lowest possible cost. Although bonding might be thought of as a substitute to liability rules, bonding and liability are actually complements. Some of the same elements that confound successful working of liability rules also limit the effectiveness of bonding mechanisms.

The analysis also introduces a number of lingering questions. For instance, it is clear that there are similar motivations for minimum financial requirements and bonding mechanisms. What is less clear is whether these instruments are close substitutes, and the conditions where one instrument is preferable to another. The analysis also shows that the appropriate level of the bond amount is a function of firm's capital assets and the probability distribution over expected reclamation costs. These issues will have to be addressed if effective public policies for bonding issues are to be developed.

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References

Arizona State Mine Inspector, 1999. Abandoned and Inactive Mine Survey, Pamphlet.

Becker, G.S., Stigler, G.J., 1974. Law enforcement, malfeasance, and compensation of enforcers. Journal of Legal Studies 3, 1–18.

Bohm, P., Russell, C.S., 1985. Comparative analysis of alternative policy instruments. In: Kneese, A., Sweeny, J. (Eds.), Handbook of Natural Resource and Energy Economics. Elsevier Science Publishers, New York, pp. 395–460.

Carman, M.D., 1997. Regulatory and transactional bonding: a primer on surety bonding for the mineral lawyer. Proceedings of the Seventeenth Annual Eastern Mineral Law Institute, 7–1(23).

Cohen, M.A., 1999. Monitoring and enforcement of environmental policy, In: Tietenberg, T. Folmer, H. (Eds.), International Yearbook of Environmental and Resource Economics, Vol. III. Edward Elgar publishers, (in press).

Constanza, R., Perrings, C., 1990. A flexible assurance bonding system for environmental management. Ecological Economics 2, 57–75.

Cooter, R., Ulen, T., 2000. Law and Economics. Addison-Wesley, Reading (MA).

Cropper, M., Oates, W.E., 1992. Environmental economics: a survey. Journal of Economic Literature 20, 675–740.

Deisley, D.L., 1991. Bonding for reclamation of oil, gas, and hard rock minerals development. Proceedings of the Rocky Mountain Mineral Law Institute, 19–1(42) (1991).

McElfish, J.M. Jr., Bass, S.P., Bernstein, T., Sheldon, E., 1996. Hard Rock Mining: State Approaches to Environmental Protection. Environmental Law Institute, Washington (DC).

Miller, C.G., 1998. Use of financial surety for environmental purposes. Paper prepared for the International Council on Metals and the Environment.

Montana Office of the Legislative Auditor, 1994. Hard rock mining regulation, Reclamation Division, Department of State Lands: performance audit report. Office of the Legislative Auditor, Montana Legislature.

Perrings, C., 1989. Environmental bonds and environmental research in innovative activities. Ecological Economics 1, 95–110.

Shavell, S., 1984. Liability for harm versus regulation of safety. Journal of Legal Studies 13, 357–374.

Shavell, S., 1986. The judgment proof problem. International Review of Law and Economics 6, 45–58.

Shavell, S., 1993. The optimal structure of law enforcement. Journal of Law and Economics 36, 255–287.

Shogren, J.F., Herriges, J.A., Govindasamy, R., 1993. Limits to environmental bonds. Ecological Economics 8, 109–133.

United States Department of Agriculture, Office of the Inspector General, 1996. Forest Service Management of Hazardous Material at Active and Abandoned Mines. USDA, Audit Report No. 08601–1–At. Atlanta.

United States General Accounting Office, 1986. Public Lands: Interior should ensure against abuses from hardrock mining. Government Printing Office, Washington, DC.

United States General Accounting Office, 1987. Federal Land Management: Financial Guarantees Encourage Reclamation of National Forest System Lands. Government Printing Office, Washington, DC.

United States General Accounting Office, 1988. Surface Mining: Cost and Availability of Reclamation Bonds. Government Printing Office, Washington, DC.