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*Investment in Private Water Development: Property Rights and
Contractual Opportunism during the California Gold Rush*

by **Mark Kanazawa**

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Department of Economics
Carleton College
One North College Street
Northfield, MN 55057
Telephone: (507) 646-4109
Facsimile Number: (507) 646-4044

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Abstract

This paper explores the development of water supplies by private ditch companies during the California Gold Rush. Using data taken from newspaper stories, mining camp by-laws, and district court cases, its principal findings are that uncertain property rights, and significant contractual enforcement costs that permitted miners to capture a substantial portion of the surplus from private water development, probably had a discouraging effect on investment by ditch companies in water supply. Imperfect capital markets, and transactions and search costs, prevented organizational adjustments that would have eliminated this investment disincentive.

Keywords: Water supply, gold mining, specific investment, contractual opportunism

I. Introduction

In recent years, steadily increasing demand for water in the face of static supplies in many regions of the world has generated growing economic pressures to develop and allocate water more efficiently. Toward these ends, there has been growing interest in ways to restructure water supply arrangements, which in recent historical times have been dominated by public ownership and distribution.¹ Scholarly support for novel institutional arrangements that more heavily emphasize private control stem from perceptions that public providers have been subject to political influence, mismanagement, corruption, attenuated property rights, and isolation from market discipline.² Initiatives for greater private involvement have been undertaken in numerous settings including the western United States, Europe, Africa, and South America and in many cases have resulted in significantly improved water industry performance.³

Private arrangements have not been without their problems, however. The econometric evidence is mixed at best that private water utilities outperform their public counterparts, at least in the United States.⁴ Reservations about reliance on private entities include concerns regarding monopoly power, inadequate access to capital markets, affordability, universal access, and externalities, all of which go far toward explaining why it is rare to find totally unregulated private

¹ This is a common recent theme in urban water supply in a number of developing countries[Shirley(2002)]. For evidence for Europe, see Vickers and Yarrow(1991), Menard and Saussier(2002). Water supply was dominated by private developers in the United States for most of the 19th century[Crocker and Masten(2002)].

² See, for example, Crain and Zardkoohi(1978); World Bank(1994), pp. 2-7; Anderson and Snyder(1997), pp. 50-53; Shirley(2002), pp. xvii-xix.

³ See, for example, Anderson and Snyder(1997), p. 191; Vickers and Yarrow(1991), Masten and Saussier(2002). The studies in Shirley(2002) broadly support that increased private involvement has resulted in welfare gains in many developing countries. See, for example, Alcazar, Abdala, and Shirley(2002), Alcazar, Xu and Zuluaga(2002), Shirley, Xu and Zuluaga(2002).

⁴ A large scholarly literature investigates this issue. For some representative studies, see Crain and Zardkoohi(1978); Feigenbaum and Teeple(1983); Bhattacharyya et al.(1994).

water suppliers.⁵ In the vast majority of cases, the government has maintained significant (sometimes considerable) involvement; for example, through auctioning of concessions, leasing agreements, monitoring of firm activity, and numerous contractual stipulations.⁶ Consequently, many economic studies have examined incentive issues that arise when it is costly for governments to precommit not to siphon off rents from the private companies through, for example, price regulation and outright expropriation of assets.⁷ The threat of government expropriation can have a chilling effect on the propensity for private firms to undertake appropriate investments.⁸

A related possibility is that investment can be discouraged by expropriation of rents by customers of private companies, which can arise when it is costly to enforce contracts for water supply. For example, it may be difficult to prevent customers from engaging in “takings” of water that they would otherwise be paying for, or to prevent customers from unilaterally renegotiating contracts to try to gain more favorable terms.⁹ Such takings are more likely to occur in certain institutional settings characterized by relatively high enforcement costs, such as developing countries.¹⁰ When these costs are sufficiently high, water development is discouraged because private developers anticipate reduced returns on their investments. This possibility has not, of

⁵ See, for example, World Bank(1994), p. 4; Anderson and Snyder(1997), pp. 50-53; Shirley and Menard(2002), pp. 37-39.

⁶ Menard and Saussier(2002), p. 443.

⁷ See, for example, Williamson(1979), pp. 257-58; McChesney(1987); Levy and Spiller(1994).

⁸ McChesney(1987); Levy and Spiller(1994). But see Noll(2002) and Shirley and Menard(2002) for discussions that deemphasize the disincentive effects of the threat of government expropriation.

⁹ Rent expropriation by consumers can also occur through the political process, as emphasized by some economists [see Noll(2002), p. 50, Crocker and Masten(2002), p. 331], which could be manifested through the actions of the government regulators. The point here is, however, the slightly different one that expropriation may occur through direct private action by consumers.

¹⁰ A great deal of evidence suggests that contractual enforcement costs for water supply are extremely high in many developing countries. See World Bank(1994); Alcazar, Abdala, and

course, been overlooked by economists, who have recognized for some time that contracting parties often have incentive to behave opportunistically given investments in specific capital. Existing scholarly studies, however, typically focus on contractual or organizational adaptations whose purpose is to economize on transactions costs.¹¹ Contracts and vertical integration data, though relatively easy to find, often provide little direct information on the actual opportunistic behavior itself: the strategies of the players, the margins on which they competed, and the manner in which investment was discouraged as a result. In addition, econometric studies of contracts often suffer from insufficiently rich data, which has led some economists to call for more detailed case studies.¹²

The circumstances of the California Gold Rush of the 1850's provide a unique opportunity to examine direct evidence on private water development within an uncertain institutional environment. In response to rapid technological change, gold mining production in California quickly became heavily water-intensive, which gave major impetus to private development of water supplies.¹³ Private investment was, however, discouraged by legal uncertainty regarding the land and water rights of ditch companies while interestingly enough, miners repeatedly opposed ditch company efforts to gain increased rights security. In addition, water development required significant investments in site-specific capital, which generated numerous opportunities for contractual holdup. Because enforcement costs were high, opportunistic behavior by miners could not be easily overcome through long-term contracting. One solution was vertical integration of mining and ditch operations, but miners often lacked access to sufficient capital and ditch

Shirley(2002), p. 67; Haggarty, Brook, and Zuluaga(2002), pp. 169-70; Crocker and Masten(2002), p. 344;

¹¹ Goldberg(1976); Williamson(1979, 1985); Joskow(1987); Crocker and Masten(1988).

¹² Masten and Saussier(2002), pp. 289-90.

¹³ Paul(1947); Kelley(1959); Hundley(1992), pp. 67-77; Greenland(2000).

companies experienced large transactions costs and search costs that hindered the purchase of mining operations.

As a result of all these factors, miners were able to expropriate a significant portion of the quasi-rents associated with ditch systems. This they accomplished in various ways including nonpayment for water supplied, miners' strikes for lower prices, and opposing attempts by ditch companies to acquire secure land and water rights. These various opportunistic behaviors were facilitated through the organizational mechanism of local miners camps and districts, which helped overcome various collective action problems.¹⁴ Yet miners' opportunism was limited by their recognition of the importance of water to mining success and their desire not to unduly discourage water development. The story told here explains the dual facts that water development continued to occur throughout the decade (miners did not try to capture all available rents) while miners persistently pleaded for more water development projects to be undertaken (miners managed to capture a significant portion of the rents, providing disincentives for investment).

The remainder of the paper develops these arguments at length using data from a variety of sources including newspaper articles, mining camp and mining district by-laws, state supreme court rulings, and court cases from the district courts of Nevada and Placer Counties. The next section provides background information on gold mining in early California and the manner in which it was prosecuted. Section III goes on to discuss various impediments to water development, noteworthy among which were insecure property rights to land and water. Section IV develops the conceptual framework, which uses a model of incomplete contracting to show the tendency for ditch companies to underinvest under reasonable assumptions, and the superiority

¹⁴ Crocker and Masten mention the difficulties posed by collective action in deemphasizing the importance of water supply customers [Crocker and Masten(2002), p. 331]. For more on the organizational role played by mining camps and mining districts, see Shinn(1948), Umbeck (1977, 1981), Zerbe and Anderson (2001), Clay and Wright(forthcoming).

of vertical integration as an organizational form when investment disincentives are strong. Section V documents that miners were frequently opposed to attempts by ditch companies to obtain secure land and water rights before investments were undertaken, while at the same time being not insensitive to the potential for investment to be discouraged. Section VI documents that miners actively engaged in efforts to capture quasi-rents after investments had been made, including strikes for lower prices and non-payment for supplied water. Section VII provides some evidence regarding the dearth of formal water supply contracting, which is attributed to major enforcement costs. Section VIII concludes and draws some tentative lessons for private water development in developing countries.

II. Mining Technologies and Water Supply

The story has been told many times of how, in early 1848, James Marshall discovered gold in the tailrace of a sawmill owned by John Sutter on the American river, an event which triggered a mass-migration of miners to California. Gold was quickly discovered throughout a swath of the foothills of the Sierra Nevada Mountains, roughly 50 miles wide and 120 miles long, ultimately covering all or part of eleven counties. Over the next twelve years, hundreds of millions of dollars worth of gold was produced in California, the vast bulk of it taken from this region of the Sierras.¹⁵

The search for placer gold deposits was largely a hit-or-miss proposition. The miners who initially fanned out over the Sierra foothills typically had little idea where the gold was located and only crude technological know-how at their disposal.¹⁶ More than one observer has

¹⁵ One of our more reliable estimates of gold production is provided by Thomas Berry, who calculated that from 1848 through 1860, over \$616 million worth of gold was produced in California. See Berry(1984), pp. 74, 76.

¹⁶ This is quite a common theme in many accounts of the early Gold Rush. See, for example, Marks(1994), pp. 153-58; Rohrbough(1997), pp. 123-25. On the technological

compared the process of hunting for gold to a high-stakes lottery.¹⁷ Discoveries of gold or even rumors of discoveries often triggered a mad rush of prospectors to the site of the purported strike. Newcomers were often successful at inducing miners to share their new-found gains, through peaceful persuasion, claim-jumping, organized pressure to revise mining camp rules, and even theft, violence, and murder.¹⁸ All of which meant that any miner who discovered gold had every incentive to conceal his good fortune for as long as possible, though they were not always successful.¹⁹

Water was a crucial factor input in the gold production process, though the role it played evolved dramatically within a very short period of time. In placer mining, one of the two main branches of gold mining, the essential function of water was to facilitate the separation of gold from the otherwise worthless rocks, earth, and gravel containing it.²⁰ Early placer mining was dominated by the use of labor-intensive techniques such as *panning* and *rockers* and *cradles*, which were used to extract the gold by miners situated at or near sources of surface water. Miners quickly discovered, however, that productivity could be increased by piping water through boxes called *long toms*, into which gold-bearing material was shovelled, the mixture stirred, and the heavier gold particles made to fall through perforations in the bottom of the tom.²¹ Long

primitiveness of the early miners, see Paul(1947), pp. 44-48; Marks(1994), pp. 156-57; Limbaugh(1999), pp. 27-29.

¹⁷ Marks(1994); p. 156; Rohrbough(1997), pp. 193-94; Cornford(1999), p. 87.

¹⁸ Rohrbough(1997), pp. 217-220. See Clay and Wright(forthcoming) for evidence that the “open access” nature of gold mining was directly reflected in the by-laws of mining camps. Though coercive actions undoubtedly occurred, some evidence suggests their incidence may be exaggerated in popular accounts[See Zerbe and Anderson(2000)].

¹⁹ Marks(1994), pp. 166-68.

²⁰ The other main branch was quartz mining, which employed quite different gold extraction methods.

²¹ According to Bancroft, long toms were first introduced in 1850 [Bancroft(1888), p. 410]. Long toms were first mentioned in accounts in the Alta Californian in February 1851 (See 2/8/51 issue), but apparently experienced rapid diffusion throughout much of the mining regions. By June 1851, the Sacramento Union was reporting that long toms were in “general use” in and

toms were superceded by even longer *sluice boxes*, into which water was piped and material was shovelled, with the gold being caught on riffles attached to the bottom of the boxes. By applying water in a continuous flow, these new methods dramatically increased mining productivity, while using considerably more water than the previous methods.²² However, productivity gains were kept down by the fact that gold-bearing material was fed into the separating apparatus manually, thereby limiting the amount of material that could be processed.

Ground-sluicing, the next important technical advance, increased productivity by dispensing with the need to manually feed material into the separating mechanism. Under this method, a flow of water was directed over a gold-bearing hillside, and the resulting mixture of water and material directed into sluice boxes, which would vent the water while capturing the gold.²³ An important improvement in the efficiency with which water was applied occurred in the mid-1850's, with the invention of *hydraulic mining*.²⁴ Under this method, water was directed through hoses in high-pressure jets against gold-bearing hillsides. The water and materials would wash down and again be directed into long sluice boxes to extract the gold. Hydraulic mining steadily grew in popularity and eventually became a common method of mining in much of the gold mining regions.

around Volcano Diggings(Alta Californian, 6/12/51). Thereafter, references to long toms were quite common.

²² The first reference to sluicing in the Alta Californian occurred in May 1851(See 5/12/51 issue). By the end of 1851, reference to sluicing was becoming increasingly common. See Alta Californian, 11/18/51, 12/22/51, 1/5/52, 2/3/52.

²³ The first detailed account of ground sluicing in the Alta Californian is found in 1/14/53, referring to operations in the area around Table Mountain in Tuolumne county.

²⁴ Edward Mattheson is widely credited with the invention of hydraulic mining in 1853, though it apparently took awhile for it to enjoy widespread use. See, for example, Bancroft (1888), p. 412; Paul(1947); May(1970). The first mention of hydraulic mining in the Alta Californian occurred in June 1853, and described it as “A new method of mining in hill diggings ... as novel as it is efficient.” (Alta Californian, 6/7/53), which is consistent with the histories.

As mining technologies evolved over time, so did the manner in which water was procured by miners. Under the early methods of mining requiring little water, it was a simple matter for miners to meet their own water needs. Most of the initial strikes occurred on or near rivers and streams, which was thus where panning and rocker-and-cradle mining largely took place, with miners simply taking and using what little water they needed.²⁵ When strikes occurred at “dry diggings” physically removed from surface water sources, initially miners simply hauled their earth to the nearest source of water, mostly using backpacks, carts, or animal power. It was not long, however, before miners conceived of the idea of bringing water to the dry diggings. Ditches were being completed in Nevada County as early as March 1850.²⁶ Some evidence indicates that ditch projects were undertaken as early as fall of 1850 in Tuolumne County.²⁷ One of the earliest references in the Alta Californian to such a scheme is found in February 1851, in which a miner in Sonora described a plan to build a ditch to bring water to various claims in Tuolumne County:

“A plan of great merit for bringing water into the dry diggings has been designed by Thomas Frazer, a skilful miner of Yankee Hill Diggings. He proposes to take the water from a creek that is a tributary of the Stanislaus, seven miles from Pine-log Crossing. The creek has sufficient elevation if the water is carried in canal along the sides of the hills, parallel with the Stanislaus, to carry it over a gap at the crossing. It will then have sufficient elevation to take it to the heads of all the gulches. It would supply all the following diggings with water, viz: Yankee Hill, Columbia, Shaw’s Flat and Humbug, and many other without name.”²⁸

Given the large search costs involved in the process of gold discovery described earlier, it is not surprising that this ditch project was apparently undertaken to fill an existing demand for water;

²⁵ When strikes were made in the beds of rivers, a quite different technological problem was presented by water, which often involved diverting it around the strike site through wooden flumes, which was heavily capital-intensive. Such river mining companies are not considered in this study.

²⁶ Thompson & West(1970), p. 171.

²⁷ Alta Californian, 8/4/52.

²⁸ Alta Californian, 2/8/51.

namely, to supply water to a number of diggings already in operation. Water developers had to wait and see what (and where!) the demand was before they were willing to invest significant resources in a ditch project: the water followed the gold, not the other way round. We will return to this point shortly.

Early ditches were small affairs: at most a few miles and incapable of conveying large amounts of water.²⁹ It was not long, however, before much longer and more massive ditch projects began to be undertaken. In May 1852, the Sacramento Union reported that the 45-mile-long Bear River and Auburn Canal was about to be completed in Placer County: it was eventually completed in November.³⁰ That same month, the Union reported the progress of another substantial ditch project in El Dorado County, estimated to cost \$100,000 to construct.³¹ By August, the Sonora Herald was announcing the near-completion by the Tuolumne County Water Company of a large ditch capable of serving 500 to 1000 long toms, all year round.³² The massiveness of this undertaking is suggested by the following description:

“(The Tuolumne Canal) must have originated with men of gigantic energy and enterprise, for few persons would have ever made the attempt to construct a flume for miles on the side of a precipitous rock, where a single misstep would send them a thousand feet into the ravine below... Five miles from the dam is a bridge, 30 feet high and 800 feet long, that conveys the water across a ravine; and a few rods farther on, a tunnel, 300 feet long, 4 by 6 feet, arched and well-supported, conveys the water to a deep ditch, winding and turning on the side hills, to a distance fifteen miles from the dam. Here a natural ravine, crossed at right angles at the bottom by Five Mile Creek, takes the water, and by a flume ten miles long, the creek is tapped and the water carried direct to Columbia. From here a ditch has been constructed, ten miles in length, that takes the waste water to the various diggings below.”³³

²⁹ Paul (1947), p. 161; Alta Californian, 2/8/51, 7/11/51.

³⁰ Alta Californian, 5/23/52, 11/13/52.

³¹ Alta Californian, 5/28/52.

³² Alta Californian, 8/4/52.

³³ Alta Californian, 8/23/52.

Ditch construction continued at a furious pace for several years. Figure 1 shows total ditch mileage in the state for most years from 1855(the earliest year for which aggregate data are available) to 1865, as reported by the State Engineer's Office.³⁴ By 1855, more than 2,500 miles of ditches existed in the state, all of it situated in eight mining counties with two – Nevada and El Dorado – accounting for over two thirds of the total. Within two years ditch mileage had more than doubled to over 5,100 miles, at which point it began to level off, reaching a high of nearly 5,600 miles in 1859. Virtually all of these ditches were in mining counties. According to Governor Weller, the entire ditch system had cost \$13.5 million to construct, a figure that represented over 2.6% of the total value of gold produced in the state up to that time.³⁵

III. Impediments to Water Development

The creation of this massive ditch system did not come easily. Aside from the sheer physical challenges associated with constructing extensive ditches over uneven and sometimes treacherous terrain, water developers also experienced a number of entrepreneurial, financial, and legal difficulties. As mining moved increasingly to dry diggings and the value of ditch systems became increasingly apparent, miners made major efforts to develop water, typically by banding together into joint stock companies. However, they often lacked sufficient capital resources, including access to capital markets, to successfully undertake the construction of a lengthy ditch. Consequently, many ditch projects started by miners were taken over by outside financial interests.³⁶ Other projects were initiated by outside interests. Outsiders, however, often lacked appropriate expertise or a sufficient appreciation of the magnitude and complexity of the task of

³⁴ These data are contained in the annual reports of the State Engineer.

³⁵ Journal of the Senate, 10th session(1859), p. 38. See also Alta Californian, 1/6/59. The total gold production value figure of \$516.3 million used in this calculation is based upon the estimates of Berry(1984), p. 84.

³⁶ See, for example, Paul(1947), pp. 165-67; Alta Californian, 12/28/57.

engineering, constructing, and maintaining a reliable supply of water through a ditch.³⁷ Many early ditch companies failed, which undoubtedly increased the perception among outside investors that investments in ditch projects were risky. This was probably particularly the case among foreign investors, who had invested heavily in mining in California during the early 1850's.³⁸ Much evidence indicates that the inability to obtain financing was commonly a major obstacle to successful prosecution of a ditch project.³⁹

Another important obstacle to successful water development in the 1850's was an uncertain legal environment that created insecure property rights in land and water. One set of legal issues involved the peculiar conditions of land ownership that prevailed in early California. The original discovery of gold occurred prior to statehood and in particular, before a number of issues had been resolved concerning the legal status and disposition of the mining regions. Upon statehood, the mining regions all became part of the public domain; that is, public lands belonging to the federal government. This meant that legally speaking, miners and ditch companies were all illegal trespassers who were taking millions of dollars worth of gold and water resources that technically belonged to the federal government. The fact of federal ownership had certain legal ramifications, perhaps the most important of which was that miners and ditch companies could not claim private ownership of the lands they occupied. Consequently, for a number of years miners and ditch companies lived with uncertainty over the legal status of their land and water rights.⁴⁰

A series of state supreme court rulings during the 1850's made it clear that miners and ditch companies existed on the public lands at the sufferance of the federal government. A series

³⁷ Paul(1947), p. 165; Greenland(2000), pp. 73-74; Alta Californian, 10/28/52.

³⁸ See, for example, Spencer(1995), p. 3.

³⁹ See, for example, Greenland(2000), pp. 74-75; Alta Californian, 12/27/51, 2/26/55, 4/5/55, 3/22/56, 11/21/56, 5/26/57.

of rulings consistently established the rights to mine and divert water on public lands.⁴¹ Just as consistently, however, the courts made it clear that any rights claimed were not fee simple but rather, were possessory rights, which would have to give way if the federal government ever asserted its rights. In Tartar v. Spring Creek, for example, the court ruled that a prior claim only established:

“a *quasi* private proprietorship, which entitles the owner to be protected in its quiet enjoyment against all the world but the *true owner*[i.e., the federal government] ... as against the privileges granted to miners.”⁴² (emphasis added)

Similarly, in Merced Mining Co. v. Fremont, the court argued that:

“the owner of a mining-claim has, in *practical effect*, a good vested title to the property, and should be so treated, until his title is divested, by the exercise of the higher right of the superior proprietor[i.e., the federal government]. His rights and remedies, in the meantime, are not trammelled by the consideration that the higher right to reclaim the property exists in another, which right may *possibly*, but will not *probably*, be exercised.”⁴³ (emphasis in original)

The seeming assurances provided by Merced did not, however, eliminate the popular perception that the federal government could intervene and expropriate lands and resources in the mining regions at any time. In 1857, for example, an editorial appeared in the Nevada Journal that reflected mining concerns over their tenuous rights:

“What, in the mining counties, is a ‘recognized and established private right’? As against the United State Government there is none such. We have the lowest species of possession – by mere sufferance – in mining claims, and in all other improvements. We are liable at any time to be ousted by an act of the government.”⁴⁴

⁴⁰ McCurdy(1976); Kanazawa(1998).

⁴¹ See Hicks v. Bell, 3 Cal 219(1853); Stoakes v. Barrett, 5 Cal 37(1855), Irwin v. Phillips, 5 Cal 140(1855).

⁴² 5 Cal 396(1855).

⁴³ 7 Cal 317(1857), at 327. See also Kelly v. Natoma Water Company, 6 Cal 105(1856); Maeris v. Bicknell, 7 Cal 261(1857).

⁴⁴ Alta Californian, 11/16/57.

A week later, the Marysville Express was expressing similar concerns regarding the legal status of ditch companies:

“By the decisions of the State Courts, ditch owners are protected in their rights, but, as we have said before, it is by mere sufferance;... Should the Supreme Court of the United States not sustain those doctrines, and insist upon the common law doctrine of riparian rights which has been overthrown by judicial decisions in this State, then our ditch-owners, who are the very life of the mining interests, will be without protection.”⁴⁵

Aside from the general specter of federal expropriation, anyone interested in developing water had to overcome certain legal obstacles including difficulties in acquiring secure water rights and secure rights of way for their ditches. Rights of way were sometimes difficult to obtain because they were subject to legal challenge by miners desiring to retain water locally or to extort rents. Obtaining water rights of reasonable security was made difficult by the fact that waterways were typically used in common by miners, which resulted in frequent disputes over rights to the water. The most common type of dispute during this period involved diversions of water that either deprived downstream claimants of water or degraded it in quality. In resolving these disputes the courts were confronted with a variety of issues, including the rights of prior claimants, water quality degradation, the selling of water, and the conditions under which rights would be forfeited, to name only a few. The complexity of the issues, along with the fact that it took time for the courts to resolve them, meant that for a time anyone wishing to develop water could not be certain of precisely what their rights were.

Some evidence suggests that during the 1850's, investment in ditch systems in California was discouraged by the legal uncertainty surrounding the property rights of water developers. In December 1857, for example, the Alta Californian was observed editorializing that ditch con-

⁴⁵ Alta Californian, 11/24/57.

struction was being discouraged by the insecurity of property rights of ditch companies and urging Congress to step in:

“Let Congress throw around this species of property a sufficient guarantee of its reliability, and capitalists will then seek it as a profitable investment... instead of the present system of fruitless begging for funds to forward these great works being resorted to by the projectors of lines of ditches.”

More evidence on this point is provided in section V.

IV. Ditch Company Investment and Ownership Structure

For economists, of course, it is practically axiomatic that insecure property rights can discourage investments by denying investors the opportunity to appropriate the entire associated income stream. The story is, however, more complicated when dealing with certain types of investments that have a *relationship-specific* component. The construction of a ditch to service a mining community, for example, constituted a relationship-specific investment: undertaken at a specific location to service miners in that location. Once built, the absence of a resale market meant that any such investment likely contained a significant sunk component that, all else equal, generated the possibility of opportunistic holdup by mining companies as customers purchasing water.⁴⁶ Mining companies were also required to make relationship-specific investments such as certain types of hydraulic equipment and later on, bedrock drainage tunnels.⁴⁷ During the 1850's, however, their specific investments were probably dwarfed by those made by ditch companies.

To see the effect of these considerations on investments and ownership structure, let us consider a simple two-period model in which investment occurs in period one, and then negotiation over the terms of exchange of the water developed occurs in period two. Assume that it was

⁴⁶ See, for example, Klein, Alchian and Crawford(1978), Williamson(1979).

⁴⁷ See, for example, Greenland(2000), pp. 67-69.

costly for mining and ditch companies to contract over all dimensions of investment in water supplies *ex ante*. For intuition, note that typically there was a great deal of uncertainty regarding the cost of constructing a ditch system, some of which extended for miles through difficult terrain and posed numerous engineering challenges. Water supplies were uncertain due to natural climatic variations and legal disputes. These factors made it costly for mining and ditch companies to make binding contractual commitments *ex ante*, even over fundamental contract parameters such as prices and quantities, not to mention second-order parameters such as the timing of supply and risk-sharing in the case of supply interruptions. Assume, however, that negotiations over water exchanges in the second period could occur at relatively low cost once uncertainty surrounding construction costs and legal challenges had been resolved.⁴⁸ This implies that once water was developed, exchanges could occur to maximize total surplus contingent on the level of *ex post* investment.⁴⁹

The problem was, however, that *ex ante* investment decisions could be distorted because they were made before binding contractual commitments for second-period exchanges could be consummated. In the counterfactual case where such commitments could be made at low cost prior to the investment decision (and assuming symmetric information regarding costs of production), efficient levels of investment are predicted to occur in equilibrium, in a simple application of the Coase Theorem. When such commitments cannot be made, however, inefficient levels of investment occur to the extent that investing firms are forced to bargain away a portion of the

⁴⁸ Uncertainty over water supplies would not, of course, have been entirely eliminated *ex post* so in reality transactions costs would have been lower, but not zero.

⁴⁹ For similar models of investment and ownership structure, see Grossman and Hart (1986), Hart and Moore(1990). This model has been applied to a number of issues including public versus private ownership of firms[Hart, Shleifer and Vishny(1997)] and legal rules [Bebchuk(2001)].

surplus in second-period exchanges and this is built into investor expectations.⁵⁰ Generally speaking, factors that lowered a company's expectations that it would be able to capture rents would have tended to discourage investment by that company.

Surplus capture could be achieved in two related but conceptually distinct ways: either through contractual negotiations in the second period over terms of exchange for the water developed and/or by engaging in contractually unspecified activities that extracted rents from the other party. Miners could, for example, engage in strategic bargaining, challenge or preempt ditch company water rights, develop alternative sources of supply, strike for lower prices, or simply refuse to pay (when enforcement was costly). Ditch companies could play off mining companies against each other, supply water degraded in quality, or subject miners to supply interruptions by economizing on upkeep of ditches and reservoirs. Generally speaking, companies on both sides had incentive to engage in low-cost activities that increased their ability to capture rents. Such activities included ones that enhanced their bargaining position in contractual negotiations, and taking ownership of companies in order to gain control over actions that were difficult to specify contractually.⁵¹

The preceding discussion suggests a potential inefficiency that arose when ditch companies developed water and then sold it to mining companies. Mining companies experienced a tradeoff between first-period investment in water development and second-period capture of rents: the more rents they tried to capture *ex post*, the less incentive ditch companies would have to invest in water development *ex ante*. That is, reduced investment in water development was one of the potential costs to miners of attempting to capture more rents. That investment outcomes could be inefficient is suggested by considering the extreme case where miners were able

⁵⁰ See, for example, Grossman and Hart (1986).

to capture all of the surplus, in which case ditch companies would have lost all incentive to invest. A more likely outcome would be miners capturing only a portion of the surplus, thus preserving ditch company incentives to invest, but at a lower level than in the efficient Coase equilibrium. This discussion suggests that when ditch companies developed water, mining companies walked a fine line, desiring greater surplus while trying not to overly discourage investment in water supplies.

This is not entirely the end of the modeling story, however, since distortions in investment such as just described could generate pressures for changes in firm ownership patterns in order to reduce inefficiencies resulting from these distortions.⁵² Specifically, the greater were the lost incentives to invest, the more pressure there was for mining and water development to reside in one entity. This was particularly true when specific investments by one party dominated in terms of producing second-period value, which was probably the case since as we have seen, specific investments by ditch companies dominated mining investments.⁵³ Indeed, as we have seen, miners commonly tried to develop their own water but frequently lacked the necessary financial resources. On the other hand, ditch companies desiring to vertically integrate into mining production faced significant transactions costs associated with large numbers of miners and incentives for miners to conceal the quality of their claims. In addition, search costs to locate and identify paying claims were typically quite high, as we saw earlier.⁵⁴ These considerations made it costly for vertical integration of mining and ditches to occur. The overall implication is that imperfect capital markets, transactions costs, and search costs importantly shaped the

⁵¹ Grossman and Hart(1986) focus their attention on the latter, while assuming away issues of bargaining.

⁵² Klein, Alchian, and Crawford(1978); Williamson(1985); Grossman and Hart(1986).

⁵³ For fuller discussion of these points, see Grossman and Hart(1986).

ownership structure of the industry, forcing it into a suboptimal ownership pattern that led to underinvestment in water development, to the extent that miners were successful at capturing the associated surplus.

V. Miners v. Ditch Companies

Much evidence suggests that mining companies were deeply ambivalent about their relationship to ditch companies. On the one hand, there is no question that miners viewed water development as absolutely essential to the successful prosecution of mining. Indeed, during the 1850's mining companies were commonly heard extolling the value of water to their operations when it was being supplied⁵⁵ and exhorting ditch companies to bring water in when it was not.⁵⁶ During the dry winter of 1854-55, for example, the Alta Californian published a number of pleas for water development, including the following:

“The great complaint from the mines is want of water. Only give us water, say the miners, and we will make business good all over the State. But if the rains won't come, what are they to do? If the mountain won't go to Mahomet, Mahomet must go to the mountain. If the water won't come to the miners, the miners must go to the water. It is now evident that the only way for the miners, and, indeed, for the whole State, to be saved from the effects of long-continued drouths(sic) is to take the water from the beds of the rivers and carry it in canals over the gold-bearing country. Such canals have been constructed in many parts of the country, and those canals have saved the country from absolute ruin. By the aid of them, many men are kept at work who would otherwise be idle a large part of the year.... But to get the water to those points where it is needed requires a large outlay of capital, and in many instances more than it is possible for the miners in the vicinity to command...”⁵⁷

⁵⁴ Recent studies have emphasized the importance of search costs, characterizing the search for gold as open access races for a limited number of paying sites. See McDowell(2002); Clay and Wright(forthcoming).

⁵⁵ See, for example, Alta Californian, 11/12/52, 12/3/52, 2/9/53, 5/2/53, 7/14/53, 12/10/53, 1/9/54, 3/29/54, 4/25/54, 6/16/54, 2/17/55.

⁵⁶ Alta Californian, 6/26/54, 11/8/54, 2/4/55, 2/9/55, 2/28/55

⁵⁷ Alta Californian, 2/9/55.

On the other hand, mining companies commonly positioned themselves against attempts by ditch companies to acquire water rights and rights of way, and to increase the security of these rights. Mining opposition was reflected, for example, in the by-laws of a number of mining camps and districts that imposed restrictions on the rights of ditch companies to gain access to and develop water. The 1856 code of Little Humbug Creek in Siskiyou County, for example, specified that:

“no person or persons shall be allowed to divert the waters by a ditch or otherwise from Little Humbug to the prejudice of the miners working on the Stream.”⁵⁸

Similarly, according to the 1856 code of Columbia District in Tuolumne County:

“Water flowing naturally through gold bearing ravines, may not be diverted from its natural course without the consent of parties working on said ravine, and when so diverted, it shall be held subject to a requisition from any party interested.”⁵⁹

These code provisions suggest that many mining companies were concerned that providing ditch companies with unrestricted rights to develop water might well deprive them of at least a portion of the available surplus.

A series of resolutions passed at a miners’ meeting at Diamond Springs in El Dorado County in 1854 conveys more fully the miners’ position and reflects deep miner ambivalence with regard to the rights of ditch companies. The resolutions began with a statement that water was an “indispensable element” in mining, which justified prohibitions on diversions of water from any waterway “when the same is needed by the miners on said (waterway) to work their claims.” This was followed by a resolution that prohibited anyone from constructing dams

⁵⁸ U.S. Mining Laws and Regulations(1885), p. 291. See also *Maine Little Humbug Creek*(1856), *Ibid.*, p. 293.

⁵⁹ Heckendorn and Wilson(1856), p. 78. For similar provisions in early mining codes, see *Ibid.*, p. 78[*Brown’s Flat*(185?)]; *Ibid.*, p. 9[*Columbia*(1856)]; U.S. Mining Laws and Regulations, p. 286[*Oregon Gulch*(1855)]; *Ibid.*, p. 297[*Hungry Creek*(1857)]; *Ibid.*, p. 278[*Weaver-ville*(1853)]; Rice v. Emmons, Placer County District Court Case #103(1855)[*Brushy Canyon* (1853)].

across gulches or ravines to collect water for purposes of sale, unless the water was “distribute(d) free to the miners below their dams and reservoirs what water would naturally flow through said gulch or ravine.” Additional resolutions granted to ditch companies rights of way and permission to construct dams and reservoirs but only provided that miners were not injured in any way.

And lastly was a forceful statement in opposition to grants of land to ditch companies:

“Resolved, That we are utterly opposed to granting strips of land through the mines for the benefit of Water Companies, whereby they will become possessed of thousands of acres of the mineral lands, believing it to be a system of favoritism unconstitutional and unjust, and caculated (sic) to work disastrously against the mining interest; aiding to build up an oppressive Water Stock Aristocracy...”⁶⁰

Proponents of the ditch industry made several attempts during the 1850’s to secure legislation that would shore up the legal rights of ditch companies and in each instance encountered stiff opposition from mining interests. One early example of this occurred in 1852 when the legislature considered a bill that would give ditch companies a long-term exclusive right to divert water from streams from which they claimed a water right. The Alta Californian probably spoke for many miners when it attacked the bill as promoting local water monopolies, despite acknowledging that:

“legislation is required to protect the rights of those who have invested their capital and industry in (ditch projects) to overcome natural obstacles which oppose a profitable and continuous working of a large portion of our gold mines.”⁶¹

In the following year, the Miner’s Advocate came out strongly against legislation favorable to the ditch industry, while publishing what amounted to a “laundry list” of grievances against ditch companies:

“We are always sure to hear of damages sustained by them, while we (the miners) are more frequently the sufferers by their aggressions and encroachments upon our rights and privileges. For example, when our natural resources(the water that

⁶⁰ Alta Californian, 2/14/54.

⁶¹ Alta Californian, 4/7/52.

flows from the heads of ravines and gulches) are cut off from us, and put in reservoirs midway of a stream, and then compel us to pay for the use thereof. Also, the running water over our claims, and deluging and damaging us more than their ditches benefit us; and in many instances cases occur where a large reservoir breaks and comes down in a perfect torrent, carrying every thing before it, such as sluices, toms, &c., &c., besides doing irreparable damage to claims, where weeks of labor have been expended in order to prepare them to work.”⁶²

A defender of the ditch industry responded that far from wanting special privileges, ditch companies simply wanted protective legislation:

“so that projectors of ditches and canals might know before their capital was invested what privileges the law would guarantee them.”⁶³

In September 1857, a convention of ditch owners met in Sacramento and came out strongly in support of legislative pressure to petition Congress to grant rights of way on federal lands to ditch companies. Two months later, a bill petitioning Congress for rights of way on public lands and endorsed by the convention appeared in the Alta Californian. This bill also stipulated that the federal government guarantee not to claim or enforce any water rights it might have “by virtue of her ownership of the lands, against any owners of ditches, canals or flumes for mining purposes” in the state.⁶⁴ In support of this measure, the State Journal argued that “the right of way for ditches, and the privilege of sufficient ground for reservoirs (was) indispensable to securing the requisite capital for ditch companies.”⁶⁵ The Alta Californian also came out in favor of Congress granting permanent rights of way on the public lands, arguing that doing so would:

“remove the main obstacle which now exists in the way of constructing ditches over new localities not yet worked. Capital will then flow in at cheap rates, and this species of property, besides adding greatly to the sources of State revenue,

⁶² Alta Californian, 11/15/53.

⁶³ Ibid., 11/15/53.

⁶⁴ Alta Californian, 11/7/57.

⁶⁵ Alta Californian, 11/7/57.

will become an exceedingly profitable source of investment to those who engage in those enterprises.”⁶⁶

Mining interests, however, vigorously opposed this bill on the grounds that it would give ditches “an absolute right of way” over mining claims and other property, “destroying valuable improvements of every kind, for the benefit of one branch of business”.⁶⁷ In addition, if the federal government agreed not to enforce its water rights in the public lands, they argued:

“every drop of water in the mining streams of California may be diverted by the ditches now or hereafter located, no matter how appropriated at present for other mining purposes... Miners would be compelled to buy of ditches, no matter if by time honored custom and by judicial decision they appropriated, owned and used the water as their own, for years. If the United States yields up its (water) rights, it yields up those of all claimants under it, except those of owners of ditches, and the resources of the country pass into the hands, virtually, of a vast monopoly.”⁶⁸

VI. The Ex Post Struggle over Surplus

The struggle between mining and ditch companies to capture rents did not cease, however, once ditches were constructed. A good deal of miners’ energy was expended on efforts to secure more favorable terms of exchange and outright attempts to avoid payment. A common complaint among miners during this period, for example, was that ditch companies charged miners too much for water. It was not long after the completion of the first ditch projects that we begin to observe such complaints. In February 1853, for example, the Alta Californian reported that miners near Columbia and Springfield in Tuolumne County were publicly complaining about water rates charged by the Tuolumne County Water Company and negotiating with a rival company to extend ditches to their location.⁶⁹ In November of that year, it was reported that

⁶⁶ Alta Californian, 12/24/57.

⁶⁷ Alta Californian, 11/16/57.

⁶⁸ Alta Californian, 11/16/57. See also the resolutions of a miners’ meeting in Butte County, Alta Californian, 12/12/57.

⁶⁹ See also Alta Californian, 3/1/53. There is some evidence that competition among ditches was indeed an effective way to drive down water prices. In August 1859, for example,

miners in Tuolumne County were carting their dirt over a mile to a spring in Springfield “rather than paying an exorbitant price to the water companies for muddy water”.⁷⁰ By 1855, such complaints were becoming much more frequent, and were thereafter observed in a number of other counties, including Nevada, Calaveras, Shasta, Amador, Butte, and El Dorado.⁷¹

Miners did not, however, stop at merely voicing their grievances over the pricing practices of ditch companies. Beginning in 1855, we observe numerous instances throughout the mining regions of miners going on strike to obtain lower water rates. In March of that year, miners around Columbia in Tuolumne County went on strike and refused to take water from the local ditch company until it had reduced its rates.⁷² This was followed in November of that year by a miners’ strike at Nevada and Red Dog in Nevada County, where the miners were demanding a rate reduction of eight cents per inch.⁷³ These miners were later joined in their strike by miners from Waloupa, Brown’s Hill, and Pine Hill.⁷⁴ In March 1856, it was reported that nearly one thousand miners at Mokelumne Hill in Calaveras County were on strike demanding a rate reduction by the Mokelumne Hill Canal.⁷⁵ Later that month, the Nevada Journal reported that such strikes had “taken place in various parts of (Nevada) county”.⁷⁶ By early 1858, miners in Horse-town and Townsend Flat, both in Shasta County, were on strike to secure lower water prices.⁷⁷

the Marysville Democrat reported that the completion of a ditch from Deer Creek to Timbuctoo, in Nevada county, caused the local price of water to fall by 33%. By later that year, the Alta Californian was reporting that competition between two ditch companies to provide water to miners in the French Corral Ridge district in Nevada county was causing a significant reduction in water prices.

⁷⁰ Alta Californian, 11/7/53.

⁷¹ See, for example, Alta Californian of 3/31/55, 11/29/55, 2/25/56, 3/7/56, 5/27/56, 4/22/57, 4/28/57, 1/20/58, 1/26/58, 2/1/58, 2/22/58, 9/23/58.

⁷² Alta Californian, 3/31/55.

⁷³ Alta Californian, 11/29/55.

⁷⁴ Alta Californian, 2/25/56.

⁷⁵ Alta Californian, 3/7/56.

⁷⁶ Alta Californian, 3/25/56.

⁷⁷ Alta Californian, 1/20/58, 1/26/58.

In April 1859, miners at several camps in Nevada County were reportedly on strike, seeking a 40% reduction in water rates.⁷⁸ For a quantitative picture of striking activity, Table 1 provides a complete listing of every miners' strike reported in the Alta Californian for the period 1849 to 1859. Apparently, miners' strikes occurred with some regularity after 1855: altogether, we observe at least sixteen strikes in seven counties, involving at least 21 different mining camps.⁷⁹

In order to improve their chances of success during strikes, miners employed various organizational mechanisms, sometimes written into formal by-laws of the striking miners. In 1855, miners striking for lower water prices in Columbia district, Tuolumne County, agreed to publish the names of strikebreakers in the local newspaper.⁸⁰ In January 1858, miners at Horsetown in Shasta County passed a resolution to boycott any local merchant who withheld credit from a striking miner.⁸¹ Later that year, striking miners in El Dorado County passed a resolution restricting agents of the Gold Hill Canal Company from locating any claims in the local district for the purpose of "selling the same to persons not eligible to citizenship, as they have done heretofore", probably referring to Chinese miners.⁸² As a final example, local mining laws commonly stipulated that claims had to be continually worked or were liable to be jumped. To counter the potentially chilling effect of such provisions on their ability to sustain extended strikes, miners at Table Mountain in Calaveras County passed a resolution during a strike in 1859 over water rates "that no claim be jumpable for the period of one year after the adoption of these resolutions, in

⁷⁸ Alta Californian, 4/20/59, 4/24/59.

⁷⁹ Lack of data makes it impossible to know in percentage terms how many mining camps were subject to striking activity. These data are presented to convey that: (1) miners' strikes for lower prices were probably not an isolated incident, and (2) strikes appear to have been correlated with the rise of water-intensive mining.

⁸⁰ Littlefield(1983), p. 423.

⁸¹ Alta Californian, 1/20/58.

⁸² Alta Californian, 2/1/58.

case the proprietors of (Table Mountain) ditch persist in holding up the present high price of water.”⁸³

The actual success of miners in achieving price reductions through strikes varied a great deal. In a few instances, miners were able to obtain the desired rate reduction. In many cases, miners were able to achieve at least a partial reduction.⁸⁴ In at least one instance, miners went out and formed their own company rather than pay the rates demanded, and successfully built themselves a ditch. This occurred in early 1856, when miners in Nevada County went out and formed their own company, the Miners’ Ditch.⁸⁵ On the other hand, an example of a particularly unsuccessful strike occurred in Amador County in late 1857, when a miners’ strike for lower rates collapsed in a little over two weeks.⁸⁶

In any case, some evidence suggests that the price of water was generally falling during the late 1850’s. Figure 2, for example, reports all references in the Daily Alta Californian to the price of water being charged by ditch companies, from 1855 to 1859.⁸⁷ In all, there were fifteen references to the price of water, expressed in dollars per miner’s inch, for seven different counties. The time trend seems decidedly downward, despite upward demand pressures due to the spread of water-intensive mining techniques such as ground sluicing and hydraulic mining. The suggestion is that demand pressures were more than offset by supply expansions, which suggests not only that ditching was profitable but that miners were sharing enough quasi-rents with ditch companies to encourage continued water development.

⁸³ Alta Californian, 12/28/59.

⁸⁴ See, for example, Alta Californian, 11/22/57, 2/1/58, 3/15/58. See also Paul(1947), pp. 324-25.

⁸⁵ Alta Californian, 3/25/56.

⁸⁶ Alta Californian, 9/30/57, 10/14/57.

⁸⁷ Various issues, Alta Californian. I found no references to the price of water prior to 10/10/55. See also May(1970), p. 49.

Aside from striking for lower prices once ditch systems were in place, another avenue open to miners was simply not to pay for the water furnished by the ditch companies, hoping that significant enforcement costs would enable them to reap some rents. To examine the extent to which this occurred, I have collected over 200 court cases tried in the county court of Nevada County during the years 1857 through 1862. Nevada County is an apt subject of study because it was an extremely active mining region from very early in the Gold Rush. It was also where hydraulic mining was first introduced, which explains why it was one of the first areas to experience major ditching activity, as we observed earlier. The court cases include every action involving a ditch company tried in the Nevada County court from 1857 through 1860, and every case brought by a ditch company against miners for nonpayment for water supplied during the entire six-year period to 1862.⁸⁸

Focusing on the nonpayment cases alone, in all there were 28 complaints filed, by fifteen different companies (see Table 2). In each case, an action was brought to recover an amount of money that was owed, in almost all cases entirely for water supplied for mining.⁸⁹ The total dollar amount in dispute was \$18,645.45, or an average of almost \$666 per action. These are not trivial amounts of money for ditch companies whose systems on average cost less than \$23,000 to construct.⁹⁰ Furthermore, certain companies were involved in multiple actions and were thus especially hard-hit, with the Miner's Ditch company being involved in the largest number of actions, five. Finally, recall that all of these data pertain to only one county, albeit an especially water-intensive one. If ditch companies in other mining counties had comparable experiences

⁸⁸ The court records for Nevada County only begin in 1857 because of a fire that swept through Nevada City in 1856, which destroyed many public documents, including court records.

⁸⁹ In a couple of cases, the defendant is indebted for other wares and merchandise, in addition to the water provided.

then there were probably dozens, maybe even hundreds, of nonpayment suits filed altogether in the gold regions during this period.

Closer inspection of the nonpayment cases in Nevada County reveals further evidence that miners may have deliberately used nonpayment as a strategy to extract rents. Table 2 reveals, for example, that in eighteen out of the 28 actions, the court ruled for the plaintiff; indeed, there was not one single ruling for the defendant in the entire data set. In almost all of these rulings, the plaintiff was awarded the entire amount owed, plus its costs of suit. Furthermore, the process of obtaining a ruling took very little time. The last column in Table 2, for example, reports the amount of time that elapsed between the date of filing of the initial complaint and the date of the final ruling. In eleven of the seventeen rulings for which information is available, the ruling was handed down in less than a month. In only two cases did the process last more than three months. All of this suggests that the typical case simply involved a miner trying to avoid paying what he owed, as opposed to a genuine contractual dispute. In virtually all cases, the court upheld the complaint of the ditch company in all its particulars.

Such an interpretation only makes sense, of course, if it was costly for plaintiff ditch companies to actually recover their court award. However, the evidence suggests this was the case. In the remaining ten cases lacking a ruling, the available documentation in the court records make final disposition of the case unclear. In most of these cases, the court records contain no evidence that the defendant ever made an appearance. For example, in four cases a summons was issued for the defendant to appear in court, and then the court records end. In many of these cases, the defendant may have simply quietly departed the scene, and it is easy to imagine that the authorities would have found it difficult to track them down. The same argument applies to

⁹⁰ Thompson & West list forty-six major ditches in existence in Nevada County in 1857. Among the ones for which cost information was available, the average cost of construction was

the cases where the court made a ruling, where in a number of cases, the defendant never appeared and the court ruled that the defendant was in default. It is also noteworthy that the court records from these cases provide very little evidence regarding whether payment was actually enforced, because a set of detailed judicial procedures were in place to deal with bankruptcies and foreclosures. Indeed, during the 1850's the Alta Californian contained a number of references to court-ordered property sales by sheriffs, where the proceeds are used to satisfy court awards.⁹¹ The complete lack of evidence regarding enforcement in these nonpayment records suggests that enforcement did not occur.

VII. Long-Term Contracts?

The preceding discussion strongly suggests that enforcement of water supply contracts between mining and ditch companies was costly. Indeed, if enforcement costs were low, then one way to deal with opportunistic behavior was to write long-term contracts that spelled out the terms of water supply in advance.⁹² However, the language used in the complaints filed in the actions for nonpayment in Nevada County suggests that contracting may typically have been rather informal. Consider, for example, the following wording contained in the complaint in Miner's Ditch v. Pennsylvania Co. in the Nevada County District Court, brought in 1857:

“(the plaintiff) at the special instance and request of the said defendants ... sold and delivered water to the said defendants, (and) they the said defendants undertook and then and there faithfully promised the said Plaintiffs to pay them so much money as the said water at the time of the said sale and delivery was reasonably worth, when they the said defendants should be thereunto afterwards requested.”⁹³

slightly more than \$22812. See Thompson & West(1970), pp. 171-72.

⁹¹ See, for example, Alta Californian, 12/22/53, 7/29/54, 4/23/56, 5/13/59.

⁹² See Williamson(1979), Joskow(1987).

⁹³ Miner's Ditch Co. v. Pennsylvania Co., File #386, Nevada County District Court, dated May 26, 1857. On file at Searls Historical Library, Nevada City, CA.

This passage, which is quite typical of wording used in the complaints for nonpayment, suggests an informal arrangement, where the price to be paid is not even specified beforehand. The likely interpretation is that at the time, enforcement costs were sufficiently high that there was little advantage to writing contracts that explicitly spelled out the terms of a long-term supplier-demand-er relationship.⁹⁴

Indeed, there is very little evidence to support the position that formal contracting between miners and ditch companies occurred in any significant way during the 1850's.⁹⁵ During this entire period, I was able to find only one reference in the Alta Californian to miners engaging in a written contract with a ditch company. This occurred in February 1853, when it was reported that miners in Tuolumne County, angered at the pricing policies of the Tuolumne County Water Company, wanted to contractually bind themselves to buy water from a competitor ditch company to encourage that company to supply water. According to the Alta Californian, these miners:

“petitioned the Hydraulic Company to bring their water through Columbus, ... and in order to induce (it) to cut a ditch, they propose to bind themselves in writing to use water from this Company and not from the other so soon as they get the water in. They also propose to engage to sell no claims except with this stipulation.”⁹⁶

It is unclear, however, whether such a contract was ever consummated. By the end of the year, the Hydraulic Company was experiencing serious financial difficulties, including legal proceed-

⁹⁴ The question arises of why we would observe *any* supply contracts in equilibrium if enforcement costs were high. One possibility is that informal norms and customs, possibly based on notions of fairness, may have constrained opportunistic behavior by miners to some extent. For a recent view on the importance of fairness during the Gold Rush, see Zerbe and Anderson (2001).

⁹⁵ Umbeck(1981) examines mining contracts at length, but his study contains nothing on contracts between miners and ditch companies.

⁹⁶ Alta Californian, 2/11/53.

ings brought by creditors.⁹⁷ Meanwhile, in March 1853 the Alta Californian was reporting that relations between miners and the Tuolumne County Water Company had improved.⁹⁸ It is possible that the miners used the threat of binding themselves to buy water from the Hydraulic Company simply to extract concessions from the Tuolumne County Water Company, without ever actually going through with it.⁹⁹

One actual water supply contract from the early 1850's can be found in the Placer County District Court case file of Duell v. Bear River and Auburn Water and Mining Co. This written contract, signed by some 100 miners, is reproduced below in its entirety:

“We the undersigned miners on the Auburn Ravine having claims located on said ravine which claims we are unable to work owing to the want of water, we therefore petition the Bear River and Auburn Water and Mining Company to introduce and suffer to pass down said Ravine a sufficient amount of water to supply the demand or so much as the company may have space and for the use of which we agree to pay the collector for said company each week the sums set opposite our respective names; we recognize the right of the Bear River and Auburn Water and Mining Company to the use of Ravine for conveying their water and parties using the water of said company are justly bound to pay for the same at all times when there should not be sufficient natural water in said ravine for mining purposes. Auburn September 22, 1853”¹⁰⁰

This contract speaks to the desire on both sides for some kind of formalized arrangement for water delivery where expectations are reasonably clear, yet is also suggestive of the limits of contracting within the institutional setting of the time. Many contingencies are left open including the quantity and quality of water to be delivered, not to mention the length of time for which the

⁹⁷ Alta Californian, 12/8/53.

⁹⁸ Alta Californian, 3/15/53.

⁹⁹ The problem with this explanation is, of course, that such a threat would not have been considered credible by the Tuolumne County Water Company if enforcement costs were significant.

¹⁰⁰ Placer County District Court File #173(1854), on file at the Placer County Court Archives, Auburn, CA.

contract is to hold, and remedies and responsibilities in case of breach.¹⁰¹ The miners are even given an “out”, not being required to pay when sufficient water is available naturally, which suggests a successful taking of some quasi-rents. And even though the contract nominally obligates the miners to pay specified weekly fees to the ditch company when water is scarce, it is not at all clear how binding this obligation in fact is, given the likely magnitude of enforcement costs. Overall, there is no evidence of a long-term binding contractual commitment, in all likelihood due to significant costs of enforcement.

VIII. Conclusions

This study of water development during the California Gold Rush conveys some object lessons regarding investment within an uncertain institutional environment. The problem posed by uncertain property rights was more than the usual economist’s concern about investment disincentives resulting from incomplete appropriation of the expected income stream. Equally important was the private struggle between miners and ditch companies over the sharing of the rents from water development characterized by significant specific investments. This struggle was manifested both in the *ex post* struggle over quasi-rents made possible by significant enforcement costs and in the *ex ante* struggle over establishing property rights to essential water and land inputs in the first place. It should be added that the disincentives to investment in water development occurred in the absence of concerns about public expropriation through the usual regulatory channels, as no regulatory mechanism was in place in California at the time.

The experiences of Gold Rush ditch companies carry some interesting lessons for water development in developing countries, which share certain institutional characteristics with Gold Rush California. Both settings are characterized by relative insecurity of property rights and

¹⁰¹ That quantities of water are not contractually specified probably reflects the fact that

significant contractual enforcement costs. Under these conditions, private water companies may encounter resistance to their efforts to obtain the requisite property rights, to the extent that customers believe they will be competing with the companies for rents from water development. This competition need not be head-to-head competition for property rights but may entail other legal actions designed to affect relative bargaining positions in the later struggle over quasi-rents. Companies may also encounter post-contractual hold-up from customers, resulting in tendencies to inefficiently low levels of investment in water supply. Public authorities in developing countries charged with granting water concessions to private operators may want to be concerned about investment disincentives, particularly when private operators are responsible for making investments¹⁰² and receive the return on their investments.¹⁰³ Furthermore, when concessions are auctioned off, the possibility of customer opportunism will lower government bidding revenues, to the extent that opportunism is built into operator expectations of future incomes. Government revenues are likely to be lower under leasing arrangements for the same reason. At the same time, customers are benefited, at least in the short-term, by the ability to engage in contractual holdup. Public efforts to clarify property rights *ex ante* and reduce contractual holdup *ex post* should be made with full recognition of the potential tradeoff between lowered rents to water customers and greater incentives for investment.

measurement technologies were highly imperfect at the time. See Pagenhart(1969), pp. 89-91.

¹⁰² Responsibility for investment is often devolved onto private operators. See the studies in Shirley(2002).

¹⁰³ The problem does not go away, of course, when the government retains responsibility for investment, as customers are just as likely to engage in contractual holdup with a government agency.

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Table 1: Miners' Strikes over Water Rates Reported in Daily Alta Californian, 1849-1859

Date Reported	Camp/District	County
3/31/55	Columbia	Tuolumne
11/29/55	Nevada, Red Dog	Nevada
2/25/56	Campo Seco, Chile Camp, Red Flat, Worth's Hill, others	Calaveras
2/25/56	Waloupa, Brown's Hill, Pine Hill	Nevada
3/7/56	Mokelumne Hill	Calaveras
3/31/56	Not available	Calaveras
5/27/56	Not available	Shasta
12/28/56	Not available	Nevada
9/30/57	Not available	Amador
1/20/58	Horsetown	Shasta
1/26/58	Townsend Flat	Shasta
2/1/58	Gold Hill	El Dorado
2/22/58	Oroville	Butte
11/11/58	Independence	Calaveras
4/20/59	Columbia Hill, Kennebec, Chimney Hill	Nevada
4/24/59	Columbia Hill, Humbug, others.	Nevada
12/28/59	Table Mountain	Calaveras

SOURCE: Various Issues, Daily Alta Californian, 1855-1859

Table 2: Disputes over Nonpayment for Water Sold, Nevada County, 1857-1862

Plaintiff	Defendant	Year	Amount	Disposition	Length of Process
Miner's Ditch	Enterprise Co.	1857	\$432.20	Ruling for P	2 _ mos.
Miner's Ditch	Pennsylvania Co.	1857	\$496.48	Ruling for P	?
Rock Creek et al.	Cooke et al.	1857	\$481.00	?	
Grizzly Water Co.	Gouche	1857	\$677.10	Ruling for P	16 days
Grizzly Water Co.	Rindorer et al.	1857	\$440.22	Ruling for P	6 mos.
Miner's Ditch	Waller, White et al.	1858	\$386.55	Ruling for P	3 wks.
Miner's Ditch	Stewart & Bros.	1858	\$847.00	?	
Spring Creek Co.	Rowe	1858	\$411.00	?	
Tisdale et al.	Brown et al.	1858	\$953.00	?	
Kidd	Hawkeye Co.	1858	\$3138.42	Ruling for P	2 mos.
Kidd et al.	Lachman	1858	\$776.00	?	
York Mining Co.	Williams et al.	1859	\$519.80	Ruling for P	Minimal
Phelan	Roach	1859	\$303.00	?	
Miner's Ditch Co.	Chevrefile et al.	1860	\$500.84	?	
Nevada Water Co.	Lough	1860	\$322.20	?	
Eureka Lake Co.	Cummings	1860	\$319.16	Ruling for P	2 _ wks.
Eureka Lake Ditch	Henry	1860	\$616.00	?	
So. Yuba Canal Co.	Sullivan et al.	1861	\$309.00	Ruling for P	2 wks.
Chalk Bluff Ditch Co.	Fulton et al.	1860	\$636.00	Ruling for P	3 mos.
Eureka Lake Co.	Spicer et al.	1861	\$690.00	Ruling for P	4 _ mos.
So. Yuba Canal Co.	Hicks et al.	1861	\$1509.97	Ruling for P	2 wks.
Eureka Lake Co.	Conley et al.	1861	\$744.61	?	
Eureka Lake Water Co.	Chapman	1861	\$317.00	Ruling for P	2 wks.
Eureka Lake Water Co.	Haskell et al.	1862	\$359.80	Ruling for P	3 wks.
Eureka Lake Water Co.	Bonney et al.	1862	\$853.30	Ruling for P	7 wks.
Whartenby et al.	Rose et al.	1862	\$793.00	Ruling for P	3 wks.
Whartenby et al.	Cooney et al.	1862	\$482.13	Ruling for P	2 wks.
Eureka Lake Water Co.	Ogle et al.	1862	\$330.67	Ruling for P	3 wks.

Figure 1: Number of New Incorporations, Ditch and Integrated Mining/Ditch Companies, 1851-1862

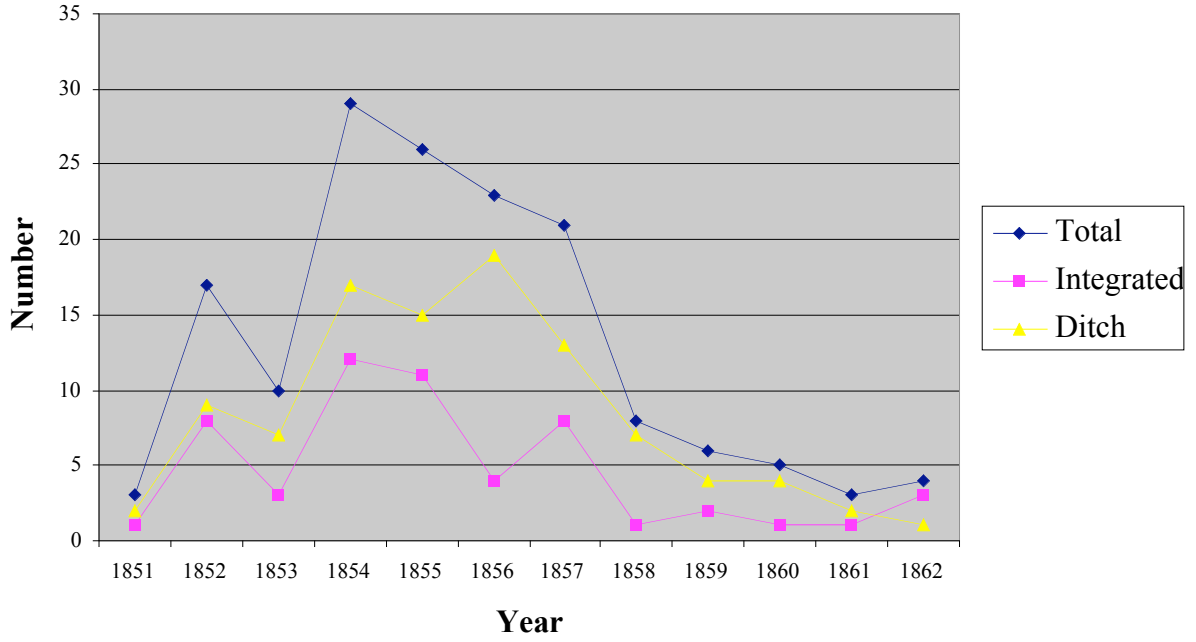


Figure 2: Price of Water, 1855-1859

