THESIS

WESTERN WATERS:

NEW MEXICO'S BIG DITCH

AND

GROUNDWATER IN COLORADO'S SOUTH PLATTE VALLEY

Submitted by

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In partial fulfillment of the requirements

for the degree of Master of Arts

Colorado State University

Fort Collins, Colorado

Spring 2008

COLORADO STATE UNIVERSITY

JUNE 20, 2007

WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY NICOLAI ALEXANDER KRYLOFF ENTITLED WESTERN WATERS: NEW MEXICO'S BIG DITCH AND GROUNDWATER IN COLORADO'S SOUTH PLATTE VALLEY BE ACCEPTED AS FULFULLING, IN PART, REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS.

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ABSTRACT OF THESIS

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Water is at the heart of history in the American West. This connection ought to be especially lucid to westerners, but in fact the opposite is often true. Water seems to pour out of our faucets by magic – its origins hidden, its journey obscure. Environmental history can help reclaim the lost relationships between people and this vital substance which shapes western landscapes, livelihoods, and lives. The main goal of the essays herein is to contribute to this understanding.

This thesis consists of two distinct but related historical threads, both dealing with western water. The advantage of writing two separate, concise pieces of historical analysis for this volume is their added flexibility as publishable items. To achieve the shorter lengths necessary for this approach, extensive historiographical research was condensed in the final articles, though much of it is still evident in the footnotes and bibliography of each essay. An additional benefit derived from two short articles is an expanded temporal, topical, and geographical scope. Western water is a vast subject, and many important stories remain untold. In this pair of essays, I have attempted to recover some fragments of this forgotten past.

The first article analyzes water in territorial New Mexico, by way of an elaborate structure called the Big Ditch. In 1869, the ditch marked the territory's first trans-basin

diversion of water. Now rotted and practically forgotten, this remarkable engineering disaster introduced new ways of thinking about the desert's most vital and precious resource. Its construction represented the beginnings of a subtle yet pervasive shift in the way people thought about and used the region's water. Long allocated in common and tied to the land under Spanish and Mexican regimes, water was conceptually separated from land during territorial American governance. The Big Ditch embodied this transition, conveying water as a private commodity for personal profit. In addition, the ditch heralded an age of scientific management and technological control over natural resources. By transporting enormous quantities of water to an entirely different drainage basin, it symbolized new concepts of domination over the arid environment. This dimly remembered historical episode not only illuminates an understudied period in New Mexico's water history, but also reconciles two seemingly contradictory narratives of western American history: fragmentation and consolidation. For although legal, technological, and conceptual changes in New Mexico's waters were introduced piecemeal by local men serving local interests, they also became part of a larger process of hegemonic diffusion of similar ideas across the West. The Big Ditch offers a rare glimpse of these conceptual undercurrents at work.

The second essay explores the history of groundwater use on the productive farmlands of northeastern Colorado. In the valley of the South Platte River, underground water represented both a great opportunity and an intractable problem. While its users and managers struggled to assert opposing conceptions of this water's fundamental purpose and meaning, its natural movement underground eroded longstanding foundations of western water allocation. As cities and farms became increasingly reliant

on the renewable aquifer beneath the valley floor, water's independent motion caused natural processes to become entangled with human-made systems of law, property, and administration. As a result, thousands of acres of former farmland in eastern Colorado stand dry today, despite resting atop millions of acre-feet of water. This history analyzes the shifting attitudes that influenced the use of this water in the South Platte valley, and the ways in which people's activities and ideas became enmeshed with circumstances largely beyond their control. Ultimately, it provides insight into an important but little-understood subterranean resource, while exposing the roots of a difficult problem that farmers, scientists, and lawmakers are still trying to disentangle.

Taken together, these essays follow an emerging trend in environmental history. The first essay deals exclusively with a human manipulation of water, and the legal and conceptual changes that accompanied the process. The second is an attempt to place water itself within the center of the story, illustrating the independent agency of a substance people do not fully control. Moreover, the first approach is consistent with traditional accounts of water history; the second is more in line with recent environmental history generally. This shift is important. It reflects a broader acknowledgement, not least my own, that human history is entwined with larger processes that operate by their own inscrutable terms. The history of the American West is partly a history of water; consequently, water's history is inseparable from our own.

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Acknowledgements

The completion of this volume involved both struggles and satisfaction. For the latter, I am indebted to many people for their insight and encouragement. Jared Orsi was kind and exacting – all I could have hoped for in an advisor. Mark Fiege kept my interest in environmental history burning, and Doug Yarrington's patient advice always seemed to come at just the right time. I must also thank Robert Ward, whose depth of understanding water and its history is truly remarkable, and Tom Cech, whose knowledge about the South Platte first kindled my interest in that story. My research was made infinitely more productive and rewarding by Patty Rettig and the rest of the staff at the Colorado State University Water Resources Archive. Thanks also to the staff of the Colorado Historical Society, Zimmerman Library at the University of New Mexico, and the New Mexico State Archives in Santa Fe. I gratefully acknowledge the support of the American Water Resources Association, Colorado Chapter. I want to thank my brother Alex and parents Paul and Cherene, who will probably never read this but love me anyway, and my wife Leah, who is part of everything I do. Lastly, I wish to acknowledge my deep respect for the people of New Mexico and Colorado, who inherit these histories.

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The Big Ditch: Technology, Law, and Profit in the Waters of Territorial New Mexico

The Big Ditch was a marvel of ambition. It was designed to carry more than a million gallons of water daily over a distance of nearly forty-two miles. Built high in the Sangre de Cristo Mountains of northern New Mexico, its creaky wooden flumes crossed dizzying ravines and wrapped around treacherous peaks, winding a path that bridged arroyos and blasted through bedrock. At one point, a single half-mile aqueduct spanned a sheer canyon seventy-nine feet deep. The Big Ditch was a remarkable feat of nineteenth century engineering. It was also an utter failure.[1]

The disappointment was not lost on the expectant miners at Humbug Gulch. For over a year they had waited for water, and many helped construct the ditch's final miles. Without water, the miners claimed plots of useless dirt; with it, they could wash their rich gravel down inclined sluices, where pools of strategically placed mercury bonded with gold dust as worthless rocks tumbled down the chutes. But because most gulches in the Moreno Valley dried up by late spring, these claims could be worked for only a few short

[1] The most complete early description of the Big Ditch appears in Rossiter Raymond's *Statistics of Mines and Mining* (Washington: U.S. Govt. Printing Office, 1869), 391-2. A later account is in Fayette Jones's *New Mexico Mines and Minerals* (Santa Fe: The New Mexican Printing Company, 1904), 144-5. The ditch's carrying capacity was determined in miners' inches, a measurement subject to local variations. Normally, it meant the volume of flow through an opening one inch by one inch, with the water six inches deep above the opening. Jones, an engineering consultant, calculated the ditch's total capacity at 9,720,000 gallons every twenty-four hours. By contrast, the calculations of Paige Christiansen in *The Story of Mining in New Mexico* (Socorro: New Mexico Bureau of Mines and Mineral Resources, 1974), 36, put the total volume at only 1,512,000 gallons per day. Douglas Littlefield, in "Water Rights during the California Gold Rush: Conflicts over Economic Points of View," *The Western Historical Quarterly* 14, no. 4 (Oct., 1983): 414-34, estimates that 600 miners' inches would amount to roughly 6,393,600 gallons in twenty-four hours. Given this wide variation, I have chosen the middle estimate.

months between snowmelt and summer, and even then only intermittently. The miners needed the Big Ditch to work.[2]

Residents of nearby Elizabethtown also looked forward to the project's completion. E-town, as it was known, had sprung up almost overnight with the gold boom on Old Baldy Mountain in 1867. Within two years, on the eve of the ditch's completion, it boasted a summertime population of about 2,000, with perhaps an equal number of people living in the immediate area.[3] These people, mostly miners and laborers, supported the town's burgeoning commercial enterprises – restaurants, general stores, brothels, a gambling house, and a stagecoach line. According to an old-time resident, the boomtown's dance halls, hotels, and saloons provided enough liquor "to keep everyone drunk until 1870." Still, a brewery was added in 1868.[4] In addition, several newly-built sawmills profited from the town's rapid expansion. The miners needed the Big Ditch, and Elizabethtown needed the miners' money.

The ditch's progress also loomed large for its financiers and builders. The project was no small undertaking: it provided jobs for as many as 600 men during the height of construction in summer 1868.[5] The project initially cost $210,000 – a sizeable sum for the time – and was paid for by some of northern New Mexico's most notable citizens.[6] At the top of the list was Lucien B. Maxwell, a prominent rancher soon to become the

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[2] For an excellent description of 1860s sluicing methods and technology, see Arthur J. Phillips, *The Mining and Metallurgy of Gold and Silver* (London: E. and F.N. Spon, 1867), 139-51.
[3] Christiansen, 36.
[4] A good description of business in Elizabethtown during this time appears in Jim Berry Pearson, *The Maxwell Land Grant* (Norman: University of Oklahoma Press, 1961), 27. A primary source is the *Santa Fe Weekly Gazette*, 4 July 1868.
[5] The Santa Fe *Daily New Mexican*, 17 July 1868, and 18 November 1868, twice reported 600 men at work on the project. Raymond and Jones assert that no more than 420 men were employed at any one time, but this number may not account for contracted labor, which was used throughout construction.
[6] Jones, 145, and Raymond, 392, agree upon the total cost of construction.

largest individual landowner in the history of the United States.[7] Joining him were John Dold and Morris Bloomfield, successful Elizabethtown merchants; William Moore and William Kroenig, promoters and real-estate holders from Fort Union; Valentine Shelby, a merchant and stagecoach-line operator; and Capt. Nicholas S. Davis, the project's chief engineer. Together, these men directed the Moreno Valley Water and Mining Company, a corporation organized to sell water to the eager miners. For these enterprising individuals, the Big Ditch was a huge investment which promised even bigger returns.

Because the ditch carried the hopes of so many people, its completion was greatly anticipated. One newspaper lauded the project as "the greatest piece of public improvement within the borders of New Mexico." [8] Miners, businessmen, and investors alike waited for water to spill into Humbug Gulch. When the first trickle finally appeared on July 9, 1869, after months of soaring expectations, the results were dismaying: less than a quarter of the necessary water arrived at the end of the ditch, leaving the project's engineers scrambling for answers. New Mexico's first big gold rush was doomed, ruined by the scarcity of water. The Big Ditch, though it would operate inefficiently for more than thirty years, was a disappointment to most miners and an embarrassment to its creators. For all but a few stalwart gold-seekers, the incredible structure gradually faded from memory.

Despite the ditch's failure, an important change occurred that fateful day in July. It was subtle, perhaps not evident to the miners gathered at Humbug Gulch whose imaginations were dazzled by dreams of gold and profit. Even to most scholars of New Mexico's water history, the significance has not been apparent. The Big Ditch carried in

[7] Pearson, 9.
[8] *Daily New Mexican*, 18 November 1868.

its crude wooden flumes something less tangible, more oblique than the muddy water of the Red River. It brought strange ideas. This marvelous engineering disaster introduced to New Mexico new ways of thinking about the desert's most vital and precious resource.

For hundreds of years, the region's water was allocated in common, as an element tied to the land through which it flowed, from Pueblo times through the centuries of Spanish and Mexican purview. The Big Ditch marked a change in the relationship between land and water. The structure's purpose was to furnish water as a commodity, usage of which was not guaranteed by land ownership or mining activity. Water became liquid property, a thing to be bought and sold. Although the Big Ditch never made anyone wealthy, its very existence transformed water from a common good to private property with every gallon.

The ditch also altered water's meaning beyond any abstract legal conceptions. Being the territory's first great hydraulic appropriation, it heralded an age of scientific management and technological control of natural resources. Water in New Mexico had for centuries been diverted into *acequias*, community ditches used for small-scale farming, watering livestock, and domestic purposes.[9] But the Big Ditch represented a departure: by transporting enormous quantities of water to an entirely different drainage basin, it symbolized new concepts of domination over the arid environment. Water became quantified and monitored, then turned against the land through hydraulic mining, a technique new to New Mexico and one with problematic environmental consequences. With these developments, water was quantified and exploited in unprecedented ways.

[9] A rich historical literature has developed exploring the importance of New Mexico's *acequias*. For a good introduction, see *Journal of the Southwest* 32, no. 3 (autumn 1990): special issue on water in New Mexico; Michael C. Meyer and Michael M. Brescia, "The Treaty of Guadalupe Hidalgo as a Living Document: Water and Land Use Issues in Northern New Mexico," *New Mexico Historical Review* 73, no. 4 (October 1998): 321-345.

Lastly, the Big Ditch embodied shifting economic attitudes regarding the proper uses of water. During the ditch's lifespan, regional business priorities shifted from agriculture to mining, then back again. By the late nineteenth century, the owners of the Maxwell Land Grant largely ignored placer mining, struggling instead to develop their property through modern techniques of irrigation. This decision represented a shift in ideas about using water for profit. When placer mining finally reawakened near the Big Ditch, investors poured money into new technologies designed to conserve water. As these economic developments outpaced the ditch's utility, it fell into disuse and began to rot away. But the legal, technological, and economic changes embodied by its decaying trestles had already assumed a life of their own.

The Big Ditch's historical implications are twofold. First, its story sheds new light on an overlooked phase in New Mexico's water development. Second, it offers a rare glimpse of the intersection between two opposite narratives about western water history. The first contribution is mostly temporal. While historians have emphasized New Mexico's 1907 water code as a major turning point in state's treatment of water, they have often overlooked the processes of developmental expediency at work in the decades leading up to the new law. The builders of the Big Ditch and others like them introduced principles of water's commodification, technological management, and conceptual treatment long before such principles were enshrined in a legal code. These novel trends in New Mexico's water management evolved locally in nineteenth-century, not suddenly in 1907 by top-down decree.[10]

[10] Even the most thorough treatments of water in New Mexico have overlooked the importance of the territorial period for introducing novel ideas about water. See Ira G. Clark, *Water in New Mexico: A History of its Management and Use* (Albuquerque: University of New Mexico Press, 1987); Hana Samek

This finding is in keeping with a broader narrative of western water development, offered by historians such as Norris Hundley, Jr. and Donald Pisani. Both argue that the direction of water development in the West was charted haphazardly by competing and colluding government and private interests: Hundley's *The Great Thirst* emphasized the wide range of fragmented interests that shaped western water development, while Pisani drew attention to competition among local factions and the drive for speedy economic growth in a collection of essays, *Water, Land, and Law in the West*. By contrast, a different narrative is present in works such as Donald Worster's *Rivers of Empire* and Marc Reisner's *Cadillac Desert.* These studies portray western water management as the product of a monolithic force, guided by economic elites and government technocrats. In short, whereas Pisani and Hundley argue that western water development was shaped mainly by fragmentation and competition, Worster and Reisner point to a concentration of interests as the primary force behind water development in the West.[11]

If the story of the Big Ditch seems at first to support Hundley's and Pisani's perspective of localized fragmentation, the ditch's history also implies an incipient coagulation of imported ideas about water and its use. For although the Big Ditch was a fragment of private local activity, the commodification and scientific management of water were not ideas homegrown in New Mexico, but rather were transplanted by men from the California goldfields. Additionally, when New Mexico's 1907 water code formally recognized these transformations in water's conceptual identity, impetus also

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Norton, "'Fantastical Assumptions': A Centennial Overview of Water Use in New Mexico," *New Mexico Historical Review* 73 (October 1998): 371-387.

[11] Norris Hundley, Jr., *The Great Thirst: Californians and Water: A History* (Rev. ed., Berkeley: University of California Press, 2001); Donald J. Pisani, *Water, Land, and Law in the West: The Limits of Public Policy, 1850-1920* (Lawrence: University Press of Kansas, 1996); Marc Reisner, *Cadillac Desert: The American West and its Disappearing Water* (New York: Viking, 1986); Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1985).

came from outside the territory – administrators believed that Colorado's water laws would put New Mexico at a disadvantage if their territory did not confirm a similar system, and they drew on the ideas first introduced by the Big Ditch to remain on even footing with interstate competitors for water. In short, the story of this doomed hydraulic contraption links together two seemingly opposed historical narratives of western water: fragmentation and consolidation. While legal, technological, and conceptual changes in New Mexico's waters were introduced piecemeal by local men serving local interests, they also became part of a larger process of hegemonic diffusion of similar ideas across the West – a common set of ideas for thinking about, fighting about, and ultimately controlling water. The Big Ditch represented both fragmentation and consolidation at the same time.

The people who initially brought these new concepts to New Mexico probably gave little thought to water's conceptual or legal status. They likely appreciated its more obvious qualities on their hot, thirsty march from California across the Arizona desert. When in 1862 more than two thousand Union volunteers led by Colonel James H. Carleton arrived in Santa Fe to drive Confederates out of New Mexico, the Civil War in the territory was already over. These soldiers, mostly ex-farmers and miners, came to the territory with gold in their blood. Members of the California Column would later kindle at least five major mineral strikes in the region, and one soldier claimed that they had prospected the entire route to Tuscon. Their stated mission, however – to defeat the invading Confederate Texans – had been accomplished without them, and they spent

their remaining enlistments waging brutal campaigns against Navajos and Apaches. In their spare time, some prospected for gold. [12]

As the men were discharged, some scattered through the hills and valleys of New Mexico to test the land's possibilities. One of these veterans was Peter Kinsinger. Formerly a miner in the California gold rush, Kinsinger was commissioned along with two other men in 1866 to investigate traces of copper near Mount Baldy, some thirty-five miles northeast of Taos. While preparing camp one October afternoon, one of the men absently panned the gravels along Willow Creek. What he found startled them all: flecks of gold sparkling among the rocks and dirt. The excited prospectors swore themselves to secrecy, but during the winter, news of the discovery spread throughout the territory and into Colorado. Thousands of miners poured into the area the following spring, and New Mexico's first big gold rush was on.[13]

Before long, prospectors worked every stream, creek, and gulch in the Moreno Valley.[14] As with most gold strikes, many claimants preferred placer mining to lode mining, the latter of which involved digging large shafts and tunnels to find underground mineral veins. Placer mining, by contrast, relied on water to wash gold from surface gravels. The first process was expensive and labor-intensive; the second required only primitive implements and the presence of water. But water was a problem. By July, no snow remained on the surrounding mountains, and most streams dried up. Despite some promising developments during the 1867 season – miners formally organized their

[12] Darlis A. Miller, "Carleton's California Column: A Chapter in New Mexico's Mining History," *New Mexico Historical Review* 53 (January 1978): 5-38.
[13] The story of gold discovery near Mount Baldy is repeated in many sources. A contemporary account appears in the *Santa Fe Weekly Gazette*, 20 June 1868. Pearson and Jones also provide good descriptions, as does Lawrence R. Murphy, "Boom and Bust on Baldy Mountain, 1864-1964" (MA thesis, University of Arizona, 1964).
[14] *Santa Fe Weekly Gazette*, 4 July 1868.

district, while nearby Elizabethtown grew into a permanent settlement – the water shortage hampered the region's initial progress.

A solution came from Captain Nicholas S. Davis, who had arrived with Kinsinger during the Civil War as part of Carleton's Column. Davis doubtless recalled the magnificent structures in California built to carry distant water to dry diggings.[15] These projects had sparked the West's first major conflicts over water, challenging American notions of water's proper use and legal status. Easterners and their European forebears generally recognized a riparian system of water allocation: water was part of the property through which it flowed, and rights of access were relative to each other, meaning that upstream users were not allowed to obstruct the flow to downstream users. But California's gold fields presented new exigencies. Because rich gravels often existed far from living streams, miners began to divert water to these dry areas. Isolated as they were from external law and authority, mining camps in the 1850s were compelled to forge their own regulations,[16] and many embraced the standard of prior appropriation. Under this doctrine, the first person or group to actively utilize a quantity of water became the owner of that amount, regardless of its location or intended purpose, as long as it was applied toward a beneficial use, such as farming, stock-watering, milling, or mining activity.[17] This doctrine, however, was not universally accepted, and conflict sometimes

[15] Moreno Mining and Water Company investor Morris Bloomfield (*Santa Fe Weekly Gazette*, 20 June 1868) credits Davis with originating the idea for the Big Ditch. Murphy suggests that Maxwell may have come up with the idea, based on an article appearing in the *Mining and Scientific Press*, 11 January 1868. I reason, however, that Davis, an engineer from California, was more likely to have been exposed to similar ditch ideas, and have therefore chosen to trust the local source.

[16] Charles Howard Shinn, *Mining Camps: A Study in American Frontier Government* (New York: Harper & Row, 1965), 134-135.

[17] A good general description of the prior appropriation doctrine can be found in David H. Getches, *Water Law in a Nutshell*, 2nd ed. (St. Paul: West Publishing Co., 1990) 74-186.

erupted between diverters and miners with riverside claims.[18] California courts, with no legal precedents to follow and no guidance from a federal government confronting civil war, usually adjudicated on behalf of prevailing local business interests – sometimes supporting prior appropriation and other times upholding riparian rights.[19] Consequently, local economic interests often shaped early water rights more than consistent, overarching legal principles.[20]

As water diversion projects in California became larger and more elaborate, their construction required greater labor and capital. Whereas many early ditches were small joint-stock ventures financed by miners who intended to personally use the water, larger developments encouraged considerable outside investment. Capitalist stockholders, not miners, controlled this water, and their companies often dealt exclusively in water's sale. These corporate powerhouses came to dominate California's hydraulic landscape by quashing smaller competitors with the threat of costly litigation.[21] Water companies such as these could reap enormous profits – one provider in 1854 reported returns of forty-two percent *per month* to its investors.[22] Moreover, the legal position of these companies was strengthened shortly after the Civil War by the 1866 Mining Act, an ambiguous federal statute which upheld appropriative water rights which were "recognized and acknowledged by the local customs, laws and decisions of courts."[23] This act effectively rubber-stamped existing standards, thereby bolstering the position of anyone who could

[18] Pisani, *Water, Land, and Law in the West*, 31.
[19] For the ambivalence of California courts, see Donald J. Pisani, *To Reclaim a Divided West* (Albuquerque: University of New Mexico Press, 1992), 25-7. Also see Littlefield, 420.
[20] These findings support the historical narrative focused on fragmentation and speedy economic development shaping western water institutions. See especially Pisani, *To Reclaim a Divided West,* 29; *Water, Land, and Law in the West*, 34.
[21] Pisani, *Water, Land, and Law in the West*, 25-30.
[22] Pisani, *To Reclaim a Divided West*, 19.
[23] The 1866 Mining Act is excerpted in Getches, 195.

influence local guidelines. In this context of legal approval and financial promise, Captain Davis hatched his scheme to bring water to New Mexico's Moreno Valley mines.

It would not be an easy task. The Red River, a tributary of the Rio Grande, flowed just eleven miles west of the parched placer mines, yet it lay on the opposite side of a chain of formidable mountains. After surveying the situation, Davis proposed a circuitous forty-two mile route cutting through a weak point in the range, whereby a lengthy ditch could transport the water through a system of wooden flumes and aqueducts.[24] This ambitious enterprise, while promising huge profits if successful, could be accomplished only by enormous investment.

Lucien B. Maxwell, the region's largest landowner and wealthiest individual, was interested immediately. An eccentric rancher with a penchant for gambling,[25] he had amassed a small fortune by obtaining government contracts to sell provisions to both local Indians and the federal soldiers sent to subdue them. He also collected tribute from the farmers occupying his land.[26] His property, a large, vaguely delineated Mexican land grant which he had acquired through purchase and inheritance, bordered or perhaps included the Moreno mines. Maxwell, himself a stakeholder in several claims, collaborated with prominent Elizabethtown businessmen to form the Moreno Water and Mining Company, which invested $115,000 to build Davis's elaborate ditch.[27] In May 1868, with the required capital in place, construction began.

[24] Although iron pipes were preferable (Raymond, 476), the region's isolation likely discouraged this option.
[25] Pearson, 21. A full biography of Maxwell is offered by Lawrence R. Murphy, *Lucien Bonaparte Maxwell, Napoleon of the Southwest* (Norman: University of Oklahoma Press, 1983).
[26] Murphy, *Lucien Bonaparte Maxwell*, 122, 126.
[27] This original investment figure is cited by both Raymond and Jones.

At first, the project progressed rapidly. In just over a month, eight miles were completed, with an equal distance under construction. Investor Morris Bloomfield predicted the whole project would be finished by September, supplying water to "about twenty-five square miles, all gold producing, enough to employ thousands of men for a generation."[28] Meanwhile, many claims dried up with the summer heat, and business in Elizabethtown sagged. A correspondent from the *Santa Fe Weekly Gazette* reported only four to six mines working, with more than a thousand miners waiting for water.[29] But the difficult route through the mountains delayed construction, and by November, work stopped for winter with nine miles left to go.[30] Still, when construction pushed forward the following March, optimism prevailed, and investor Valentine Shelby sold his large Elizabethtown store to Maxwell for increased interest in the ditch.[31] Rates for water delivery were established, set by duration and quantity of anticipated use.[32] For the first time in New Mexico's history, water would become a saleable commodity.

It was a strange arrangement for an ancient land. For centuries, effective management of water had been fundamental to all human endeavors in this desert climate. Archeological remains at Chaco Canyon and Mesa Verde, for example, reveal evidence of large dams and water works for communal use, while the Hohokam societies of central Arizona also developed extensive canal systems.[33] When Spaniards arrived in New Mexico in the sixteenth century, they were impressed by the Pueblo irrigation works along the upper Rio Grande, which Castaño de Sosa in 1591 called "incredible to anyone

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[28] *Santa Fe Weekly Gazette*, 20 June 1868.
[29] *Santa Fe Weekly Gazette*, 4 July 1868.
[30] *Daily New Mexican*, 18 Nov 1868.
[31] *Daily New Mexican*, 16 March 1969.
[32] A table of rates and delivery appears in Raymond, 392.
[33] Michael C. Meyer, *Water in the Hispanic Southwest: A Social and Legal History 1550-1850* (Tuscon: University of Arizona Press, 1984), 12.

who had not seen them with his own eyes."[34] The Spaniards brought their own ideas about water, and in 1598 Juan de Oñate claimed for Spain all of New Mexico, "from the leaves of the trees in the forests to the stones and sands of the river."[35] But despite its putative status as the property of the Spanish monarch, the region's water continued to be managed in common and at the local level.

Early Spanish officials recognized the necessity of reliable water supplies for establishing permanent settlements, and they chartered land grants accordingly.[36] The settlers of this isolated territory, without access to easy mineral wealth or outside markets, survived on small irrigated farms and ranches, making water management vitally important.[37] Because it was impractical for each landholder to build and maintain a personal irrigation system, community ditches called *acequias* arose as the principal basis for water allocation. Settlers cooperated in the construction, use, and upkeep of these networks, which became central features of community identity. Although individuals owned their houses and gardens, *acequias* were community assets, not to be sold for profit or alienated from the land. They were administered by elected officials called *mayordomos,* who settled disputes and supervised sharing arrangements.[38] When intractable disagreements came to governors or magistrates, they aimed for compromise and common welfare rather than determining winners and losers – priority of right was

[34] Quoted in George P. Hammond and Agapito Rey, *The Rediscovery of New Mexico, 1580-1594* (Albuquerque: University of New Mexico Press, 1966), 282.
[35] Quoted in David J. Weber, *The Spanish Frontier in North America* (New Haven: Yale University Press, 1992), 77.
[36] John O. Baxter, *Dividing New Mexico's Waters, 1700-1912* (Albuquerque: University of New Mexico Press, 1997), 16.
[37] Clark, *Water in New Mexico,* 15.
[38] For more information on *acequias,* common property, and community identity, see Michael C. Meyer and Michael M. Brescia, "The Treaty of Guadalupe Hidalgo as a Living Document: Water and Land Use Issues in Northern New Mexico," *New Mexico Historical Review* 73, no. 4 (October 1998): 321-45.

balanced against issues of need, injury to other parties, and other considerations.[39] The *acequia* system, which changed little under Mexican government,[40] remained the basis of water management in New Mexico for more than two centuries.

After the Mexican-American War, when General Stephen Watts Kearny's troops hoisted the American flag above the Palace of the Governors in Santa Fe in 1846, the *acequia* institution did not simply evaporate. In fact, the Treaty of Guadalupe Hidalgo in 1848 pledged that "property of every kind" in the annexed territory "shall be inviolably respected" by the United States government.[41] During the 1850s, customary water rights remained in place, as Hispanic electoral majorities carried local elites into many judicial and legislative positions.[42] But following the Civil War, a transformation began to occur. East of the Taos Valley, in the Moreno placer grounds, the Big Ditch signaled the arrival of a new era.

When the first gallons filtered into Humbug Gulch, a price was placed upon water in New Mexico for the first time. Although pre-existing diversion canals also crossed the surrounding landscape, these smaller ditches represented usufruct rights to water directly related to the enterprises of mining or agriculture. The Big Ditch, by contrast, made water into a commodity of abstract ownership, independent from land rights or any productive undertaking. The Moreno Valley Water and Mining Company had no mineral claims of its own; it was purely a speculative venture designed to sell a physical substance.[43] Conceptually, its water was no different from other saleable materials – livestock,

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[39] Baxter, 30. See also Charlotte Benson Crossland, "Acequia Rights in Law and Tradition," *Journal of the Southwest* 32 (Autumn 1990), 279-87.
[40] Baxter, 48.
[41] United States Senate, *The Treaty Between the United States and Mexico*, 30th Congress, 1st Session, Executive Document 52 (Washington, D.C.: 1848), 47.
[42] Baxter, 72.
[43] Jones, 145.

produce, or gold. A vital resource, one that for centuries in New Mexico had occupied a special position connected to land and community, was redefined.

This odd transformation was not questioned by the legal and political systems of the young territory; to the contrary, they were instrumental in bringing it about. The county's probate judge, whose job it was to decide local water-rights issues, was none other than Maxwell, who had financed much of the project.[44] Among his many business associates were Territorial Governor Robert B. Mitchell and Chief Justice John P. Slough, who were involved land-speculation schemes benefiting from the growth of the Moreno mines.[45] These men, part of a nebulous consortium of politicians, lawyers, and businessmen known to its detractors as the Santa Fe Ring, sought to profit from many vaguely described land grants scattered across the territory.[46] The Maxwell Land Grant was the largest of these. Like many grants in the territory, its boundaries were ill-defined and contested, which presented opportunities for those with eloquence, guile, and connections to engage in land speculation. Any form of property development, such as the provision of water to exploit mineral wealth, benefited the participants in these schemes. Because the alignment of business and government in New Mexico often made their interests one and the same, private enterprise was left to decide water's legal status in the Moreno Valley.[47]

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[44] *Daily New Mexican*, 16 March 1869.

[45] In 1867 Maxwell, Mitchell, and Slough collaborated on a speculative effort to build a settlement to rival Elizabethtown, named Virginia City after Maxwell's daughter. But due to the site's distant location from the mines, the venture proved to be a failure, and only fifteen houses were started when the project was abandoned. Murphy, "Boom and Bust on Baldy Mountain," 9.

[46] A good explanation of the Santa Fe Ring appears in Howard R. Lamar, *The Far Southwest, 1846-1912: A Territorial History* (Albuquerque: University of New Mexico Press, 1966), 122-3.

[47] These findings again support the historical position represented by Hundley and Pisani: fragmented localized interests shaped western water more than centralized directives and top-down decrees.

But private enterprise could not save the Big Ditch. By the time of its completion in 1869, it had cost investors $210,000 and was supplying water to just over a dozen claims, returning less than $1,000 per week not counting maintenance costs.[48] Of the six hundred miners' inches of water it promised, only about a hundred arrived at the mines; the balance was lost to evaporation and leakage. Pundits readily offered their recommendations: caulk the flumes with clay, or build reservoirs at the ditch's head to increase the overall flow.[49] The second solution was soon attempted, costing an additional $20,000, but to little avail.[50] As the gulches dried up for the third consecutive season, discouraged miners began to move on to better prospects.[51] Without a steady financial base, Elizabethtown entered an irreversible slide, and the Moreno Valley Water and Mining Company abandoned its offices the following season.[52] Four of the seven principal investors sued the company over the next three years,[53] and the defective ditch eventually ended up in the hands of majority investor Valentine Shelby.[54] Several years later, Maxwell brokered a deal with an old associate, who bought the ditch for a mere $12,000.[55] Although it was never efficient, the Big Ditch would function for more than twenty years, enabling new technological uses of New Mexico's water.

In 1869, the year the ditch disappointed the miners at Elizabethtown, thousands of feet of canvas hose littered the Moreno mining camps.[56] The clutter signified a

[48] Raymond, 393.
[49] Raymond, 391.
[50] Jones, 145.
[51] *Daily New Mexican*, 26 August 1869.
[52] United States Territorial and New Mexico Supreme Court Records, New Mexico State Records Center and Archives, Santa Fe, New Mexico. Case # 84, 1872: Valentine S. Shelby vs. Moreno Water & Mining Co.
[53] Colfax County, N.M. Records, New Mexico State Records Center and Archives, Santa Fe, New Mexico.
[54] Jones, 145.
[55] C.M. Chase, *The Editor's Run in New Mexico and Colorado* (Fort Davis: Frontier Book Co., 1968), 60.
[56] Raymond, 393-4.

technology relatively new to the territory, one that traced its roots to the giant ditches of the California gold fields more than a decade earlier.[57] Hydraulic mining, developed in the early 1850s, was the Big Ditch's ultimate practical application. In the past, miners in California had turned to this method when accessible surface gravels panned out. In order to prospect deeper soil buried within banks of ancient riverbeds, which was often covered by deep topsoil and debris, California Argonauts invented a system to blast gravel apart with pressurized water. The resulting contraptions, known as hydraulic giants, captured water in large vertical chambers, using gravity to create pressure near the bottom. Valves released the water into reinforced canvas hoses capped by sturdy nozzles, which were aimed at high banks of gravel, undermining the base and causing the overhang to crash apart on the ground below. The soil was then washed through long sluices, where low wooden slats, or riffles, caught the heavy gold particles and allowed the muddy tailings to spill out the bottom of the chute. Mercury was often pooled near the riffles to bond with smaller flakes of gold. This labor-saving technology allowed a few workers to wash enormous quantities of dirt impossible with older methods.[58] Hydraulic mining reduced labor costs and allowed access to difficult diggings, making the process ideal for mining the Moreno Valley's plentiful low-grade ore.

But the system required staggering amounts of water – some California hydraulics consumed 12,500 gallons per minute.[59] By these standards, New Mexico's Big Ditch was hopelessly inadequate. As a consequence, it quickly fell into disrepair. As investors wrangled in probate courts, Elizabethtown, which had staked so much on the project's

[57] For the development of hydraulic mining in California, see Pisani, *To Reclaim a Divided West*, 17.
[58] A thorough description of 1860s hydraulic mining procedures and technology is given by Phillips, 154-163.
[59] Phillips, 160.

success, became shrouded in "a sort of grave yard stillness," according to an 1881 observer. "The vitality of village life has departed," he noted, "no more to return, unless more water is brought from Red river."[60] But amid the shadows of despair, the ditch's new owner carved out his own private hydraulic empire.

Matthew Lynch, a longtime Elizabethtown miner, was the beneficiary of the Big Ditch's failure. He became, in the words of a 1904 correspondent, "the father of hydraulic mining in New Mexico."[61] After purchasing the ditch from Maxwell and Shelby in 1875, Lynch made the necessary repairs and accomplished, in miniature, the structure's intended purpose. Soon, six hydraulic jets were trained against the gravels and sandbars of the Moreno Valley.[62] With this system, the Big Ditch redefined water's potential through technology.

Hydraulic mining itself was unprecedented in New Mexico. Although several Elizabethtown miners employed the technique intermittently before the Big Ditch, Lynch was the first to apply it on a consistent basis and an expanded scale.[63] With water from the ditch, he was able to operate as many as four nozzles at once.[64] Because water diversions in New Mexico were previously limited to agriculture, the displacement of water for mining was an innovation. Early Spanish miners were often confounded by lack of water, forcing abandonment of potentially rich mines.[65] Later, Mexican miners prospected dry areas in the winter, shoveling snow into wooden bowls and melting it with

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[60] Chase, 62.
[61] Jones, 142.
[62] *Souvenir of the Great Elizabethtown Gold and Copper Mining District* (Elizabethtown: New Mexican Miner, 1902), 4.
[63] Small operators before the ditch are mentioned by the *Daily New Mexican*, 20 July 1868 and the *Santa Fe Weekly Gazette*, 4 July 1868.
[64] *Souvenir*, 4.
[65] Meyer, *Water in the Hispanic Southwest*, 84-5.

fire-heated rocks, thereby creating enough water for limited panning.[66] The Big Ditch was comparatively awesome, transferring millions of gallons from the Rio Grande drainage basin into the adjacent Canadian watershed to the east, which eventually flowed to the Mississippi. Its construction required not only the labor of hundreds of men, but also the engineering expertise to assemble thousands of feet of wooden aqueducts and support trestles. The design was mathematically conceived, calculating every detail from the size and depth of each flume to the exact slope of each decent.[67] From technological and engineering perspectives, both the ditch and hydraulic mining were wonders never before seen in New Mexico. Water was not only commodified, but also dominated through the implementation of large-scale technology.

But the Big Ditch required more than scientific engineering – it also demanded precise quantification of water. To sell water, it was necessary to know how much was available and what volume to allot each buyer. By contrast, agricultural diversions such as *acequias* depended largely on the judgment and experience of the elected *mayordomo*, who relied on custom and tradition to settle allocation among users.[68] Such an informal system was at odds with the emergent doctrine of prior appropriation, which encouraged quantification. Because appropriative rights entitled owners to fixed volumes of water irrespective of the needs of subsequent claimants, quantification was critical not only to ensure the original user's full allotment but also to determine how much remained for everyone else. The Big Ditch, in which water was initially measured to calculate profit, presaged the scientific quantification of water throughout New Mexico.

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[66] Josiah Gregg, *Commerce of the Prairies* (Norman: University of Oklahoma Press, 1954), 120.
[67] Raymond gives the most detailed specifications of the project's design, 392.
[68] Crossland, 279.

Matthew Lynch, however, probably never intended to sell his water. Instead, he continued to blast the banks of the Moreno Valley for gold until being killed by a falling tree in 1880.[69] The ditch passed to his son James, who with his brother Patrick continued hydraulic operations for another fourteen years.[70] During that time, major changes would accelerate the obsolescence of the Big Ditch. Hydraulic mining, seen as a godsend in the 1860s, was increasingly criticized as a destructive practice. An early observer's praise of the process contained subtle undertones: "Man has in the hydraulic process taken command of Nature's agencies, employing them for his own benefit."[71] But this attitude of technological dominance over water would assume other manifestations as well, which were ultimately to end the reign of hydraulic mining. As a new type of agriculture arose in the West, hydraulic techniques were banned in many districts because they presented a threat to potential farming.[72] The age of irrigation had begun.

Irrigation, of course, was nothing new to New Mexico. It had existed for hundreds, perhaps thousands of years, practiced on small farms watered by community *acequias*. But rapid change was afoot in the late nineteenth-century, and the territory's hydraulic landscape was about to be significantly altered. In 1878, the Atchison, Topeka and Santa Fe Railway climbed over Raton Pass at the Colorado border, linking New Mexico to the rest of the nation. Better transportation opened the territory to immigration as never before, and the population nearly tripled between 1880 and 1910.[73] This

[69] Jones, 142.
[70] Henry A. Kiker Papers, New Mexico State Records Center and Archives, Santa Fe, New Mexico. Box 9, folder 143: Estate of Matthew Lynch, 1880.
[71] Phillips, 161.
[72] Edward Sherwood Meade, *The Story of Gold* (New York: D. Appleton and Company, 1908), 139.
[73] Baxter, 81.

population boom was accelerated by the promise of new farmland created by large-scale irrigation.

In the same year the railroad arrived, John Wesley Powell presented his *Report on the Lands of the Arid Regions of the United States*, a hugely influential work that trumpeted the promise of irrigation. Productive wheat crops in California seemed to prove the potential of western soil,[74] and a contagious enthusiasm for irrigation's possibilities spread throughout the West. In New Mexico, Governor Edmund G. Ross pronounced that more than half of the territory's 78 million acres could support productive farming.[75] Other officials echoed this optimism, and soon irrigation fever was spreading throughout the region.

Private landholders were among the first to take advantage of the development. The new owners of the gigantic Maxwell Land Grant, a group of Dutch investors, had in 1887 secured a Supreme Court decision validating their claim to nearly two million acres.[76] They immediately seized upon territorial legislation which allowed irrigation companies to incorporate,[77] and during the next two years they collaborated with private investors to construct two large irrigation networks, the Springer and Vermejo ditch systems. Before long, newspapers from Denver to Holland trumpeted the availability of 1,500,000 acres of the grant's land, complete with "one hundred miles of large irrigating canals," watering 75,000 acres.[78] Other promotional materials promised that an "unfailing supply of water" would transform the arid region into a "veritable farmers'

[74] Pisani, *To Reclaim a Divided West*, 72.
[75] Ross's 1887 report to United States Secretary of the Interior is quoted by Baxter, 82.
[76] Lamar, 134.
[77] Baxter, 83.
[78] These advertisements regularly appeared in the *Santa Fe New Mexican* in late 1890s and 1900s. An undated ad from sometime after 1891 can be found in the Maxwell Land Grant Company Records, Center for Southwest Research, General Library, University of New Mexico, Box 45, folder 1.

paradise."[79] The grant's owners expected to sell irrigated land for a handsome profit, confidently predicting $25 per acre.[80] Money would bloom from the desert.

Promoters still heralded the region's mining potential, but mainly to encourage agriculture. In 1894, the Maxwell Land Grant Company declared its mineral lands "thrown open to prospectors." Significantly, this encouragement extended only to lode claims, exempting the water-consumptive placers.[81] Unclaimed water, it seemed, was too precious a commodity to waste on the low-grade ores that remained in the Moreno Valley. But marketers used the former prosperity of the placer diggings to encourage farmers. While one brochure proclaimed the Big Ditch a "great success" which had operated since its construction,[82] another emphasized mining's potential to "open up a good market for farm produce to the agriculturalist."[83] In nearly every case, the grant's promoters gave top billing to farming and ranching, portraying the presence of mining as an adjunct to these agricultural possibilities. Water had become more profitable for selling land than for extracting gold.

Ironically, these shifting economic priorities reflected concepts embodied by the Big Ditch, even as they were undermining its utility and hastening its obsolescence. The abstract ownership of water, the quantification of its volume, the scientific management of its distribution – these ideas, originally introduced to New Mexico by this doomed piece of hydraulic engineering, came to full fruition with the arrival of mass-irrigation. The Springer and Vermejo ditches were prime examples of the transition. Like the Big

[79] From an undated brochure by Rand McNally, "Guide to the Maxwell Land Grant," Maxwell Land Grant Company Records, Box 45, folder 3.
[80] Pearson, 147.
[81] Maxwell Land Grant Company Records, Box 45, folder 2.
[82] From an undated promotional brochure, Maxwell Land Grant Company Records, Box 41.
[83] "Guide to the Maxwell Land Grant," Maxwell Land Grant Company Records, Box 45, folder 3.

Ditch, both were corporate, capitalist enterprises built for profit. But while the Big Ditch was created to sell water independently, these later projects channeled it to increase the value of land. The new ditches were praised by New Mexico's 1897 commission on irrigation for their construction "according to modern scientific methods," which allowed systematic measurement and observation.[84] The Springer and Vermejo ditches were among the first projects in New Mexico to transfer scientific principles of hydrology, originally represented by the Big Ditch, to agriculture.

Mining-based legal conceptions also spilled over to agriculture. The doctrine of prior appropriation, created in California, was originally injected into New Mexico's waters by the builders of the Big Ditch. Less than thirty years later, it was the accepted formula for all water allocation. The irrigation commission's 1897 study was the territory's first formal assessment of its water resources. It decided that "great embarrassments or losses will almost inevitably occur in making any change that trespasses upon the general system of laws now in force."[85] Vested rights, in other words, anchored the doctrine of prior appropriation in place. This system was not decreed by overarching legal principals, but instead developed largely to accommodate haphazardly arranged private interests.

While these findings seem to support the model of fragmentation put forward by historians such as Hundley and Pisani, a concentration of ideas was developing in New Mexico's waters as well. A transition was unfolding, representing an intersection between two separate historical narratives: both fragmentation of interests and concentration of concepts. Not only had new ideas about water's commodification,

[84] New Mexico State Engineer Records, New Mexico State Records Center and Archives, Santa Fe, New Mexico. "Report of the Commission of Irrigation and Water Rights, 1898," 3-4.
[85] "Report of the Commission of Irrigation and Water Rights, 1898," 10.

scientific management, and conceptual status first infiltrated the territory from the outside, as in the case of the Big Ditch, but the commission also recognized Colorado's strict prior appropriation law as a threat to New Mexico's future water claims.[86] Just as the seeds of new ideas about water were carried into New Mexico from the outside, external pressure was now causing the crystallization of these concepts at the government level. The outline of a nascent transition was becoming clear: ideas about water that had diffused locally were galvanizing on a much larger scale. Although it would be several years before the national Reclamation Act of 1902 and the involvement of the federal government in western water – a crucial component of Donald Worster's hydraulic empire – western water was already assuming a hegemonic, coalescent shape. New technological and economic concepts concerning water's use were beginning to perpetuate themselves, taking hold on a larger scale than ever before. In the commission's report were buried the roots of the "hydraulic society" Worster and Marc Reisner would criticize nearly a hundred years later.

This hegemonic diffusion of new concepts about water threatened New Mexico's older *acequia* system. Optimistically, the commissioners envisioned *acequias* as being identical to other appropriators, apparently regarding community ditches as equivalents to irrigation corporations.[87] In review, the commission praised lawmakers for "their remarkable conservatism in legislating upon this subject."[88] But the transformation of water's legal status would have adverse consequences these community irrigation

[86] The committee reported concern about "the injury to the people of New Mexico by the increased and constantly increasing appropriation of water from the head tributaries of the Rio Grande in Colorado," recommending detailed scientific study and accurate information to counter Colorado's claims if necessary. The committee expressed worry that Colorado's scientific calculations and documentation of streamflows and appropriations would allow the state to claim river volumes more effectively than territorial New Mexico. "Report of the Commission of Irrigation and Water Rights, 1898," 8.
[87] "Report of the Commission of Irrigation and Water Rights, 1898," 12.
[88] "Report of the Commission of Irrigation and Water Rights, 1898," 15.

networks. New Mexico's *acequias* received mention in Frederick Haynes Newell's 1890 report on agriculture and irrigation to the United States Bureau of the Census. A protégé of John Wesley Powell, Newell had recently finished training a group of engineers on the upper Rio Grande, instructing them in the latest technologies and scientific procedures of hydraulic management.[89] He represented the vanguard of a movement throughout the West to quantify and control water. In his report, he noted the persistence of New Mexico's community ditches, many of which had remained essentially unchanged "within the memory of man." While conceding that these *acequias* allowed small farmers to preserve control of their water, he criticized the system for inefficiency and waste. "Agriculture," he commented, "as practiced under the old Mexican system, can not be said to be profitable."[90] The language of the statement is revealing: the *old* Mexican system of water management implied impending replacement by a new one; the focus on its profitability foreshadowed a rejection of traditional subsistence livelihoods and a new emphasis on profit and capital accumulation. It is unlikely Newell ever heard of the Big Ditch, but if he had, he would have been immediately familiar with its focus on profit and systematic water management.

Back in the Moreno Valley, the ditch was doing what it always had: drawing millions of gallons each day from the Red River, spilling most of it along the way. Although the nearby Taos Valley was covered by cornrows and wheat fields,[91] it is unclear whether anyone noticed or understood this massive diversion tucked high in the rugged mountains. In any case, by the late 1890s it was a perfectly legal appropriation,

[89] Baxter, 79.
[90] Frederick Haynes Newell, *Report on Agriculture by Irrigation in the Western Part of the United States at the Eleventh Census: 1890* (Washington: Government Printing Office, 1894), 194-5.
[91] *Santa Fe Weekly Gazzette*, 4 July 1868.

put to beneficial use in the faraway gold fields to the east. Small-farmers near Taos, mostly Hispanic, would have faced great difficulties confronting such a ruling – the scientific and legal changes represented by the Big Ditch worked against them. Water rights, increasingly decided in distant Santa Fe courthouses, were determined according to unfamiliar engineering concepts, complicated by technical jargon in a foreign language.[92] Also, few farmers possessed the required documentation to prove their claims to water, which some families had used for centuries. These legal and scientific developments introduced by the Big Ditch prefigured far-reaching consequences, which lasted long after its last timbers had toppled to the ground.

By 1894, the ditch had become less efficient than ever, and its hydraulic mines lost money that season.[93] Elizabethtown, on the other hand, was enjoying a small renaissance. Buoyed by the general rush of immigration to the territory, its proprietors were soon offering billiards and fine wines once again, and thanks to new refrigeration techniques, oysters on the half-shell.[94] New investors also arrived, hoping to solve the water problem in the placer fields with updated technologies. This time, their techniques focused on the conservation of water instead of increasing the supply, and their optimism gave the town renewed hope.

The first innovator was Henry H. Argue, who headed a group of investors from Buffalo, New York.[95] In 1894, he leased the Moreno Valley placer fields from the Maxwell Land Grant Company for twenty years, at five percent interest on any gold

[92] Baxter, 106.
[93] Maxwell Land Grant Company Records, Box 45, folder 2.
[94] *New Mexican Miner*, 15 December 1899.
[95] Pearson, 195.

recovered.[96] He planned to build a giant dredging machine to churn the gold-laced banks of a small pond on the upper Moreno River. Large buckets would lift gravel into sifters, which would then wash the dirt by continually recycling the same supply of water. But malfunctions plagued the machine, and in 1896 Argue purchased the Big Ditch from James Lynch for $30,000 to pursue hydraulic mining, which was considered more reliable.[97] The dilapidated ditch, meanwhile, was delivering only thirty percent of the water it diverted.[98] Argue's company made small improvements,[99] but the estimated $100,000 to run pipe from the Red River proved too expensive.[100] The company gave the dredge one more try, but after a year of frustration Argue sold his claims to H.J. Reiling. The Big Ditch changed hands as well in 1900, and although the new buyers promised to improve it with pipeline directly from the Red River, the project never materialized. The ditch soon fell into disuse.

Meanwhile, Reiling, a Chicago man who had operated gold dredges successfully in Montana, proposed a final solution to the area's water problem. His company built the *Eleanor,* a massive boat assembled 8,000 feet high in the mountains. Essentially a larger, floating version of Argue's dredge, it was designed to chew through 3,000 cubic yards of gravel each day.[101] Optimism abounded on May 1901, when the first of two 20,000-pound boilers was positioned to ascend the treacherous road winding up the Cimarron Canyon. Drivers and a team of fourteen horses struggled up the narrow gorge, with sheer canyon walls towering a thousand feet above them on either side. They rebuilt dilapidated

[96] Maxwell Land Grant Company Records, Box 45, folder 2.
[97] Pearson, 195; Maxwell Land Grant Company Records, Box 42-1.
[98] *New Mexican Miner,* 4 May 1898.
[99] *New Mexican Miner,* 14 May 1898.
[100] Pearson, 196.
[101] Pearson, 200.

bridges as the path crisscrossed the Cimarron River, and still the wagon wheels sometimes ripped through the planking under the weight of the ponderous load. Yet within two months, this dangerous journey was completed several times, and by August 20, the *Eleanor* floated atop her mountain pond, bathed in the glow of electric lights powered by onboard generators. The Elizabethtown Cornet Band struck up a celebratory tune, and fashionable eastern ladies in colorful dresses sipped refreshments on the deck. Reiling made gracious speeches to weathered miners who came to behold the strange craft.[102] Although initially profitable, the boat's success was its undoing. The decent returns in New Mexico inspired Reiling to expand his operations into Colorado, and he mortgaged the *Eleanor* to finance the scheme. But the new enterprise was a bust, and the *Eleanor* was eventually abandoned to rust on the gravels, useless, like the fossilized hulk of some Paleolithic creature. Elizabethtown had seen its last boom. Its fine hotel began to crumble; its population began to die away. At last, nothing was left. The Big Ditch, which once sustained the hopes of so many, was forgotten.

Although the Big Ditch was New Mexico's first example of water displacement on a massive scale, its power was more symbolic than transformative. Because it was a financial failure in a remote area, its existence remained largely unknown to territorial lawyers and judges; consequently, it was never cited as a precedent in any legal statute. Yet this once-impressive construction foreshadowed sweeping changes. Like the first flurry of snow before a blizzard, the ditch signaled the arrival of new ideas about water's use, management, and legal status – concepts which would soon blanket the region's ideological landscape. By the twentieth century, the ideas embodied by the Big Ditch

[102] Manville Chapman, "The Eleanor of Etown," *New Mexico Magazine*, November 1937, 21-22, 46; Pearson, 201.

were embedded in practice and codified in law. Projects such as the Springer and Vermejo ditches, which mirrored the Big Ditch by using scientific technology and corporate investment, pointed the way for similar irrigation systems throughout the region. Later, in 1905, the territorial legislature enshrined prior appropriation as the foundation of all water distribution, requiring precise measurement of flow and volume in standard units of cubic feet. In 1907, lawmakers created the office of territorial engineer, mandating the assessment, quantification, and allocation the region's water by a scientifically trained hydrologist.[103] These statutes, which remain part of New Mexico's water law today, confirmed the scientific and legal premises first represented by the Big Ditch.

The ditch's demise also reflected the region's shifting economic priorities. While the Big Ditch supplied water for mining, later projects adopted its scientific and legal approaches to promote irrigation. By 1911, water's conceptual separation from agricultural land was explicitly stated by an administrator of the Vermejo Ditch, who considered water rights to be "purely a contract which we entre into with our purchasers" which had "nothing to do with the title of the land."[104] Ironically, despite irrigation's emergence as water's most profitable use, early large-scale irrigation projects were often no more successful than the Big Ditch. No amount of scientific management or legal appropriation could completely reverse the natural scarcity of water, and the Vermejo and Springer ditches did not supply the 70,000 irrigated acres promised by their proprietors. Vermejo Ditch administrators privately concluded in 1902 that their system "should

[103] Clark, 117-122; Baxter, 104.
[104] Letter from James I. Cowan, Vice President of The Maxwell Irrigated Land Company, to E.G. Twitty, Clerk and Recorder, Raton, N.M., 13 February 1911,

furnish ample water at all times to irrigate 2,500 acres,"[105] or 67,500 fewer acres than advertised. This gross miscalculation resulted in decades of litigation from frustrated farmers. Years later, a former president of the Maxwell Land Grant Company lamented the organization's foray into mass-irrigation as "a mistake," admitting that "the water supply was over estimated by what were supposed to be competent engineers."[106] By contrast, none of New Mexico's traditional *acquias* could rival the Big Ditch in waste and inefficiency, and none equaled the Vermejo system in enmity and dissatisfaction among its users.[107] In both mining and agriculture, early projects which sought to redefine the conceptual status and economic potential of water in New Mexico fared poorly.

For all its inadequacies, the Big Ditch was a harbinger of important changes. Although historians have correctly emphasized the laws of 1907 as constituting a major turning point in New Mexico's water management, they have also overlooked the course of developmental expediency charted by business interests and their political partners earlier in the territorial period. Doubtless, the 1907 water code strengthened the central management of water and ushered in a new age of government oversight. But the foundation upon which this code rested – the conceptual separateness of water and land, the quantification and scientific management of water, the control of water through technology – all of these ideas were originally introduced to New Mexico decades before 1907. Furthermore, their initial arrival was not divined by overarching political theories

[105] Letter from the Board of Trustees of the Maxwell Land Grant Company, probably intended for administrators of The Maxwell Irrigated Land Company, undated but written prior to 15 September 1902, Maxwell Land Grant Company Records, Box 14, folder 19.
[106] Letter from J. van Houten to V. J. van Lint, 13 October 1943, Maxwell Land Grant Company Records, Box 45, folder 5.
[107] Newell, 194-5. Newell remarked that "a single well built canal" would be more efficient than "the many poorly constructed ditches."

or environmental wisdom, but instead was dictated by the requirements of expedient economic development and the pursuit of individual gain.

And yet there was something strangely coalescent about these developments as well. The seeds of new ideas about water blew through the territory from the outside, lodging more fully in New Mexico's legal system partly as a response to contend with the claims of interstate competitors for water. Thus, the Big Ditch represents a transitional stage in water history. What began as a story of fragmented water development, akin to that described by Pisani and Hundley, also contributed to an incipient "cultural subsoil" of imported ideas, which replicated themselves with surprising speed and eventually allowed a concentration of interests, as recounted by Worster and Reisner, to take root.[108] The story of the Big Ditch offers a snapshot of the intersection of these two narratives, illuminating perhaps a nascent historical transition from one to the other. Individuals trying to separate gold from gravels, peddle desert to farmers, or sell water by the miners' inch, redefined its legal status, altered its technological applications and management, and re-imagined its economic potential. In turn, they also contributed to an impending avalanche of new ideas that reached far beyond New Mexico's borders. Although the Big Ditch is no more, its legacies endure.

[108] My use of the phrase "cultural subsoil" is borrowed from Donald Worster, *Nature's Economy: A History of Ecological Ideas* (Cambridge University Press, 1977).

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2

Hole in the River: A History of Groundwater in the South Platte Valley, 1858-1969

Water moves underground. Beneath sheets of ancient shale, through gravel beds of elder rivers, its presence has long been regarded as mysterious. It moves unseen. Dowsers, or water witches, claim a special ability to auger its location; a court in Ohio once described it as "so secret, occult and concealed" that no set of laws could be applied to it.[109] Yet in many parts of the American West, extensive regional economies have become invested in groundwater, with both farms and cities supplied by it. The valley of the South Platte River, home to Colorado's largest population and most productive agriculture, is such a place.

While many of groundwater's old physical mysteries faded under the light of twentieth-century science, deeper paradoxes emerged from beneath the South Platte valley floor. In this region, water's relentless movement underground steadily eroded Colorado's approach to water administration, turning old maxims upside-down and creating new friction between water users. Ultimately, movement of water caused human and natural systems to become entwined and entangled, resulting in unexpected opportunities and intractable difficulties for water users and managers alike.

A revised approach to water's history can help explain this complicated story – to show how longstanding methods of western water management, which for more than a hundred years authored economic development, could somehow become inverted to

[109] *Frazier v. Brown*, 12 Ohio 294, 311 (1861). For a historical account of dowsing, see Walker D. Wyman, *Witching for Water, Oil, Pipes, and Precious Metals: A Persistent Folk Belief from Frontier Days Down to the Present* (River Falls: University of Wisconsin Press, 1977).

obstruct the same goal;[110] to demonstrate how a discussion about resource management was transmuted into a battle over property rights; to fathom how farmers, both those using surface flows and those tapping groundwater, could be ruined by drought while standing above an underground reservoir filled with more water than Lake Powell.[111] The history of groundwater use in the South Platte valley is a search for these explanations.

Whereas most accounts of water in the West focus mainly on human endeavors, the history of groundwater in the South Platte valley highlights water's own historical activity. Water has never been purely passive – its movements have always been braided with our own. Additionally, human conceptions of water's fundamental meaning influenced this story. Water users and managers struggled to assert conflicting conceptions of groundwater's proper function and purpose, affecting its use and management in the valley. Finally, over time, human designs became inseparable from natural processes, and people's activities and ideas became enmeshed with circumstances largely beyond their control. These are the roots of a problem that farmers, scientists, and lawmakers are still trying to solve.

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[110] Historians have recognized western water law as a driving force for economic development since the nineteenth century. Donald Pisani argued that prior appropriation sparked enterprise in the American West while stifling economic equality; Donald Worster argued that the system had a monopolistic effect, contributing to dangerous hierarchies of wealth and power. See Pisani, "Enterprise and Equity: A Critique of Western Water Law in the Nineteenth Century," *The Western Historical Quarterly* 18, no. 1 (January 1987): 15-37; and Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1985).

[111] In 2006, groundwater users of 440 wells in the South Platte valley, some of whom had already planted crops, were forbidden by law to pump water for irrigation because surface rights were not adequately protected. By contrast, a study at Colorado State University found that severe drought in 2002 forced surface-water users to give up farming at a higher rate than groundwater users. See Marshall Frasier and Eric Schuck, "Coping with Natural and Institutional Drought," *Current Agriculture, Food & Resource Issues* 5 (2004): 119-130.

An acre-foot of water would cover an acre of land to a depth of one foot. The South Platte valley aquifer contains an estimated 25 million acre-feet; Lake Powell currently holds about 21.5 million, though its full capacity is higher. See Andrea Aiken et. al., eds., *The Colorado Ground-Water Atlas* (Lakewood, Colo.: Colorado Ground-Water Association, 2000), 23-27.

Groundwater in this region is fused by nature to a living surface stream. Water moves freely between river and aquifer. This exchange, itself an example of water's motion independent of human goals, is at the heart of groundwater's history in the South Platte valley. Yet traditional historical approaches have not fully appreciated the importance of this kind of agency. Even the most prominent environmental historians have focused on human manipulations of water, especially in terms of reclamation, dams, and diversions; and on the social and environmental consequences of these endeavors. Norris Hundley, Jr., for example, emphasized primarily the deleterious effects of conflicting social interests in reclamation projects, while Donald Pisani pointed to a lack of coordinated planning and governmental leadership as the main culprit for social and environmental costs. But water's own activity was taken mostly for granted. Even Donald Worster, who has articulated environmental agency in much of the rest of his work, portrayed water itself as largely a passive canvas for human action and social change in *Rivers of Empire.*[112]

Yet even though water is not alive, it often follows courses of its own. Although its movement is generally predictable in terms of slope, gradient, and volume, it can also behave in unexpected ways. In the South Platte valley, its motion connects a river and an aquifer. In Colorado, despite the fact that surface-water rights were established separately from groundwater rights, the river and aquifer respected no such boundaries – they exchanged water naturally, creating a hydrological commons that the state's regulatory

[112] For an overview of the historiography of water in the American West, see Norris Hundley, Jr., "Water and the West in Historical Imagination," *Western Historical Quarterly* 27, no. 1 (Spring 1996): 4-31. Also see *Rivers of Empire: Water, Aridity, and the Growth of the American West.* New York: Pantheon Books, 1985. See also Worster, *The Wealth of Nature: Environmental History and the Ecological Imagination* (New York: Oxford University Press, 1993); Pisani, *Water, Land, and Law in the West: The Limits of Public Policy, 1850-1920* (Lawrence: University Press of Kansas, 1996); Hundley, *The Great Thirst: Californians and Water: A History*, rev. ed. (Berkeley: University of California Press, 2001).

structure had not accounted for.[113] In this way, the historical agency of water carved its own identity into human affairs.[114]

But human conceptions of water's meanings and purposes also influenced groundwater use in the South Platte valley. An interplay of opposing perspectives shaped attitudes about groundwater's proper use and management. In the 1930s, drought-stricken farmers, struggling to save their crops, tapped common underground supplies with little restraint or regulation. By the 1950s, however, as depletions became undeniable in many places, most western states sought to regulate groundwater in order to conserve it. In Colorado, scientists and engineers generally regarded groundwater as a vulnerable resource that required protection to prolong its use, and they were among the first to call for state regulation. But while scientists saw primarily a physical resource in need of preservation, lawmakers encountered an abstract web of overlapping property rights – including both groundwater claims that required definition and established surface-water

[113] A similar kind of natural commons regime is analyzed by Mark Fiege in "The Weedy West: Mobile Nature, Boundaries, and Common Space in the Montana Landscape," *The Western Historical Quarterly 35*, no. 1 (2005): 22-48. Fiege postulated an "ecological commons" that defied regulation or private property schemes – weeds presented a mutual problem in Montana, tumbling through fences and across property lines, linking together land that was supposed to be separate. As in the South Platte valley, these schemes and regulations ultimately hindered the consistent management of shared environmental characteristics.

[114] The portrayal of water as an active historical element has never been applied to accounts of groundwater. Scholars such as John Opie, and Geoff Cunfer have studied deep aquifers such as the Ogallala, where water has little relation to surface flows and may be accurately characterized as a passive resource, something that can be "mined." In the South Platte valley aquifer, water's motion is more dynamic. In some historical studies involving water, inroads have been made toward a more inclusive model. For example, Richard White illustrated the hybrid characteristics of the Columbia River valley, arguing that although the river was altered substantially by people, its natural character also endured. Likewise, Mark Fiege has argued that people could not eradicate nature from western agricultural landscapes despite their intensive efforts at environmental mastery. Both studies emphasized the blurred boundaries between people and their natural surroundings, illustrating that society and environment do not function in isolation but rather in dialogue, each reshaping the other. See Fiege, *Irrigated Eden: The Making of an Agricultural Landscape in the American West* (Seattle: University of Washington Press, 1999); and White, *The Organic Machine: The Remaking of the Columbia River* (New York: Hill and Wang, 1995). For histories of groundwater in confined aquifers, see Geoff Cunfer, *On the Great Plains* (College Station: Texas A&M University Press, 2005); John Opie, *Ogallalla: Water for a Dry Land* (Lincoln: University of Nebraska Press, 1993); Theodore Steinberg, *Slide Mountain, or the Folly of Owning Nature* (Berkeley: University of California Press, 1995), 82-105. For a comparison of groundwater law across the west, see Robert G. Dunbar, "The Adaptation of Groundwater Control Institutions to the Arid West," *Agricultural History* 51 (1977): 677.

claims that required legal protection. Between these two perspectives were farmers, most of whom perceived access to groundwater as vital to economic survival. To produce irrigated cash crops such as sugar beets and potatoes, they sought to achieve local control over this critical part of their enterprise. They also recognized the wide diversity of local conditions that standardized groundwater regulations would be unable to account for. In short, they saw groundwater primarily as an economic necessity, and they sought to preserve local control over its extraction.[115] Collectively, the opposing perspectives of scientists, lawmakers, and farmers collided and compromised to shape groundwater's use and regulation.

Ultimately, human ideas about groundwater became entangled with the hydrological characteristics of the South Platte River and its aquifer, producing unexpected outcomes and strange difficulties. Although ancient natural forces originally made the river and aquifer, irrigation in the nineteenth century changed the fundamental character of both. Later, as overall water use in the region expanded with increased access to groundwater, delicate balances between water use and availability expanded, remaining stable under just the right combination of human and natural influences. But as regulations to preserve these tentative accommodations were debated and legislated, underlying hydrological systems worked to dissolve any clear-cut legal and administrative categories, confounding the basic principles of Colorado's water administration system. In the South Platte valley, human perceptions and natural

[115] The study of cognitive perceptions of water and its meaning represents another emergent strain in water history. For a comparison of abstract and subjective ways of looking at a river, see Linda Nash, "The Changing Experience of Nature: Historical Encounters with a Northwest River," *The Journal of American History* 86, no. 4 (March 2000): 1600-1629.

conditions sculpted the use of groundwater, producing a series of fragile accommodations between people and their surroundings – a world made by humans and nature together.

Throughout most of its reaches, the South Platte River is a muddy agricultural workhorse, churning across Colorado and Nebraska for more than 400 miles. Its journey begins in melting snow. Starting high in the Rocky Mountains, snowmelt rushes through rugged valleys, merges with icy creeks, and spills onto the thirsty plains. There, the river meanders – and sometimes gushes – through the city of Denver, whose residents once panned its banks for gold, but later used it as a municipal dump. Recently, the river's urban stretch has been remade into a flood-proof greenway, complete with wide swaths of open vegetation, bicycle trails, even a kayak park.[116] Flowing north through Denver, the river absorbs the Big Thompson and Cache la Poudre Rivers before taking an easterly turn. It flows toward the state's northeastern corner some 150 miles distant, irrigating along the way much of the state's most productive farmland.[117] Finally, the river enters Nebraska, later to mingle with the North Platte, Missouri, and eventually Mississippi Rivers. Surrounding its bed, unbroken plains extend in all directions, flat as the sea. But this uniform landscape conceals the uneven contours of an earlier age.

Below the ground, the South Platte valley aquifer is more than 200 feet deep in places, containing perhaps 25 million acre feet of water.[118] A mixture of sand, clay, and gravel, it sprawls beneath the flowing stream and its tributaries like a shadow, filling lost subterranean channels once carved by Pleistocene rivers. But its water is not ancient. In

[116] The river's urban rehabilitation began in the 1960s. For an introduction, see Joe Shoemaker, *Returning the Platte to the People: A Story of A Unique Committee, the Platte River Development Committee* (Westminster, Colo.: Greenway Foundation, 1981).
[117] U.S. Environmental Protection Agency. *The South Platte River in Colorado* (Washington: U.S. Department of Agriculture, 1999).
[118] Aiken et al., 23-27.

fact, the aquifer's vast subterranean storage is more the product of nineteenth-century farming than of continental uplifts and Ice Age glaciations. Unwittingly, people altered the aquifer and the river above it, which changed people and their institutions in return. At once ancient and recent, natural and artificial, the aquifer has tested the limits of the West's oldest principles of water management.

The South Platte River's appearance belies its importance. Novelist James Michener described "a sad, bewildering nothing of a river…a wandering afterthought, a useless irritation."[119] Denver's founders gave it no great respect – the offices of the *Rocky Mountain News* originally were built on stilts in the muddy bottoms of Cherry Creek as it emptied into the South Platte, its editor remarking in 1860 that he was "not yet inclined to believe the Indian claims that the whole settlement is subject to flood."[120] By 1864, he was convinced. That summer, the newspaper's 3000-pound press was swept downstream, along with entire buildings and most of downtown Denver, in a massive torrent that killed twelve people and wreaked perhaps a million dollars worth of property damage.[121] Such volatility characterized not only the river itself, but also helped create the giant aquifer beneath it.

Roughly a million years ago, the ancestral South Platte developed drainage patterns similar to those evident today. Following a general continental uplift, the ancient river began to carve deep channels into the Tertiary sediments of the high plains east of the Rocky Mountains, down to the bedrock shale deposited by inland seas more than 80 million years prior. These channels – sometimes many miles wide and hundreds of feet

[119] James, A. Michener, *Centennial* (New York: Random House, 1974) 65.
[120] *Rocky Mountain News*, 1 August 1860.
[121] Robert L. Perkin, *The First Hundred Years: An Informal History of Denver and the Rocky Mountain News* (New York: Doubleday & Company, Inc. 1959), 209-225.

deep in places – gradually filled with a mixture of clay, sand, and gravel, collectively called alluvium. Over time, erosion caused the river's slope to decrease, and more materials were gradually deposited. These were washed and rewashed as Ice Age glaciers froze and melted in the high mountains, leaving behind relatively clean beds of sand and gravel along the course of the South Platte and its ancient tributaries. By these processes, the geologic structure of an alluvial aquifer was formed.[122]

Today, the South Platte flows over this gravel bed, as do the other major rivers in eastern Colorado, each within its own channel of alluvium. Among these rivers, which include the Arkansas and Republican, the South Platte's aquifer is the largest, containing a volume many times greater than the annual flow of the surface stream.[123] In places, tongues of alluvium also underlie dry tributaries that once coursed with water. The South Platte alluvial aquifer is, unlike the vast Ogallala to the east, intimately connected to surface flows – water can easily seep into the aquifer from the South Platte River, or vice versa depending on the height of underground water levels. While the Ogallala is confined by impermeable materials and cannot be refilled in foreseeable human generations, the South Platte's aquifer is renewable. Like a giant sponge beneath a leaky faucet, it can dry out or become saturated depending on surface conditions.[124]

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[122] L.J. Bjorklund and R.F. Brown, *Geology and Ground-Water Resources of the Lower South Platte River Valley between Hardin Colorado, and Paxton Nebraska* (Washington, D.C.: GPO, 1957); Morton Bittinger, "Ground Water Management Vital to Comprehensive Development of River Basin Water Resources," *Colorado Farm and Home Research* 12, no. 4 (1962).

[123] The river's average surface flow is some 1.4 million acre-feet annually; an acre-foot of water is the amount necessary to cover an acre of land to a depth of one foot. The South Platte River's annual surface flow is cited in P.K. Bash and R.A. Young, *The Role of Tributary Ground Water in Irrigated Crop Production in the South Platte Basin: Results from a Survey* (Fort Collins: Colorado Water Resources Research Institute, 1994).

[124] For historical accounts of groundwater use from the Ogallala aquifer in the Midwestern states, see Cunfer and Opie. For an account of Ogalalla use in Texas, see Donald E. Green, *Land of the Underground Rain: Irrigation on the Texas High Plains, 1910-1970* (Austin: University of Texas Press, 1973).

Its water can also be extracted. This ancient, hidden water-bearing formation, created by epic natural forces, has been altered by people. Yet for many years, its presence was virtually unknown. The river's flow was intermittent over the plains – subject to great flooding, but often disappearing into the sand during summer months: "more of a quicksand than a river," recalled one early settler.[125] This unassuming watercourse was already the site of one tremendous historical event. In 1858, a man named William Green Russell fished a few bits of gold from a muddy tributary of the South Platte, sparking the greatest single mass migration in American history.[126] Farmers, miners, and merchants poured into the valley in droves, and by 1861, water was being siphoned from all the principal streams in the river's upper reaches for mining and irrigation.[127] This activity was sanctioned by the newly formed Colorado Territory as a right "so universal and imperious that it claims recognition of the law."[128] By the time Colorado reached statehood in 1876, water was treated as a transferable public commodity.

The legal severance of water from land was a departure. In the East, following English common law, water and land were basically inseparable: owners of property bordering a lake or river had a right to use the adjoining water. Under this system, known in legal parlance as the Riparian Doctrine (derived from the Latin word *ripa*, meaning the bank of a stream), a watercourse was, in most cases, forbidden to be modified or

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[125] Statement of Charles Huffsmith, 13. Box 26, Papers of Delph E. Carpenter and Family, Water Resources Archive, Colorado State University (hereafter DEC).
[126] For an environmental history of the Colorado gold rush, see Elliott West, *The Contested Plains: Indians, Goldseekers, and the Rush to Colorado* (Lawrence: University of Kansas Press, 1998).
[127] Tom Cech, "Water Development and Management Along the South Platte River of Colorado," in *Water and Climate in the Western United States*, ed. William M. Lewis, Jr. (Boulder: University of Colorado Press, 2003), 153-159.
[128] *Yunker v. Nichols*, 1 Colo. 551 (1872). See also Gregory J. Hobbs, Jr., "The Role of Climate in Shaping Western Water Institutions," *University of Denver Water Law Review* (Fall 2003), 10.

diminished to the detriment of other riparian property owners. Shortages were shared equally by all affected landowners.[129]

A different system developed in California during the gold rush of 1849. Streams were often inconveniently located for mining purposes: overlying a promising bed of gravel, or too distant from gold deposits to be useful. To solve either problem, water had to be redirected from its normal channel. It could then be treated as an independent property right, established by diversion and subsequent application, conceptually separate from the underlying land. When there was not enough water for everyone (as was often the case in the crowded goldfields), rights were fulfilled according to their dates of priority: the earliest right received its full allotment first, then the second right, and so on until all rights were satisfied, or until no water remained. Thus, shortages were borne unequally by those with later rights, but the investments of early claimants were protected. This system, called the Doctrine of Prior Appropriation, was hotly contested in some California camps, marked by violence and contradictory court rulings.[130] But prior appropriation found a true champion in Colorado. Whereas California adopted a mixture of riparian principles and prior appropriation, Colorado proclaimed the purest priority system in the country: a strict code known as the Colorado Doctrine. Groundwater would become this system's greatest challenge.

The presence of underground water was recognized almost immediately by American farmers and settlers in the South Platte valley, even if it was not fully understood. As early as 1860s, freighters and cattle drivers carried shovels and scrapers

[129] For a concise explanation of riparian water rights, see Robert Dunbar, *Forging New Rights in Western Waters* (Lincoln: University of Nebraska Press, 1983), 59-61.
[130] Donald J. Pisani, "Enterprise and Equity: A Critique of Western Water Law in the Nineteenth Century," *The Western Historical Quarterly* 18, no. 1 (January 1987): 15-37.

to dig for water along the river during hot summer months, when the river would disappear into its deep gravel bed. Travelers sometimes sunk bottomless kegs or boxes into the dry riverbed to use as makeshift wells.[131] Although flows were generally reliable near the mountains, farther onto the plains the South Platte often became intermittent, especially in summer. "It just soaked away," one traveler remembered, turning into a series of shallow pools; "alive but standing," connected by no discernable surface flow.[132] Charles Lent, a farmer and ditch-rider who came to the valley in 1896, remembered uneven summer flows near the turn of the century: "The river used to be so low," he recalled, "we could cross it with just a common pair of Sunday shoes on without getting your feet wet."[133] In effect, the river would simply sink away into the vast aquifer below.

Unbeknownst to the early settlers, human activity had already begun to change the character of both the river and the aquifer beneath it. In the upper reaches of the South Platte, heavy farmland irrigation was causing what one contemporary called a "revolution in natural conditions."[134] This revolution was due to seepage water, an occurrence which was articulated scientifically for the first time in the valley by L.G. Carpenter, a researcher at Colorado's State Agricultural College in Fort Collins. In 1897, Carpenter posited a "filling of the subsoil" by irrigation runoff near the valley. Underground water levels had risen in some places by forty to sixty feet, and were continuing to rise.[135] Before irrigation came to the region, spring floodwaters commonly surged down the

[131] Statement of George A. Hodgson, 3. Box 26, DEC.
[132] Statement of David Camp, 3. Box 26, DEC.
[133] Statement of Charles H. Lent, 1-2. Box 26, DEC.
[134] Statement of Charles C. Huffsmith, 16. Box 26, DEC.
[135] L.G. Carpenter, *Seepage or Return Waters from Irrigation*, The State Agricultural College Experiment Station, Bulletin 33 (Fort Collins: Colorado Agricultural College, January 1896), 4, 51.

South Platte. But beginning in the 1870s, irrigation companies built reservoirs to capture and save these flows. When farmers applied this storage water to their crops, a substantial volume soaked into the porous soil below rather than flowing away as floodwater, evaporating, or being absorbed by plants. This seepage eventually reemerged in the river downstream, causing volumes in the South Platte and its tributaries to increase. Most important to irrigators, the flows became more regular during late summer and autumn, when the river historically had been lowest – and when many crops most needed water. Carpenter predicted these flows would only increase, valuing them at more than two million dollars and counting. As these flows increased and became more regular, irrigators filed legal claims to the additional surface water.

Farmers were not oblivious to the river's change. Henry DeVotie, farmer and president of a ditch company near Greeley, noticed autumn flows steadily increasing downstream from his farm following years of irrigation and reservoir construction on the South Platte. "The subsoil is saturated," he asserted in 1922, "and a large amount now gets back to the river, making the river flow more uniform than ever before." Here was an intersection of human and natural conditions: Farmers responded to the unreliability of rainfall by irrigating their crops, and in turn, this application of irrigation water changed the river's essential characteristics. Altered flow patterns were recorded by cottonwoods – "a rank hearty growth," a cattleman observed in 1918, had occurred all the way from Denver to the state line, with the trees becoming smaller and younger proceeding downstream.[136] These additional flows served as the basis for new surface water rights. As availability of water increased, human use expanded accordingly.

[136] Hodgson, 3. Box 26, DEC.

Early farmers also displayed an awareness of conditions below the earth. DeVotie noted that "irrigation not only assists plant growth, but also serves the purpose of underground storage of water."[137] Some farmers were tapping this underground storage even before the turn of the century. In 1889, E.F. Hurdle drilled the first recorded irrigation wells in the South Platte basin, using a steam engine to operate the pumps. Within a few years, a neighbor sought an injunction against him for diminishing the flow of a nearby creek. But the court ruled in Hurdle's favor. Despite finding a probable connection between groundwater and creek water, allegations of the well's detrimental impacts were "vague, conflicting, and indefinite."[138] The ruling established the legal precedent that groundwater was somehow connected to surface flows, but it also exposed the difficulty of demonstrating specific injuries in court based on that relationship.

Moreover, Hurdle's case revealed a basic awareness of large volumes of usable water underground. Over the next several decades, agriculturalists tapped this underground water with increasing regularity. But soon, signs of stress also emerged – some farms became pocked by dry wells as pumps surged or sputtered, indicating that something was wrong underground. Increased pumping strained the established accommodation between water use and availability, setting off alarms among scientists at the nearby agricultural college.

One of Colorado's foremost groundwater researchers was William E. Code. He began work as an irrigation engineer at the state's Agricultural Experiment Station in 1928, and for the next thirty years devoted his career to groundwater investigations. His commitment to data collection along the South Platte and other agriculturally productive

[137] Statement of Henry M. DeVotie, 20-23. Box 26, DEC
[138] *McClellan v. Hurdle*, 3 Colo. App. 430 (1893).

river basins was unmatched by any researcher before him. In the spring of 1944, as war raged across three continents and scientists worked to split the atom in Los Alamos, Code scoured the backroads of rural Colorado, measuring water in a cold, silent aquifer. On May 22, he set out from Fort Collins armed with a Kodachrome camera. Driving past fields of alfalfa, he stopped frequently to visit farmers, photographing their wells and recording local water-levels. He helped some irrigators repair broken pump motors; others he joined for ranch-style barbeques, all while discussing equipment and pumping operations. He braved sudden thunderstorms and washed-out roads, observed the work of a well-digger and a water witch, and interviewed a bank executive who was lending money for irrigation pumps and drilling.[139] For Code, the journey was part of an ongoing ritual – over time, his inventories grew to include thousands of wells, making him the region's leading scientific authority on the subject.

But Code was alarmed by trends he saw in his hydrographic charts. These saw-toothed patterns mirrored water-levels at various wells, with each jagged point representing a fluctuation in the water table through spikes and troughs. Typically, levels dropped during the irrigation season and recovered as groundwater recharged through precipitation, irrigation seepage, and the South Platte's flow. But in certain areas, the overall trajectories pointed noticeably downward, indicating that groundwater extraction exceeded recharge in those locales. Already, Code had tried to dispel the "unfortunate idea" that groundwater was inexhaustible, warning that dropping water tables meant a reduction in well capacities, potentially causing many to go completely dry. At the same time, he was attuned to the considerable investments many farmers had made in

[139] Code recorded his experiences in a 1944 field book entitled "Ground Water Investigations." Box 8, Groundwater Data Collection, Water Resources Archive, Colorado State University (hereafter GDC).

groundwater. “An irrigation well is something more than a hole in the ground,” he wrote. Rather, it was a considerable investment, often made on credit.[140] Code feared an economic crisis would follow widespread groundwater depletion.

To protect both water-tables and financial investments, Code called for legislative action. He pointed to examples of severe groundwater depletions in California and Arizona, urging Colorado’s lawmakers to choose a different path.[141] The connection between groundwater and surface water was by this time widely recognized. A U.S. Geological Survey report in 1940 mentioned that where wells operated near the South Platte, surface flows were surely reduced: “in those areas,” the report affirmed, “the water levels are being maintained at the expense of the river.”[142] While acknowledging this connection, Code’s overriding concern continued to be the conservation of an underground water supply.[143] In essence, he sought to avoid a disruption of the existing accommodation between groundwater use and its availability, worrying that haphazard exploitation would lead to rapid depletion. Like many conservation-minded scientists of his era, Code advocated regulation of this natural resource largely to ensure its continued availability for future use.

Environmental conditions, meanwhile, encouraged and accelerated well-drilling. From 1930 to 1940, a savage drought seared Colorado and most of the West – the most widespread and longest lasting in the state’s history.[144] Not coincidentally, irrigation wells also proliferated dramatically during this time, from 654 statewide to nearly 3,000

[140] W.E. Code, “Pumping Moves Eastward,” *Western Farm Life*, 1 June 1937.
[141] W.E. Code, “Colorado Needs Ground-Water Legislation,” c1954. Box 16, GDC.
[142] W.N. White and C.V. Theis, “Proposed ground-water investigations in the drainage basins of South Platte, Arkansas, and Republican Rivers in eastern Colorado,” (United States Department of the Interior Geological Survey, August 1940), 15. Box 15, GDC.
[143] W.E. Code, “Use of Groundwater for Irrigation,” *Western Farm Life*, 15 January 1948.
[144] Thomas B. McKee et al., *A History of Drought in Colorado: Lessons Learned and What Lies Ahead* (Fort Collins: Colorado Water Resources Research Institute, 2000), 15.

by the decade's end, with nearly two-thirds located in the South Platte valley. The increase was no accident. Even before the drought, advisors at a northern Colorado economic conference recommended "that pumping from wells be encouraged as a supplemental water supply."[145] As the drought intensified, the South Platte's flows dwindled alarmingly, and farmers looked to save their crops.[146] Wells offered abundant water in a time of short supply.

But pump irrigation did not come without problems. In addition to depleting groundwater supplies, wells captured seepage water that was moving toward irrigation canals and the South Platte. Some farmers objected that their surface-water rights were being interfered with. Code concluded that because groundwater moved so slowly (perhaps three miles a year, he calculated, depending on local conditions), pumping had not greatly impacted surface flows.[147] Nevertheless, J.M. Dille of the Northern Colorado Water Conservancy District noted in 1942 that "complaints have been loud" among surface-water irrigators. Strangely, however, no litigation had materialized. "Many irrigation men are on both horns of the dilemma," he explained to a Denver audience. In other words, many surface-water irrigators in the valley had wells of their own.[148] In fact, Code calculated in 1943 that fully 82 percent of existing wells were operated in conjunction with surface rights. Despite an acknowledged correlation between the South Platte and its underground water, the overlapping use of these two sources dampened litigation among farmers.

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[145] "An Agricultural Program for the Irrigated Region of Northern Colorado," 1930. Box 73, Colorado State University Extension Collection (hereafter EXT).
[146] White and Theis, 5. Box 15, GDC.
[147] W.E. Code, "Does Irrigation Pumping Affect Stream Flow?" *Western Farm Life*, 1 June 1938.
[148] J.M. Dille, "Irrigation Problems in Northern Colorado," October 1942. Box 27, DEC.

As the drought subsided by the 1940s, several human developments sustained and even increased groundwater use. With the onset of World War II, farmers ramped up crop production to supply the American war effort. Along the South Platte, an agricultural planning committee in 1944 emphasized the necessity of high crop yields, recommending that irrigation pumps be run on a 24-hour basis "for economical use of water."[149] After the war, well-drilling continued as a form of drought insurance – if the rains again vanished, farmers wanted to be prepared.[150] Additionally, groundwater irrigation offered at least two distinct advantages over surface supplies. First, its availability was not immediately affected by a sudden dry spell, and second, it was available precisely when and where a farmer needed it. This second advantage was especially important in places where surface irrigation was inefficient, such as Prospect Valley, which was situated along a tributary of the South Platte. In this locale, ditch water was unreliable and was allotted on a rotational basis. A farmer might not need water when his turn came to use it; other times, it might be unavailable when his crops needed it most. Groundwater irrigation solved this problem by providing water on demand, and Prospect Valley farmers embraced the technique fully. Some even sold surface rights to finance down-payments on wells.[151] Use of underground water both provided protection against drought and offered farmers greater control over the timing and application of irrigation water, increasing its popularity among South Platte farmers.

But these characteristics alone were insufficient to fuel the boom: technology also played an important role. Centrifugal pumps, built in England as early as 1754, underwent a series of revisions in the early 1900s to increase their efficiency. Improved

[149] "Good Farming Practices in Morgan County," 1944. Box 73, EXT.
[150] W.E. Code "Pumping for Irrigation," *The Western Farm Life* 49, no. 2 (1947).
[151] W.E. Code, "Pumping in Prospect Valley," *Western Farm Life*, 1 May 1938.

rotary drills soon followed, allowing the wider bore necessary to install improved pumps.[152] Oil and gasoline gradually replaced steam power, and by the 1930s, rebuilt automobile engines were driving high-speed pumping equipment.[153] But there were cheaper alternatives. High-speed diesel engines were introduced in the late 1930s, providing efficiency at about a quarter the fuel consumption of gasoline. Still, the initial cost of drilling wells and installing pumps was formidable.[154] But power costs soon dropped throughout the West, pushing the number of wells even higher.

Electrification was part of a national vision. Since World War I, scientists and government officials had seen in electricity the potential for revolutionary social changes: an end to congested urban slums and coal-fired factories, replaced by a revitalized countryside where clean hydroelectric power could energize decentralized industries with the flip of a switch.[155] In 1935, the federal government created the Rural Electrification Administration to finance loans for local cooperatives, which would then provide electricity to remote areas.[156] When Morgan County Rural Electric arrived in the South Platte valley in 1938, pump irrigators were targeted to help finance the endeavor, thereby increasing the region's reliance on groundwater. Code saw the connection between pumps and electrification almost immediately. In 1936 local petitioners near the Wyoming border hired him to investigate pumping possibilities in their own area. "Should pumping for irrigation be found feasible," Code reported, "the load on the lines

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[152] For a thorough description of centrifugal pump and rotary drill technology, see Green, *Land of the Underground Rain*, 38-61.
[153] Green, 126-127.
[154] Code estimated in 1937 that pumping equipment alone would cost an irrigator between $4,000 and $5,000. W.E. Code, "Pumping Moves Eastward," *Western Farm Life*, 1 June 1937.
[155] Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970* (New York: Viking, 1989), 298-309; Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: The Johns Hopkins University Press, 1983).
[156] Harry Slattery, *Rural America Lights Up: The Story of Rural Electrification* (Washington: National Home Library Foundation, 1940).

would be greatly increased and would favor the building of lines which otherwise would not be economically possible."[157] Pump irrigation, powered by electricity, could make rural electrification in northern Colorado a reality.

In the South Platte valley, this pairing of pumps and electric power was extremely successful. By 1943, sixty percent of pumps in the region ran on electric power.[158] "Colorado's power distribution companies agree that the state's pump-irrigation farmers are pretty good customers," proclaimed *Colorado Rural Electric News*, citing that pumps used enough kilowatt hours in one year to supply a city of 30,000 people for twenty-one months.[159] Rural electric companies fostered groundwater use by reducing rates and encouraging farmers: groundwater irrigation, declared the *Rural Electric News* in 1955, "should become a habit, not just something to be resorted to only when crops are threatened by dry spells."[160] By 1959, most irrigation pumps in the valley had converted to electricity.[161]

Other technological elements melded with natural drought in surprising ways to further encourage groundwater use. The Colorado-Big Thompson project, among the largest federal reclamation projects in the West, was launched in 1938 to protect existing irrigators from drought in the South Platte basin. Using a network of reservoirs and tunnels, the project took water from the Colorado River, west of the continental divide,

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[157] W.E. Code to L.V. Toyne, "Confidential report on reconnaissance survey of rural electrification in an area in Weld County in which the towns of Hereford and Grover are located," 1936. Box 14, GDC.
[158] W.E. Code, *Use of Ground Water for Irrigation in the South Platte Valley of Colorado*, Colorado Agricultural Experiment Station, Bulletin 483 (Fort Collins: Colorado State College, September 1943), 5.
[159] *Colorado Rural Electric News*, July 1963.
[160] *Colorado Rural Electric News*, May 1955.
[161] Edward J. Farmer, "A Study of the Effect of Ground Water Law on Pumping in the Bijou Bain," (M.A. thesis, Colorado State University, 1960), 10. Farmer estimated that 5200 total wells were operating in the valley by 1959. The same year, Paul A. Schneider, Jr. of the District Engineer's Office calculated a total of 5185 wells in the valley running on electricity. Schneider to Morton Bittinger, "Recharge Evaluations of the South Platte." Box 12, GDC.

and transferred it through tunnels under the Rocky Mountains, spreading it onto the irrigated plains of eastern Colorado. Originally conceived as a supplemental water-supply plan, defense promoters advocated its use as a provider of hydroelectric power.[162] Ultimately, the project's generating capacity furnished electricity to rural cooperatives in the South Platte valley, which in turn sold it to pump irrigators.[163] This new power source coincided with the arrival of center-pivot irrigation, patented in 1952 by Coloradoan Frank Zybach. His system consisted of elevated pipes and nozzles, attached to wheeled towers, which rotated around pivots like the hands of a clock. The invention allowed for irrigation on hilly and uneven land, which could not be reached by ditches without costly leveling.[164] This system, enlivened by electricity, was combined with pump irrigation to bring more than 30,000 acres of new land into production by 1960.[165] At the same time, water from the Colorado-Big Thompson project masked the effect of wells on the flowing river, offsetting the expected reductions in seepage water caused by pumping.[166] In essence, the addition of this trans-mountain water stabilized surface flows while it encouraged groundwater use by supplying cheap electricity. These oppositional yet complimentary influences preserved a tentative accommodation between water use and availability, even as groundwater use and irrigated acreage expanded. Simultaneously,

[162] Daniel Tyler, *The Last Water Hole in the West: The Colorado-Big Thompson Project and the Northern Colorado Water Conservancy District*. Niwot, Colo.: University Press of Colorado, 1992.
[163] *Colorado Rural Electric News*, "Electricity Sold from Colorado-Big Thompson Project Boosts Economy," August 1963. Also see J.M. Dille, *Irrigation in Morgan County* (Fort Morgan: Farmers State Bank, 1960), 50.
[164] *Colorado Rural Electric News*, August 1963. Also Thomas Cech and Andy Jones, *Colorado Water Law for Non-Lawyers* (unpublished manuscript in possession of the author), 27.
[165] J.M. Dille, *Irrigation in Morgan County* (Fort Morgan: Farmers State Bank, 1960), 51-52. However, irrigated acreage was already expanding in the valley before electrification arrived. See White and Theis, 9. Box 15, GDC.
[166] For more on the "masking" effect of water from the Colorado-Big Thompson project, see Lawrence J. MacDonnell, "Colorado's Law of Underground Water: A Look at the South Platte Basin and Beyond." *University of Colorado Law Review* 59, no. 3 (Summer 1988): 579-625.

however, the balance was being disrupted by declining water tables in groundwater-reliant areas.

Among the areas most threatened by depletion in the South Platte valley was the Bijou Basin, located along one of the river's typically dry southern tributaries. Farmers in this region were almost entirely dependent on groundwater for irrigation. Located several miles south of the flowing river, the underlying gravels recharged slowly. By 1956, water tables had fallen by as much as 30 feet, reducing the capacity of most wells and causing some to go dry altogether.[167] The basin was a prime example of the depletion that alarmed Code. He predicted farmers in such a region would agree that "control in some form is needed among users from a limited source."[168] But while scientists and engineers regarded groundwater primarily as an issue of resource management, farmers had a much different perspective. They conceived of the water beneath them in terms of economic survival and prosperity. Furthermore, they were attuned to the land's broad diversity of physical conditions, making them wary of any standardized regulations from outside.[169] Private investments collided with resource preservation, together contributing to the progression of groundwater's use in the basin.

Resistance among some farmers to scientific valuations was not new. As early as 1942, groundwater studies were proposed for the area. However, as one expert observed, "many local men are opposed to that. They say it would be just college theories."[170] Despite this resistance, researchers from Colorado State University (formerly the State

[167] Farmer, 13-14, 78-88.
[168] W.E. Code, "Colorado Needs Ground-Water Legislation," c1954. Box 16, GDC.
[169] James C. Scott addresses the pitfalls of applying scientific and legal abstractions to complex systems in *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998). Scott points out that standardization, by focusing only on certain criteria within a landscape, can externalize and overlook elements most critical to the people who live there.
[170] J.M. Dille, "Irrigation Problems in Northern Colorado," October 1942. Box 27, DEC.

Agricultural College) conducted extensive economic and engineering surveys in 1956. At times, they encountered suspicion among farmers, noting that "many were cautious, and reluctant to provide the information sought."[171] But the researchers were determined to gauge farmers' opinions about various types of proposed regulation for their area. Confidential interviews and surveys recorded the attitudes and opinions of the people most intimately knowledgeable about the daily experience of groundwater irrigation. Their lack of solidarity on many issues pointed to the individualistic character of groundwater use at the time. While surface-water users had been associated with cooperative endeavors since practically the beginning of irrigation – ditch companies, irrigation districts, reclamation projects – groundwater users had no such ties, needing only to drill a hole in their own land and install a pump. This individualism reflected the cacophony of opinions captured by researchers' interviews.

Despite disagreement among farmers on many points, certain refrains rang clear. While researchers focused mainly on resource depletion, most farmers saw underground water as part of an economic investment. "The land is worthless without the water," one said. "We have paid so much for what's on top," echoed another, "we need what's underneath to make a decent living." Similar language recurred throughout the interviews: "I bought the land because the water was there, and I gave the price for not one, but both." In all, 70 percent said landowners should control the water underneath their soil.[172] This attitude was not simply a manifestation of ignorance or insatiable greed. Groundwater irrigation was a costly enterprise that often required substantial credit to initiate. For many farmers, loss of groundwater would mean insurmountable debt and

[171] Farmer, 74-75.
[172] Farmer, 101-105.

financial ruin. Loss of control over their wells would amount to losing a job and a home all at once, while being saddled with mountainous debt to boot. In contrast to scientists who advocated collective management to prevent resource depletion, farmers more often conceptualized the control of groundwater as the lynchpin to their investments and livelihoods.

Groundwater users in the Bijou Basin also emphasized a broad diversity of local conditions, not easily reduced to uniform rules or regulations. Intimately familiar with the land on which they farmed and lived, irrigators pointed out incongruities not accounted for by standardized legal propositions. They especially emphasized differences in crops and soils: "The sandhill farmer does not farm his land by choice, but by necessity," one commented. "He should not be penalized or otherwise discriminated against merely because he is on marginal land."[173] Similar objections were cited against proposed rules for well-spacing: "Topography limits well locations," another said, "…a fair distance in one place would be unfair in another."[174] If regulations were inevitable, most farmers favored at least some degree of local control "to take account of dissimilarities."[175] In all, nearly 80 percent of respondents advocated purely local administration of groundwater resources, and 94 percent wanted at least some local involvement.[176] If regulation was necessary, farmers sought a flexible system that would account for this diversity of natural conditions.

But these attitudes did nothing to reverse groundwater depletions. By conceptualizing the aquifer beneath them as a chain of individual investments, no matter

[173] Farmer, 96.
[174] Farmer, 91.
[175] Farmer, 98.
[176] Farmer, 105.

how critical to their economic survival, most farmers failed to account for its connections to a larger hydrological system. Moreover, disparities in local conditions complicated any search for equitable management. By encouraging pumping to continue in spite of depletion, these attitudes threatened to upset the tentative balance between water use and supply. Code predicted a "dark and discouraging" future for regions where groundwater depletion was not regulated.[177] In an attempt to reverse this trend, state lawmakers passed a new law.

Colorado was one of the last western states to pass groundwater legislation. Former State Engineer M.C. Hinderlider suggested the state's legislative tardiness involved overlapping use of groundwater and surface water: "Well owners in various sections of the State are also owners of surface rights," he commented, "and have interests on both sides of the question."[178] The delay was perhaps also a consequence of the state's own success in developing its surface supplies so thoroughly, and providing trans-mountain water to supplement them. In developing statutory groundwater laws, New Mexico led the way in 1931, with most other states following suit in the 1940s and 50s. California struck its own path, cobbling together a system from judicial decisions dating back to the early 1900s.[179] Colorado's legal community sought to avoid this route, favoring "water administration by law, and not law by administration," as one attorney commented.[180] In fact, the Colorado Bar Association had attempted a comprehensive bill by 1946, but it was scuttled amid disagreements within the drafting committee. In 1952, a

[177] W.E. Code, "Time to Build Legal Skeleton," *Denver Post*, 27 February 1957.
[178] M.C. Hinderlider, "Groundwater Problems of My State," undated. MSS 312, Box 8, Stephen H. Hart Library, Colorado State Historical Society.
[179] Robert G. Dunbar, "The Adaptation of Groundwater Control Institutions to the Arid West," *Agricultural History* 51 (1977): 662-680.
[180] "Water Battle Launched," *Rocky Mountain News*, 3 February 1963.

bill regulating well drilling was defeated by the legislature but returned in amended form the following year. In 1953, a small-scale act was passed with practically no debate, but it required little more than the licensing of well-drillers.[181] Two years later, a Senate groundwater bill fell short by two votes, leaving a pervasive feeling that Colorado's legal code was falling desperately behind.[182]

By this time, more than five thousand wells – nobody was sure exactly how many – operated throughout Colorado, with virtually no oversight. By the 1950s, however, calls for legislative action grew louder. Engineers such as Code rallied support: "To delay would only cause a bad situation to grow worse," he wrote in 1957 in the *Denver Post*. Meanwhile, new droughts strained the unclear relationship between surface-water rights and underground water. Ditch irrigators, Code wrote, were "extremely unhappy" to see their flows dwindle away while irrigation wells, governed by no statute, continued to pump freely. Lack of legislation, he argued, jeopardized everyone's rights.[183] Other experts concurred – State Engineer J.E. Whitten remarked, "the longer we delay, the further afield we are going in this connection."[184] But among lawmakers, there was little consensus on how to proceed: "Party lines are out the window on underground water," wrote one reporter. "So are the usual sectional alliances." Although most legislators agreed on the need for groundwater regulation, they disagreed on what shape it should take.[185]

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[181] W.E. Code, "Underground Water," *Rancher & Farmer*, 22 January 1955. See also John H. Cuykendall, "Administration of Colorado Groundwater Law," c1960. Box 16, GDC.
[182] Dunbar, *Forging New Rights in Western Waters*, 181-2.
[183] Code, "Time to Build Legal Skeleton," *Denver Post*, 27 February 1957.
[184] Legislative Council Subcommittee on Water Problems, "Report to General Assembly," February 1955. Box 16, GDC.
[185] "Tax Speedup Bill Passed by Senate" *Fort Collins Coloradoan*, 12 May 1957.

In the United States, four basic legal frameworks existed for governing groundwater use. The oldest, called the English Rule, recognized absolute ownership of land and everything below it. A modified version called the American Rule was adopted in some eastern states: water was still the property of overlying landowners, but wasteful use causing injury to other users was forbidden. A third format, the California Doctrine, recognized groundwater rights as mutually correlated – each landowner was entitled to use a fair portion of the entire source, determined by the courts, and would have to share depletions proportionally. Finally, the Doctrine of Prior Appropriation severed groundwater from landownership altogether, allotting it on a first-come, first-served basis in any amount that could be extracted and put to use.[186] Colorado courts had several times ruled groundwater "tributary" to flowing streams, which seemed to indicate a leaning toward prior appropriation, which already governed surface rights.[187] But the picture was clouded by a district court in the San Luis Valley of southern Colorado, which ruled in 1953 that some groundwater use could be based on landownership.[188] Amid confusion and dissension, lawmakers made a disjointed effort to forge a workable groundwater law.

The 1957 Ground Water Act was a legislative Frankenstein. One commentator feared more than two dozen revisions would "amend it to death" before it was ever passed.[189] At issue was a basic question of ownership: "Is underground water the property of the people of Colorado or does the groundwater under your farm belong

[186] Edward J. Farmer, *Colorado's Ground Water Problems: Water and the Law*, Colorado State University Experiment Station, Bulletin 505-S (Fort Collins: Colorado State University, January 1960).
[187] *McClellan v. Hurdle*; *Safranek v. Town of Limon*, 123 Colo. 330 (1951).
[188] "Groundwater Use by Landowner OK," *Fort Collins Coloradoan*, 19 June 1953.
[189] "Plea of Ignorance on Water is No Alibi," *Denver Post*, 14 March 1957.

strictly to you?" asked the writers of Colorado's *Rancher & Farmer*.[190] The question was more than academic. By 1956, pumps irrigated more than a million acres of farmland. In addition, groundwater supplied residents of more than a hundred towns east of the Rocky Mountains.[191] Opponents of public ownership warned that neighboring states could enjoin Colorado's wells. "If we tie all of our well water to live streams," Gov. Ed Johnson warned, "the citizens of the lower states will have every right to demand that the operation of our wells cease."[192] Advocates countered that public ownership was necessary to integrate groundwater use into existing water law: "Don't be misled that the appropriation principle will take something away from you," urged Sen. Ranger Rogers.[193] But if older surface-water rights could shut down wells in times of shortage, argued Sen. Ted Gill, prior appropriation would be "a one way ticket back to thirty years ago, and no possible way to make reasonable use of this mammoth underground reservoir."[194] Other opponents pointed out that since many wells were drilled on loans, any policy disrupting them could "destroy the agricultural economy of the state."[195] In this contentious atmosphere, lawmakers settled on a pale compromise.

The only meaningful effect of the 1957 Act was to catalogue most of the state's wells by requiring permits. In this way, state administrators could at least account for groundwater use, even if fundamental questions remained unanswered. The act also created an eight-member Ground Water Commission, which could restrict groundwater use in any area it designated as critical. But the provision contained a loophole allowing

[190] "Who Owns Groundwater," *Colorado Rancher & Farmer*, December 1955.
[191] "Colorado's Next Water War," *Denver Post*, 18 November 1956.
[192] "Johnson Backs Gill Plan for Underground Water," *Fort Collins Coloradoan*, 13 December 1956.
[193] "Who Owns Groundwater," *Rancher & Farmer*, December 1955.
[194] "Opposition to Underground Water Measure," *Fort Morgan Times*, 16 March 1955.
[195] "Kelly Speaks Against Well Control Scheme," *Greeley Tribune*, 24 February 1955.

residents of "critical" areas to overturn the designation through an elected board. The new law was first tested in the Bijou Basin, which was designated as a Tentatively Critical Groundwater District in 1958. Residents faced a choice between local candidates: those who opposed any restrictions, and those who advocated further study. Tensions heightened as voting day approached. State Ground Water Commission secretary George Colburn requested police presence from the governor, citing "direct and implied threats that the election would be interfered with."[196] But on March 10, 1958, no violence was reported, and the election turned into a landslide against the designation. "The overwhelming majority of legal voters in electing this board expressed their wishes at the polls," the *Fort Morgan Times* reported. "Land owners treasure their independence."[197] The 1957 Act had not survived its first test.

Dissatisfaction with the new law was widespread. The *Denver Post* branded the act "an admitted failure," and the chairman of the Colorado Ground Water Commission conceded it had "not been a very successful experience."[198] Other commentators were less reserved, claiming that the law was "futile and meaningless and shouldn't even have been approved."[199] Maurice Rosener, chairman of the Bijou Basin's locally elected board, pointed to "mistakes" by state administrators: "The people of the Bijou Creek area had the idea that the critical designation was being forced on them – that they had no voice in the designation," he said. In fact, the law's attempts to limit pumping actually produced the opposite effect, causing a flurry of well-drilling by farmers trying to beat

[196] "Controversy Looms Over Water Election," *Fort Morgan Times*, 6 March 1958.
[197] "Well Restrictions are Defeated," *Fort Morgan Times*, 11 March 1958.
[198] "State Admits Failure of Water Well Curbs," *Denver Post*, March 15, 1958; Cuykendall "Administration of Colorado Groundwater Law," undated, c1960.
[199] "Underground Water a Problem for State Control," *Denver Post*, December 20, 1964.

the designation deadline.[200] By any measure, the 1957 Act proved ineffective as a tool for resource preservation.

But a subtle shift occurred amid the jockeying, bravado, and threats preceding the act's passage. Beforehand, groundwater in the South Platte valley had been seen as a tragic commons, a preemptive example of author Garrett Hardin's forebodings a decade later.[201] But the political debate surrounding its regulation altered the prevailing terms of the discussion. Groundwater had become "much more than a conservation issue," a newspaper editorial correctly claimed.[202] Beforehand, discussions were framed primarily in the language of resource depletion, a focus inherent in the 1957 Act itself, summed up by a Bureau of Reclamation report as a "means of curtailing the overdevelopment of groundwater use."[203] But as arguments about the proposed legislation heated up, a new focus emerged: property rights. This issue had long been recognized by Code and others, but its importance had taken a back seat to overriding concerns about conservation. Now, the political debate was being reshaped.

As early as 1954, Sen. Ranger Rogers accused well users of "robbing" the South Platte River.[204] Groundwater users fired back with property claims of their own: "Taking cubs away from a wild lioness would be a pleasure compared to trying to take water away from the farmers," boasted one representative.[205] Conceptually, groundwater users and surface rights holders were increasingly being partitioned – by administrators, lawmakers, and the media alike – into two opposing camps, each group presumably

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[200] "State Admits Failure of Water Well Curbs," *Denver Post*, March 15, 1958.
[201] Garrett Hardin, "The Tragedy of the Commons," *Science* 162 (Dec. 1968): 1244.
[202] "Underground Water Law Needed Now!" *Denver Post*, February 11, 1957.
[203] USBR Region 7 988, "South Platte River Basin Report," 1957, WGDC Box 17
[204] "Use of Underground Water Termed Threat to Streams," *Rocky Mountain News*, 17 December 1954.
[205] "Farmers, Ranchers Blast Plans to Regulate Underground Water," *Rocky Mountain News*, 7 February 1957.

separate and clearly defined. Forgotten was the fact that many farmers still alternated between the two sources, or that both supplies constituted a single hydrolological resource. The physical presence of underground water was buried by a layer of abstraction, transforming a debate formerly about conservation into an argument preoccupied with liquid property. The discussion concerning resource management was being reframed as a water war.

Between superheated property-rights arguments, lawmakers struggled to address problems unresolved in 1957. "What we've certainly got to do is to decide once and for all who owns this ground water," said Felix Sparks, director of the Colorado Water Conservation Board. "Unless this is determined, we'll never get anywhere."[206] Most legislators favored some form of prior appropriation. A state advisory committee in 1959 concluded that the system was "too deeply imbedded in our fundamental law and in vested property rights for any sweeping changes to be made."[207] But groundwater strained the principles of this long-established system of allocating surface water.

A distinctive characteristic of prior appropriation is a feature known as the "call." When a call is placed by a water-user to fulfill a senior claim, junior rights upstream are cut off in sequence, beginning with the most recent claim, until the older right is satisfied. But since nearly all wells in the South Platte valley were newer than any reliable surface claim, a call would have theoretically shut them all down instantly under strict prior appropriation. At the same time, because of groundwater's extremely slow movement, cutting off a well would have been unlikely to provide more water to the calling surface-

[206] "Ground Water Law Sought," *Denver Post*, 27 January 1965.
[207] David J. Miller and Samuel Chutkow, *Report on Ground Water Problems and Recommendations for Further Study and Legislative Consideration* (Denver: Department of Natural Resources and Colorado Water Conservation Board, 1960).

right holder until after the need had passed. Engineers such as Code recognized the "absurdities" such a system could cause. But with more than 9,000 irrigation wells statewide by 1960 – approximately 5,200 in the South Platte valley – the need for a workable law remained.[208]

Hydrological considerations found little room in the firestorm debate about property rights. Natural conditions fanned the flames. Regional droughts in 1962 and 1963 provoked accusations of "water-thievery,"[209] while local administrators urged farmers to "avoid panic…particularly the temptation to sink more wells without a prior integrated plan."[210] Meanwhile, more than two dozen ditch companies along the South Platte united to threaten litigation against groundwater users,[211] and the city of Boulder fired its "opening salvo" against well users by promising the same.[212] While the *Denver Post* lambasted groundwater users for their "appalling abuses,"[213] former governor Ed Johnson joined the fray, insisting that "instead of demagoguery about the naughty pumps, we ought to be on our knees thanking Divine Providence for this modern method of river water diversion."[214] One official summed up the situation as "virtual anarchy."[215] Following the rejection and revision of several legislative bills, the chaos finally culminated in the 1965 Ground Water Management Act.

This act settled the question of ownership. Groundwater was deemed public property under prior appropriation principles, but with certain modifications. The law sought to regulate groundwater conjunctively with surface rights, while simultaneously

[208] "Need to Update Laws on Ground, Surface Water," *Business Farmer*, 12 October 1963.
[209] *Denver Post*, 10 August 1963.
[210] "Blair Urges Self-Restraint," *Denver Post*, 9 July 1963.
[211] "Action to Block Irrigation Wells Spreads," *Rocky Mountain News*, 11 December 1964.
[212] *Boulder Camera*, 26 September 1962.
[213] "Underground Water a Problem for State Control," *Denver Post*, 20 December 1964.
[214] "Big Ed Blasts Suggestions on Colorado Ground Water," *Rocky Mountain News*, 13 January 1965.
[215] "Ground Water Laws Sought," *Denver Post*, 27 January 1965.

allowing for its "full economic development."[216] Recognizing that not all basins shared equal characteristics, lawmakers separated underground water into several categories. In relatively self-contained formations, such as the Ogallala beneath the state's eastern High Plains, groundwater was deemed "non-tributary," meaning it had no significant connection to any flowing river. This water was exempted from priority, allocated instead based on landownership. By contrast, alluvial groundwater – such as that of the South Platte valley – was considered "tributary," to be administered in priority by the State Engineer in conjunction with established surface rights. But the act also contained provisions for creating "designated" groundwater basins, separately managed districts with local input within self-contained prior appropriation hierarchies. Lawmakers hoped that, by protecting surface rights and allowing for some economic development, they had at last put the state's groundwater problems to rest.

Opposition to the new measures did not materialize immediately, thanks to wet weather. In 1965, the South Platte River engulfed downtown Denver once again, causing upwards of $500 million in damages, but the heavy rains also doused any conflict over groundwater use.[217] Still, some experts predicted a "traumatic summer" for the new legislation if the weather changed.[218] Quickly, the Bijou Basin became part of the state's first Designated Groundwater Basin, accommodating the region that had wrecked the 1957 Act by authorizing significant local control and insulating the basin from competition with surface rights. But some analysts wondered how the law could be effective. Although the State Engineer was responsible for administering tributary

[216] Ground Water Management Act, 1965 Colo. Sess. Laws, ch. 319.
[217] "In Earth: Liquid Gold," *Denver Post*, 18 July 1966.
[218] Raphael J. Moses and George Vranesh, "Colorado's New Ground Water Laws," *University of Colorado Law Review* 38 (1966): 295-310.

groundwater and surface rights together, the statute offered no guidelines. Also questioned was the act's constitutionality, in terms of depriving landowners of property without due process.[219] Furthermore, silence on the status of existing wells created uncertainty among groundwater users and stifled loans for new equipment.[220] When the summer of 1966 proved to be exceptionally dry, the law was challenged for the first time.

The test came from the Arkansas River, the South Platte's southern sibling. Although groundwater development in the South Platte basin was more extensive than along the Arkansas, both areas shared similar problems. In 1966, owners of senior surface rights placed a call on the Arkansas. Accordingly, the State Engineer's office ordered defendant Roger Fellhauer, whose 1935 well was drilled near the riverbed, to cease pumping. Fellhauer refused, but a district court approved the shutdown along with 38 other wells in the valley. But in 1968, the Colorado Supreme Court overturned the decision, ruling that the division engineer acted "arbitrarily and capriciously" by regulating only a small number of the valley's 1,600 or more irrigation wells without definite criteria. The division engineer protested that shutting down all junior wells would "affect the economy of the valley," adding that "we certainly can't just arbitrarily go in and shut off the water supply to a town." Nevertheless, the court's decision demonstrated difficulties of applying prior appropriation to groundwater. Justice James Groves' majority opinion was even more telling: "As administration of water approaches its second century," he wrote, "the curtain is opening upon the new drama of maximum utilization and how constitutionally that doctrine can be integrated into the law of vested

[219] Moses and Vranesh, 306.
[220] Colorado Legislative Council. *Implementation of 1965 Water Legislation*, Research Publication 114 (Denver: Colorado Legislative Council, 1966), xvi.

rights."[221] In a single sentence, Groves crystallized the problem which would continue to vex Colorado into the next century.

But the drama of maximum utilization was not really new. Code and others had championed the cause when they called for resource management in order to prolong pumping. A new generation of groundwater scientists and engineers carried the banner into the 1960s. While newspapers and legislators traded barbs about property rights, and while farmers used overlapping water sources to sustain their crops, engineers began to envision the South Platte valley aquifer as a form of quasi-bionic technology – a half-natural machine that could be manipulated and regulated for maximum productivity. Already humans had transformed the valley's dry gravels into a productive water-bearing resource; now researchers contemplated how to utilize that supply fully. As legislative revisions brewed in the state capitol, scientific perspectives would again meld and clash with visions of investments and property rights to shape accommodations between people and their environment.

Even before the *Fellhauer* decision, Colorado's general assembly had funded a full scientific study to examine the state's groundwater situation. One of the leading investigators was engineer Morton Bittinger, a professor at Colorado State University who, following Code, was among the state's top groundwater experts. Bittinger had also contributed similar studies before the 1965 Act, but according to one correspondent, these findings were "virtually ignored" by the law's drafting committee.[222] Bittinger's previous statements contained many of the same ideas he offered to the general assembly in 1968. He proposed "conjunctive management" as a way to maximize the valley's water,

[221] *Fellhauer v. People*, 167 Colo. 320 (1968).
[222] "Underground Water a Problem for State Control," *Denver Post*, 20 December 1964.

asserting that this system also provided "the only logical solution" to conflicts between groundwater use and surface-water rights.[223] Because of the intimate relationship between the South Platte River and its underlying aquifer, he advocated their management as a single supply.

Pointing to the aquifer's enormous storage capacity, Bittinger envisioned an underground reservoir that scientists could "manipulate" to achieve its full use. "If only one-fifth of this could be used for planned cyclical storage," he reported, "it would add considerably to a total water plan for the system."[224] To accomplish this goal, the aquifer would be drafted heavily during dry cycles, and then artificially recharged during wet periods by transferring surface supplies underground.[225] He added that because the aquifer would not be constantly full, surface rights would at times need to be served from underground.[226] Bittinger sought to shape nature by using technology, but his vision also represented a much deeper relationship. The river basin had been transformed first through irrigation technology, opening the way to further technological exploitation by drills, pumps, and center-pivot sprinklers. But as water from the river mingled uncontrollably with water from the aquifer, causing property rights to become entangled, a new conception emerged – the aquifer itself as technology. Bristling with pumps, this nature-made reservoir could serve as a device for water management, much in the same manner as a human-built reservoir on the surface. By utilizing the river and its underlying aquifer in this way, Bittinger promoted a technology at once natural and artificial.

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[223] Morton Bittinger, "Colorado Ground Water Quiz," c1960. Box 15, GDC.
[224] Morton Bittinger, "The Role of Ground-Water Reservoir Management in the Comprehensive Development of the Water Resources of the South Platte River Basin," in Miller and Chutkow.
[225] Basic artificial recharge was first employed in the South Platte basin in 1939, when the Henrylyn Irrigation District began intentionally filling a leaky reservoir in order to raise water levels in the Prospect Valley. This type of activity has grown considerably and is now practiced at many sites. See M. M. Skinner, "Water Resource Management in the Prospect Valley Area, Colorado," 1963. Box 13, GDC.
[226] "Problems of Conjunctive Use of Surface Water and Ground Water Supplies," 1963. Box 16, GDC.

He was not alone in this vision. As early as 1952, engineer Royce Tipton had offered a similar plan of "intelligent coordination" to utilize groundwater more fully. As opposed to curtailing pumping to protect vested surface-water rights, Tipton advocated more wells, not fewer. "This is directly opposed to former thinking on the subject," he admitted,[227] explaining that temporarily lowering the water table by pumping was not necessarily negative: "No ground-water reservoir can be developed without mutual interference of wells and in some cases without ultimate interference with the flow of some stream." Like Bittinger, he proposed that surface rights would be satisfied by wells during times of drought, which would ultimately achieve "the best use that could be made of the waters of the South Platte."[228] These ideas were hardly anathema within the scientific community. They were echoed by Robert Glover, whose 1968 *The Pumped Well* would become an accepted reference for determining the impact of groundwater extraction on stream flows. In 1959, he wrote that the "proper relationship" between groundwater and surface irrigation would be achieved by compensating surface rights with groundwater during times of drought. "It would be necessary," he wrote, "to pump the water table down to low levels if the drought were long continued," adding that groundwater and surface water actually complimented each other – surface diversions recharged the aquifer through irrigation seepage, while pumps prevented waterlogging of land, emptying the aquifer sufficiently to allow for floodwater storage.[229] Ultimately,

[227] Royce J. Tipton to Judge Stone, 1952. MSS 312, Box 8, Stephen H. Hart Library, Colorado Historical Society.
[228] Royce J. Tipton, "Technical Considerations in the Preparation of a Ground-Water Law," 1952. MSS 312, Box 8, Stephen H. Hart Library, Colorado Historical Society.
[229] Robert E. Glover to A.R. Chamberlain, 1959. Box 14, Papers of Robert E. Glover, Water Resources Archive, Colorado State University (hereafter REG).

each of these experts advocated more intensive manipulation of the South Platte's alluvial aquifer through increased pumping.

This use of groundwater as an underground reservoir had distinct advantages. Not only was the capacity of the South Platte valley-fill aquifer much greater than the basin's combined surface flows, but its water was also protected from evaporation. And unlike a surface reservoir, it was relatively insulated from erratic snowmelts from year to year. It was free from silting – the buildup of mud and sediment at a reservoir's bottom which gradually reduced storage capacity. Furthermore, construction costs were nonexistent, no inundation of farmland or towns was necessary, and no dams needed to be maintained. On the other hand, measuring the volume of water in an aquifer was more complicated than reading a single gauge height in a surface reservoir, because groundwater levels were not the same in all locations. Also, because outflow occurred at many points instead of a single spillway, regulation would be more difficult. But perhaps the most daunting obstacle to an aquifer's technological regulation existed in human institutions and imaginations. "The biggest problem," Bittinger commented, "seems to be in getting a satisfactory marriage between the physical facts, which cannot be changed, and the existing legal, economic, social, and other institutional situations which resist change."[230] Likewise, Tipton felt compelled to urge legislators to keep their minds open, "without inhibitions due to former intimate and long-time association with the operation of the surface-water code."[231] Glover was equally concerned: "Much of the consideration has been devoted to the legal aspects of the case," he wrote, "with the result that the

[230] Morton Bittinger, "Comments on Papers Presented at the Ground Water Section of the Western Resources Conference," 1960, in Miller and Chutkow.
[231] Tipton to Stone, 1952. MSS 312, Box 8, Stephen H. Hart Library, Colorado Historical Society.

possibilities for constructive action have been ignored or forgotten."[232] The difference was one of perspective. Scientists and engineers tended to envision groundwater as a physical resource, something to be manipulated through technology, even as a technology itself. But to farmers and lawmakers, groundwater more often represented economic investment, or a tangled web of property rights administration and legal precedent. These visions competed to determine a course of action.

Each of these conflicting perspectives found some expression within the 1969 Water Rights Determination and Adjudication Act. The new law required tributary wells to obtain legal priority dates, but it also allowed them to pump out-of-priority under certain conditions. In essence, the 1969 Act attempted to reconcile vested rights with proposition of maximum use. Retaining previously established categories of groundwater, it also introduced "augmentation," a provision allowing tributary wells to offset river depletions by finding replacement surface water to compensate senior rights. It also allowed surface rights to be served from "alternate points of diversion," including wells, if desired.[233] The law was an effort to integrate groundwater fully into the prior appropriation system while allowing enough flexibility for its continued use.

But the 1969 Act revealed the difficulties of reconciling scientific ideas of resource management with legal conceptions of property rights. Although Bittinger's findings were consulted in drafting the new legislation, his recommendations were "largely ignored," one state official commented.[234] Bittinger's report recommended that 10 to 15 percent of the groundwater beneath the South Platte be utilized, which would explicitly involve "a heavier draft upon the groundwater supplies during low runoff

[232] Glover to Chamberlain, 1959. Box 14, REG.
[233] Water Rights Determination and Adjudication Act, 1969 Colo. Sess. Laws ch. 373.
[234] Don Miles, "Status of New Water Legislation," April 1969. Box 14, REG.

years." While the 1969 Act permitted augmentation plans to allow the sustained use of groundwater, such a provision essentially required the river, and hence the aquifer below, to remain full. And while the act allowed surface rights to fulfill their claims using wells, no incentives were offered to ease this transition. "This is legal integration," remarked Don Miles, Chairman of the State Water Liaison Committee, "but in no way does it provide for the physical integration or maximum utilization of our water resources."[235] Bittinger's conception of a technologically correlated whole did not translate into a system of established property rights.

Other rifts between competing perspectives were evident as well. In the Bijou Basin, for example, farmers had injected their values into debates about groundwater, particularly in securing some local management and protection from competing surface-water rights. But other farmers were less fortunate. Glover especially criticized the discrimination between different types of groundwater within the South Platte alluvium. Physically, these distinctions did not exist. Every well, he pointed out, created a "cone of depression" – a circular depletion in the water table which radiated slowly outward, even after pumping stopped. All wells in the alluvium would deplete the river by their full consumption within five years: "If an aquifer…can be split," he argued, "then the well users in the 'immediate' portion would have to carry all of the burden of supplying water for calls from Senior appropriators."[236] Just as Bittinger's vision of the aquifer as a manageable technology did not fit precisely into a legal framework, neither did legal concepts necessarily correspond with hydrological considerations. Glover cautioned that the provisions of the 1969 Act "seem almost wholly concerned with man made laws and

[235] Miles, "Status of New Water Legislation."
[236] Robert E. Glover to Fred E. Anderson, April 1971. Box 14, REG.

enactments. There seems to be little realization that these enactments could come into conflict with overriding natural laws."[237] While differing viewpoints found representation in the 1969 Act, they did not coexist quietly.

The legislation passed in 1969 seemed favored, for a time, by nature itself. More enduring than any other legal solution to Colorado's groundwater problems, it also benefited from the wettest twenty-year span in state history, from roughly 1980 to 2000. The law also worked tolerably well throughout the wet and dry cycles of the 1970s, though not without administrative problems. "One of the biggest headaches of my job had always been getting water down to the senior irrigators along the South Platte," remembered State Engineer C.J. Kuiper. Often, when junior surface-water diversions were curtailed upstream, no water would arrive downstream to satisfy senior calls. "It was like the river had a great big hole in it."[238] The "hole" beneath the South Platte River was made by nature, consisting of thousands of years' worth of loosely composed sands and gravel. Early irrigators unintentionally filled it with water, and by the start of the twentieth century it fed the river's flow, which had grown stronger on top of it. Irrigators claimed these added volumes, expanding the accommodation between water use and availability. When drought unexpectedly disrupted this situation, farmers were inspired to tap the aquifer with new technologies – drills, pumps, new fuels, and electricity. When the drought lifted, groundwater use continued. The amount of irrigated acreage in northeastern Colorado increased, stretching the accommodation even further. When declining water tables threatened to upset this tentative balance, scientists began to see

[237] "Comments by Robert E. Glover on the Tentative proposals for revision of Colorado's Water laws," c1969. Box 14, REG.
[238] Kuiper's quote appears in Marc Riesner's *Cadillac Desert: The American West and its Disappearing Water* (New York: Viking, 1986), 444.

groundwater as a vulnerable resource, requiring preservation and careful management. But to farmers, it was a form of economic investment, and its use continued and even accelerated. This activity threatened property rights built on the river's increased flow, and new droughts inflamed the conflict. Ultimately, groundwater legislation in the 1960s struggled to preserve not a natural state, but rather a half-natural accommodation between water use and availability – a full river and the continuing use of groundwater. When severe drought returned in 2002, however, these twin goals again became difficult to reconcile.

Legal provisions, designed to preserve a particular level of accommodation, became shackles when confronted by nature's unpredictability. Old water doctrines were turned inside-out. Following the drought of 2002, a research team from Colorado State University found that farmers reliant on established surface-water rights abandoned agriculture at a higher rate than groundwater users, whose junior supplies were less immediately vulnerable to reduced rainfall. This situation, noted the researchers, was "exactly counter to the way appropriative water rights are designed to operate in Colorado."[239] Yet when this incongruity was corrected through more rigid administration, the principle of maximum utilization was impeded.[240] Because surface rights were established before groundwater rights, rigid administration threatened to prohibit groundwater use whenever surface flow decreased. In this way, prior appropriation – long an author of economic development in the West – was turned on its head by groundwater, becoming a hindrance to its economical use. The laws of 1965 and

[239] Frasier and Schuck, "Coping with Natural and Institutional Drought."
[240] In 2003, the Colorado Supreme Court upheld a ruling that the State Engineer lacked sufficient authority to approve annual augmentation plans. *Moyer v. Empire Lodge Homeowners Association*, 78 Colo. 313 (2003).

1969 were replete with attempts to "soften" prior appropriation in order to permit groundwater extraction. In addition, prior appropriation was especially likely to interfere with pumping during times of shortage, precisely when a reserve supply of water would be most necessary. This scenario was partially realized in 2006, when some farmers in the valley were forced to watch their crops burn in the sun, even though a vast underground reservoir remained physically available beneath them.[241] These contradictions continue to test the ingenuity and fortitude of scientists, farmers, and lawmakers alike, much as they have for more than half a century.

Additional issues, some of which are rapidly developing, will likely contribute new historical insights over time. For example, the post-1969 legal, scientific, and administrative acrobatics necessary to promote out-of-priority well use and groundwater recharge programs deserve stories of their own. Also, connections between groundwater use and water quality, wildlife, and recreation still need to be more fully explored, as do potential complications caused by interstate river compacts. Perhaps most important, however, is the unfolding issue of urban population growth in the West. As more and more people strain the delicate accommodations between water use and availability – and as water continues to be transferred from agricultural to municipal purposes – it seems unlikely that renewable groundwater will be ignored as a significant source of supply. Perhaps the most significant changes are still to come.

Ultimately, groundwater use in the South Platte valley illustrates not only the conflicting perspectives that shape our interactions with nature, but also the ways in which people and natural forces are interconnected. As cities and farms became

[241] The state-mandated 2006 shutdown of some 440 wells in northeastern Colorado generated ongoing media attention. For an introduction see Will Shoemaker, "Wilting away: Northern Colorado farmers say it's getting harder and harder to farm," *Brighton Standard/Blade*, 8 November 2006.

increasingly dependent on the renewable aquifer beneath the valley floor, natural processes became entangled with human-made systems of law, property, and administration. And as groundwater disputes along the South Platte ultimately became a clash of competing property valuations – not simply a case of individual greed pitted against wise resource conservation – weather and underlying hydrology left imprints of their own on the valley and its people. Inseparable, both human and non-human influences merged to create the region's greater environment. At times, these entwined forces complemented one another to create the appearance of stability between resource use and availability. Yet in actuality, these illusory periods of accommodation indicated a delicate interplay among manifold influences.

As a whole, this story can help explain how transitory arrangements between people and nature can seem stable, at least for a time. In a world made by humans and nature together, tentative balances can be tipped by forces beyond our control, but also tilted by our own actions and perspectives. Collectively, although we cannot predict the future, humans play a role in determining what shape our environments may take. We have choices in deciding which types of accommodation are worth trying to preserve. The environment will respond to our influences no matter what we choose, although not necessarily in ways we expect. This recognition can help ensure that we at least make these decisions consciously. In the meantime, beneath eastern Colorado's sun-scorched flats, water moves underground.

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