The Beginnings and Early History of Albuquerque's Water Supply, 1880-1960

JOHN SHOMAKER

PREPARED FOR
Historic Albuquerque, Inc.

WITH SUPPORT FROM
New Mexico Water Resources Research Institute
Miscellaneous Report No. 35

COVER PHOTO CREDIT

Albuquerque's Pueblo-style city water plant at 218 East Tijeras Avenue, about 1930. Albuquerque Museum, gift of John Airy.

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Introduction

This is an account of the early history of the public water supply in Albuquerque, New Mexico,[1] beginning a little before the arrival of the railroad in 1880 and the establishment of the "new town," and ending at about 1960, not long after several major changes had taken place and the municipal water system had developed into the configuration that continued until the early 2000s. This history was written at the request of Historic Albuquerque, Inc. Diane Schaller, President and a co-founder of the organization, has done much of the research, particularly the exhaustive digging through the newspapers of the time, and both Diane and Richard Ruddy, Historic Albuquerque's Program Chair, have provided valuable guidance. Tom Sims helped with information about the railroad's wells.

I am a geologist specializing in groundwater supply, and my own professional interest in Albuquerque's water began in 1965 when I joined the U.S. Geological Survey Water Resources Division staff in Albuquerque, and has continued during my years as a water-resources consultant, with the City of Albuquerque and later the Albuquerque-Bernalillo County Water Utility Authority as clients for much of the time since 1973.

Brief technical descriptions of the water system, and some of its history, have been published from time to time, beginning with W.T. Lee of the U.S. Geological Survey in 1907. Bjorklund and Maxwell (1961), also of the Geological Survey, described the system in some detail as it stood in 1960, and consulting geologist T.E. Kelly (1982) and UNM geology professor Vincent C. Kelley (1969) each provided good summaries of the beginnings of the system and the geologic setting of the groundwater supply. Erna Fergusson (1922) and Marc Simmons (1982) have given us some entertaining vignettes of the early history, and W.A. Keleher (1983) and G. Emlen Hall (1998) offer a number of engaging stories about the legal aspects of the city's water-supply development.

A great trove of early water-supply information is available in the form of the Sanborn Fire Insurance Maps. The maps are highly detailed surveys of water systems, including the sources of water; the wells; pumps; reservoirs; and distribution facilities, and importantly including the fire hydrants, that are available for Albuquerque beginning in 1891 and continuing with a set of maps every few

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[1] Albuquerque was in the Territory of New Mexico at the time the water system came into being, and until statehood in 1912.

years. The maps also describe the construction materials of buildings in the built-up parts of a city, and that information, along with the water system details, helped fire underwriters to establish insurance premiums. The maps were copyrighted, but the editions through 1957 can now be found online at the Library of Congress website.

Excellent summaries of the City's water-supply situation in 1947 and 1955 were provided in the local business magazine Albuquerque Progress, published by Albuquerque National Bank from 1934 to 1965, and available on the Albuquerque Public Library website. Much other useful information is available in other issues.

I use the term "water supply" rather broadly, to include the surface water distributed through the valley for irrigation, because it provided much of the domestic water before the advent of the municipal system and also, of course, contributes much of the recharge to the aquifer that supplies Albuquerque's wells. Although the emphasis is on the municipal system, I think it is important also to discuss the roles of the irrigation system and the Middle Rio Grande Conservancy District in the development of the valley.

I am assuming that the reader will either be familiar with the street names in Albuquerque or will consult a map; the maps in this report do not show all of the streets discussed in the text. Where the name of a street mentioned in the text has changed over time, I have given both the old name and the current one.

Groundwater exists in, and is pumped from, aquifers, as will be discussed in many places below. An aquifer is a body of permeable and water-saturated rock, or of unconsolidated or partly consolidated valley-fill alluvium—sands, gravels, silts, and clays—as in the case of the aquifer beneath Albuquerque, that will yield a useable amount of water to a well. Albuquerque's aquifer, the great thickness of valley-fill alluvium, is an outstanding example, and it has its own very extensive literature. A good place to start is the New Mexico Bureau of Geology's Decision Maker's Guide to Water, Natural Resources, and the Urban Landscape—the Albuquerque Region (Price et al., 2009).

A Different River, and a New Town

Before about 1880, which marks the beginning of a period of rapid and radical change in the water supply and the landscape itself, much of the middle Rio Grande valley was a broad, grassy floodplain with scattered cottonwoods and small farms. It may have resembled the Kewa (Santo Domingo) Pueblo lands north of Bernalillo that can be seen from Rail Runner train windows today. The village of Albuquerque occupied roughly 60 acres around what is now Old Town Plaza.

Water for domestic use was "self-supplied," in that everyone was responsible for his or her own supply. Presumably the two principal sources were the Rio Grande itself, probably most importantly through the network of acequias that conveyed irrigation water to fields, and the groundwater brought up in buckets from shallow wells. Albuquerque historian and author Erna Fergusson described the river supply this way: "[b]efore 1875…all water used in Albuquerque was hauled in barrels from the river and allowed to settle before use. The mud had a tendency to go to the bottom in time and a more or less clear fluid could be drawn off for use. It sounds rather dirty to the modern notion, but as a matter of fact it was reasonably free from germs (Fergusson, 1922)."

Although Fergusson says that all of the supply came from the river before 1875, it would be reasonable to assume that some came from shallow wells; the water table was very shallow—a well could be dug easily and quickly—and a well close to the house would be a great convenience. The water would be clear, or nearly so, although the taste (and what we think of today as water quality) would in many places have been less satisfactory than that of river water because of the long history of irrigation in the valley. Water applied to the land dissolves some chemical constituents, and the concentrations increase over time as evaporation leaves the chemicals behind in the water that remains in the ground. Besides the salts, there would have been the risk of nitrate contamination and coliform bacteria from animals (and people).

The focus of Fergusson's article was a well and pump installed in 1875 on the Albuquerque Plaza, opposite a store operated by Stover and Crary. In her telling, "[t]he gushing stream of clear cold water which came out of that green iron monstrosity was the wonder of the town. People made long, all-day journeys to see it, coming from as far away as Los Lunas in their buck-boards, buggies, and heavy family carriages," and, "[f]or several years after its installation, the Stover-Crary pump was the only one in town and anyone with a sophisticated taste for clear water was obliged to come there for it." It may be that the unique feature of the Stover-Crary well was its pump, the "green iron monster," not the well itself. The reference to "sophisticated taste" may imply that the Stover-Crary well was deeper than the others in the neighborhood, and produced water that was beyond the water-quality problems associated with irrigation water that infiltrated below the fields. It may have been the first drilled well, as distinguished from the shallow hand-dug wells.

Although the land around it had changed radically by 1891, the description of Old Town itself, which was the Albuquerque of 1879, as shown on the January 1891 Sanborn map (Figure 1) might be a reasonable approximation of the local conditions in and before the late 1870s. The map shows two wells in the vicinity of Old Town; neither is on the Plaza, and the description of the water supply is a terse "not good." The fate of the Stover-Crary well is obscure (by at least early 1882, the store was in "New Albuquerque," not on the plaza). On the 1891 map, a feature labeled "W.T." near the southeast corner of what is now the intersection of Rio Grande Boulevard and Central Avenue, and a "windmill pump" that appears to have been on what now are the grounds of San Felipe School, just north of Central Avenue between San Felipe Street and San Pasquale Avenue (about 515 feet south-southwest of the southeast corner of the plaza) are the only water-supply infrastructure shown. Neither appears to be the "green monster" on the plaza that Erna Fergusson described, and the only description of the water facilities is "not good," in the upper-right corner of the map. Presumably, the water supply was continuing as it had been.

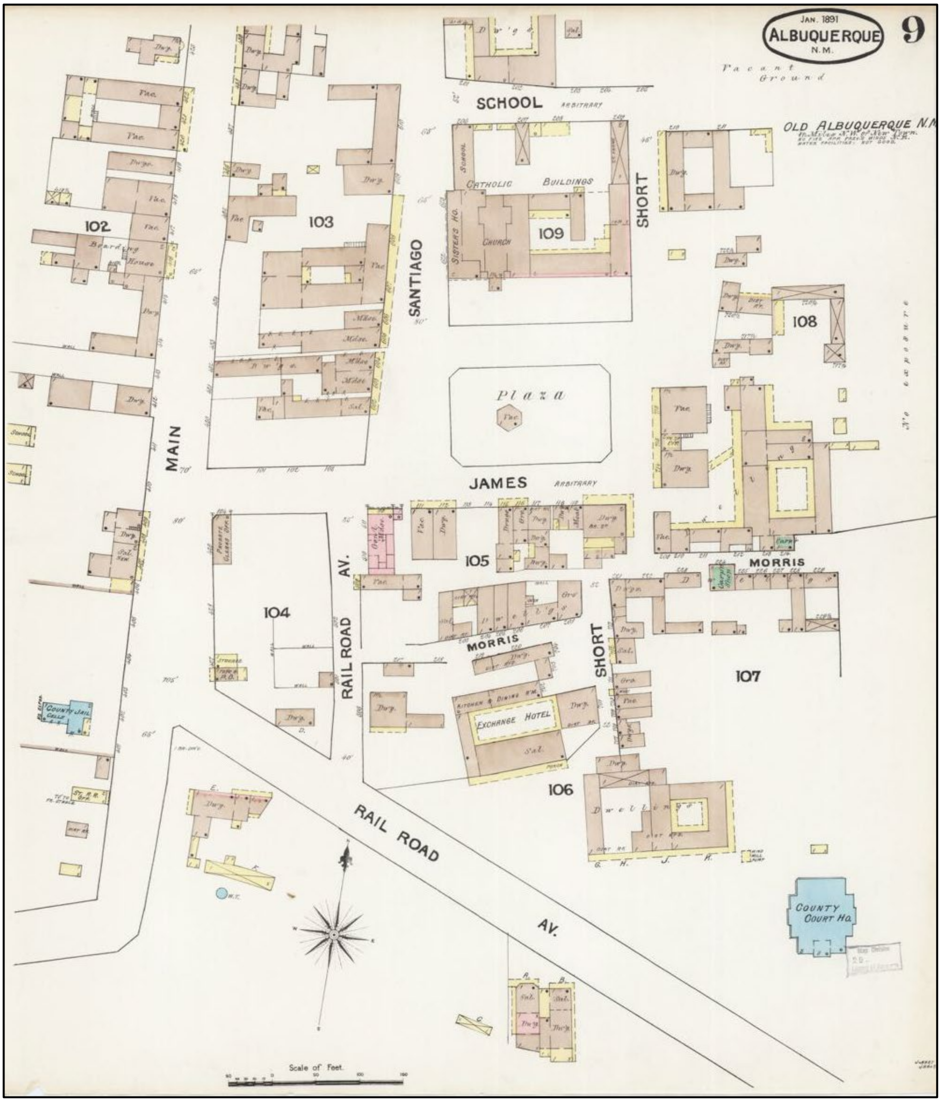

Figure 1. Excerpt from the 1891 Sanborn map showing Old Town, with the two wells described in the text, but no well on the plaza. The Bernalillo County courthouse is the building (color-coded blue to signify stone construction) in the lower-right corner. Rail Road Avenue is today's Central Avenue, Main is Rio Grande Blvd., Santiago is Romero Street, Short is San Filipe Street, and School is today's Church Street. Library of Congress, Geography and Map Division, Sanborn Maps Collection.

There must have been lots of shallow wells. In the early 1880s, the newspapers carried many advertisements for the newly popular windmills, both for sale by merchants—particularly Stover & Crary, E.J. Post & Co., Dunbar & Co., and Dunbar's successor Solon E. Rose & Bro.—and as parts of real-estate listings. Many listings for houses in town included windmills. In March 1886, the U.S. Indian Service advertised for bids for a "windmill of the Eclipse pattern, 3-1/2 horsepower, with a 50-foot tower, a double acting pump, of a 50-gallon capacity per minute, a tank of a capacity of about 4,300 gallons, and for digging a well about 65 feet deep… (Albuquerque Evening Democrat, April 8, 1886)." The windmill was to serve the new Indian School "near Albuquerque." Although E.J. Post advertised Eclipse windmills, Rose published an ad notifying the public that he was the only authorized Eclipse agent; his bid was accepted by the Indian Service. The mostly wooden Eclipse windmill was the industry standard at the time, but the newly designed steel Aermotor windmill was "one of the attractive exhibits at the fair" in October 1889 (Albuquerque Journal, October 6, 1889), and soon overtook the Eclipse. Solon Rose, however, started to advertise the Beloit Steel Windmill in 1891. A.D. Johnson was the Aermotor agent (Albuquerque Citizen, September 14, 1899).

Everything began to change about 1880. Important changes in the river and its regime were largely attributed to dramatically increased water use in southern Colorado. Profound additional changes in life and the economy in the middle valley came about with the arrival of the Atchison, Topeka and Santa Fe Railway.

The Rio Grande Joint Investigation (RGJI, 1938, pp. 303-304) describes the rapid development of irrigation in the San Luis Valley, part of the Rio Grande Basin in southern Colorado, after 1879 when the Denver and Rio Grande Western Railroad reached that valley. Although there is much uncertainty as to the acreage statistics, and there are further complications related to the hydrology of the valley and the role of groundwater from artesian wells (although most of the depletions would ultimately be at the expense of the river), it would appear that in 1870 only some 12,797 acres were in "improved land," not necessarily in irrigation, but by 1880 irrigated acreage may have grown to as much as 131,475 acres, and by 1890 to 147,830 acres. More than 300,000 acres were under irrigation in 1900. In a 1935 paper, Howell (1935, p. 13) asserted that "several hundred thousand acres of land were put under irrigation in a decade and a half by the Travelers Insurance Company and other large outfits," and "the extension of the irrigated area in Colorado with the attendant decrease of irrigation water in New Mexico was continuous until a year or so ago."

In contrast, irrigation in the Middle Rio Grande Valley of New Mexico had reached a peak development of around 125,000 acres by about 1880, and suffered a sharp decline from that year to 1896. By 1889, only 38,850 acres were "under ditch" in Bernalillo and Valencia Counties. A further but more gradual decline continued until about 1925 (Senate, 1890; RGJI, 1938, p. 70). The RGJI (p. 70) goes on to summarize how the change came about, and its other impacts in the middle valley.

> This decline [in irrigation] is attributed to a progressive increase in seeped and waterlogged areas, which at the time of the organization of the Middle Rio Grande Conservancy District in 1925, occupied almost two-thirds of the agricultural area later incorporated in that district. The seeped condition is affirmed to have been the result of decreased flow in Rio Grande which caused deposition of silt and a consequent raising of the river bed and of the contiguous water table. The decrease in river flow is asserted to have been due in part to depletions in San Luis Valley.

The seeming paradox, "the seeped condition is…the result of…decreased flow," is explained by the fact that the lower flows, and presumably larger concentrations of suspended silt attributable to erosion of newly opened agricultural lands in Colorado, led to deposition of more sediment in the river bed and the raising of the river itself, which in turn raised the groundwater levels near the river. Probably the irrigation of much more acreage in the Middle Rio Grande Valley in the mid-19th Century also contributed to the rising groundwater.

Figure 2 shows waterlogged lands near Old Town as they appeared in 1919 or 1920, after many more years under the conditions that began to prevail about 1880.

Figure 2. Waterlogged lands, probably near today's 12th Street and Menaul Blvd., in 1919 or 1920 (from Bloodgood, 1930).

Flooding in the Albuquerque part of the Rio Grande valley became more severe as a result of the rising river bed, although even before the developments in Colorado, the Rio Grande had meandered back and forth across the valley. Howell (1935, p. 15) makes the point that "all of Albuquerque, not on the mesa, is built on the flood water channel of the Rio Grande. The Santa Fe Railroad, yards, and Alvarado Hotel, are built in the unfilled low water channel through which the river flowed prior to 1874. During the flood of that year the river ran some four to six feet deep at what is now the corner of Third and Central Avenue." Howell must have meant only that flood waters came down the railroad corridor, east of old Albuquerque, in and before 1874; the river itself is shown to the west of Albuquerque on much earlier maps.

The railroad reached Albuquerque on April 10, 1880, and the first train came on April 15; of course, the train did not actually arrive in Albuquerque, but at the site of the new railroad station about 1-1/2 miles southeast of town. Very soon, a new town was laid out and lots were sold, the beginnings of what quickly became a new Albuquerque. Old Town continued to exist, of course, although it wasn't actually included within the Albuquerque city limits until 1949. At first, the water supply for the new town would have been much the same as it had been for the old one, but a rapidly developing population and commercial center soon needed a proper water supply and distribution system.

The New Town Gets a Water System

The new town grew rapidly. There was a great clamor for a water system from the beginning, but the clamor was less about the convenience of having running water in homes and businesses than it was about firefighting. Many of the new buildings, particularly the residences, were of wood construction, with stoves for heat and kerosene for lighting, and fires were frequent. An on-site well could provide a few gallons or tens of gallons per minute, and even with a few thousand gallons in storage in a tank on the roof, would have little effect on a spreading fire. A municipal system, on the other hand, could deliver millions of gallons at a rate of hundreds of gallons per minute, and at much higher pressure, to any spot in the system.

Albuquerque was desperate for a reliable water supply, and entrepreneurs were ready to help, or at least to promise to help. In 1881 and 1882, four separate water-utility companies filed for incorporation with the Secretary of the Territory. The Albuquerque Water Supply Company (N.M. Secretary of State records, Business ID No. 729) was incorporated on August 10, 1881, with an authorized stock issue of $200,000; little more is heard of that enterprise. The Albuquerque Water Works Company (Business ID No. 471) filed articles of incorporation on March 4, 1882, with an authorized stock issue of $200,000, but according to an article in the Albuquerque Journal (August 18, 1882), "this is all that was ever done, and the company might as well never have been organized, so far as attaining its object is concerned." The Journal seems to have been very impatient; only a little over four months had passed since the corporate filing.

The Journal article of August 18, 1882, goes on to say, however, that "Wednesday the following named gentlemen organized themselves into the Albuquerque Water Works Company with a capital stock of $500,000: Serapio Romero, Perfecto Armijo, C.C. McComas, Mariano Armijo, W.S. Moore, Jesus Armijo, and William B. Gray, of Albuquerque; Dr. John Synington and H.L. Warren of Santa Fe." This would actually appear to have been the Albuquerque Water Company (Business ID No. 1453), formally incorporated on August 25, 1882. This group proposed to "dam the Rio Grande north of this city and then construct a canal along the mesa which will conduct the water to a large reservoir to be built just east of the city. From this reservoir a system of pipes will be laid throughout the city." Given the frequency and severity of flooding, a dam on the Rio Grande would have been a risky undertaking, although, of course, such a dam was built much later at Angostura by the Middle Rio Grande Conservancy District.

By the next month, however, Angus A. Grant, Mariano Armijo, and others had purchased the Albuquerque Water Company, and on September 18, 1882, the Albuquerque Consolidated Water Works Co. (Business ID No. 1594, the fourth company) was incorporated. Grant seems to have had the controlling interest.

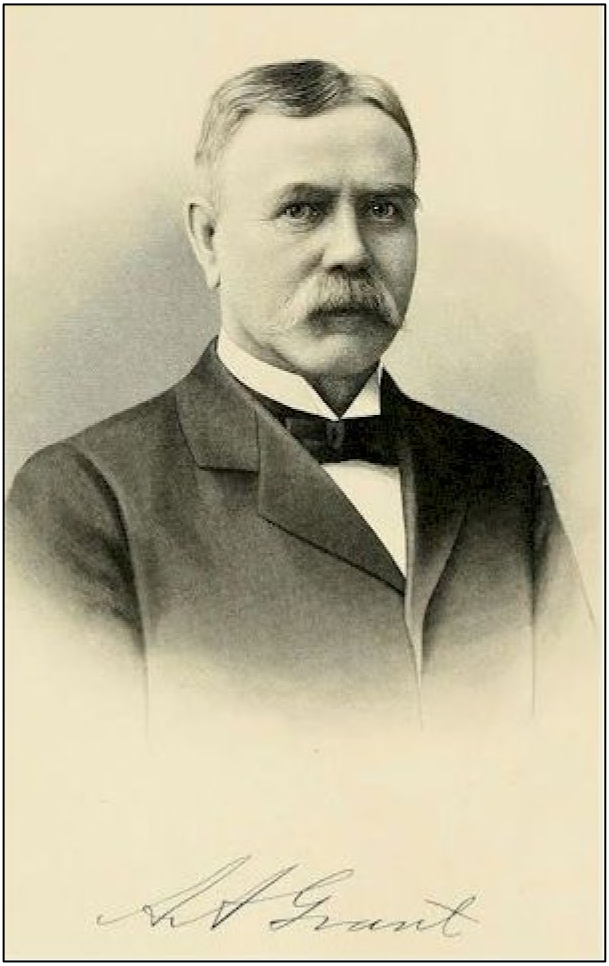

Figure 3. Angus A. Grant. From New Mexico American History and Genealogy Project website; originally from Anderson, 1907.

Angus Grant, a Canadian, came to New Mexico as a bridge contractor for the Atlantic and Pacific Railroad. He invested in basic Albuquerque businesses, and among other interests, was a founder of the Albuquerque Electric Light Company (1881), purchased the assets of the Albuquerque Gas Company, and organized the

Crystal Ice Company (1890). He was a shareholder in the First National Bank, and owned the Albuquerque Democrat (later the Journal[2]) and important real estate, including the Grant Building at Third Street and Railroad (Central) Avenue (see, e.g., Anderson, 1907). Although Grant Brothers Construction was headquartered in Los Angeles, Grant lived in Albuquerque and his grave is in Fairview Memorial Park.

Mariano Armijo built the Armijo House, Albuquerque's first "grand hotel," in the same year (1882) that he and Grant, and others, incorporated the water company. The hotel was on the southwest corner of Third Street and Railroad (Central) Avenue, and was a three-story frame building with a mansard roof in the best 1880s style.[3]

The Albuquerque Journal, and presumably the civic leaders in general, continued to be eager for the water system to be in place. The railroad would have developed a supply to provide locomotive water as soon as, or even before, the tracks reached Albuquerque, and apparently was prepared to expand it to serve the public. The railroad installed a "system of water-works about its premises at Las Vegas," and indicated an intention to establish a fire department there (Albuquerque Journal, March 3, 1883). An article of December 8, 1882, reports that the railroad company was contemplating expansion of its own supply, and would serve the public itself if the "gentlemen of the water works company did not bestir themselves at once."

At the end of 1882, the Albuquerque Water Company officials and Gustave Dye, their engineer, explained the plan as it then stood: it would include a "plunger pumping engine" to be placed near the river, and two nearby reservoirs, in which the water would be successively filtered through "granite stone" and then a finer filter material. Presumably the reservoirs were to be constructed with under-drains, over which the finer filter material, and then the "granite stone," would have been placed, so that water drawn from the reservoir would pass through the filter material on its way into the distribution system. Another reservoir, with a capacity of 500,000 gallons, would be constructed on the mesa and connected with the "engine at the

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[2] The newspaper had been the Golden Gate, the Morning Journal and the Evening Journal, and became the Daily Journal, the Evening Democrat, the Journal-Democrat, and eventually the Albuquerque Journal.

[3] https://www.historicabq.org/1865-70-hotels.html

river by pipes." The reservoir on the mesa would also have a filter bed, and water would be distributed to a system of pipes. The estimated cost of the project was $420,000, and the works would supply water to 25,000 people (Albuquerque Journal, December 10, 1882).

No construction was undertaken, though; the delay seems to have been attributable to difficulties with financing. However, by the beginning of 1884, a little over a year after the plan had been announced, Mr. Dye answered the question "[w]ill you start the work right away," with "[y]es sir, just as fast as we can possibly get at it. We leave for Denver immediately, and shall commence shipping the machinery in a very short time." He described the proposed works as "[p]recisely similar to those at Trinidad. It will be the pumping system, engines at the river, and a large reservoir on the mesa east of the city (Albuquerque Journal, January 8, 1884)." On January 9, 1884, the Albuquerque Journal told its readers that "…the water works company has been re-organized upon a business basis, …has perfected its plans, has made arrangements for securing all necessary funds, and now intends to go to work at once and in earnest." The plan at that time still contemplated pumping water from the river, up to a reservoir on the mesa.

By April, the basics of the plan were described, and included information about the reservoir, water mains, and fire hydrants, but this time the proposed source of water wasn't mentioned (Albuquerque Journal, April 2, 1884). There is a strong hint, however, that something other than direct diversion of river water was being considered: "the water furnished by the company will be the very purest obtainable anywhere and the occasional rains will not have the effect of rendering it impure or so colored as to make its use on the table unpleasant or unhealthy."

Construction of the reservoir on the mesa, by M.J. Mack, was authorized by the water company at the beginning of August 1883, and Mack broke ground on August 2 (Las Vegas Gazette, August 3, 1883). The City had awarded a franchise to the Mack company that required work to begin by that time, although the newspaper reported that the "absence of St. Louis capitalists at the seaside has delayed the enterprise."

It is not clear what happened after that groundbreaking, but it may not have been very much. The Albuquerque Evening Democrat of April 25, 1884, almost a year later, reported that "ground will be broken Monday on the mesa east of the city for the reservoir of the new water works." It was to be 198 feet by 248 feet in area, and 12 feet deep (Albuquerque Journal, April 25, 1884), a volume of about 4.4 million gallons or 13.5 acre-feet. Another estimate gives dimensions of "150 x 250 feet, and 14 feet in depth," holding 3.5 million gallons (Albuquerque Journal, May 11, 1884), although those dimensions would lead to a capacity of 3.9 million gallons.

The location of the water works was settled and the land purchased, "from Messrs. Stover, Huning, and Hazeldine," on April 6, 1884; funds from a recent sale of bonds had been received; and contracts were awarded for the pump and pipe (Albuquerque Journal, April 7 and April 21, 1884). Walter C. Graves,[4] a former U.S. Geological Survey employee, was retained by the Denver Trust Company, the bondholder, to evaluate the proposed system (Albuquerque Journal, April 2, 1884). His connection with geologists may have given him some awareness of the potential for a groundwater supply, although the USGS did not formally consider groundwater studies until 1891 (Follansbee, 1994, p. 51), and the idea to develop a supply from wells rather than a surface-water supply may have come out of his evaluation. It is also true that the railroad had already developed a well or wells close to the water-works site, possibly as early as 1879, and had at least one windmill and a 30,000-gallon storage tank in place by the time the tracks reached Albuquerque (Flint and Flint, 2021, p. 30), which would have provided some information about the potential. The railroad continued to rely on groundwater and had six wells in service by 1888 (Flint and Flint, 2021, p. 30).

The first discussions of groundwater as the source of supply for the public system seem to have been in early 1884. The new well would be a large pit, 20 feet in diameter and 50 feet deep, "deep enough to get all the water the city can by any possibility use, and at the same time shall be rid of any trouble from surface water." The well was to be lined with masonry so that the water could enter it only from the bottom (Albuquerque Journal, Friday, April 15, 1884). The derrick for the excavation was in place, and work was to start the following Monday. The prediction of the new well's capacity proved to be somewhat over-optimistic.

By May 1, 1884, "seven scrapers and two plows are being worked steadily by a force of men on the water works reservoir," and the excavation was expected to be completed by mid-May. A carload of English portland cement, the first lot of pipe, and the pumping engine were expected by the end of May (Albuquerque Evening Democrat, May 1 and May 15, 1884). Conrad Shenfield, with Gray Brothers as sub-

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[4] This may actually have been Walter H. Graves, who accompanied G.K. Gilbert in a survey of the Henry Mountains, Utah, in 1875 and 1876 (*see* Gilbert, G.K., 1877, Report on the geology of the Henry Mountains: U.S. Geological Survey, 160 p.). A Walter Graves was topographic assistant to John Wesley Powell in the second Colorado River expedition, 1871, and seems likely to have been the same person.

contractor, appears to have been the contractor that actually finished it (Albuquerque Journal, June 6 and June 27, 1884). A new plank road was to be constructed from the Santa Fe depot to the reservoir, "making a shorter road than by the Tijeras Cañon road," which was more nearly along the alignment of today's Lomas Blvd.

The reservoir was completed by late August 1884 (Albuquerque Journal, August 14, 1884), at a cost of $110,000 (Simmons, 1982, p. 233). A little over a year later, work on the water mains was progressing well, and the reservoir was "in splendid conditions for the reception of water (Albuquerque Journal, October 15, 1885)."

A notice, probably a paid advertisement, by The Water Works Plumbing Company "with Mr. William Martin, a competent plumber from Chicago," announced that water would be flowing through the mains in three weeks, which would have been early December 1885 (Albuquerque Journal, November 18, 1885). The same notice appeared again two weeks later, on December 2; there may have been a slight delay in finishing the works. The company was "ready to receive orders for gas and steam fitting and plumbing in all its branches." It is not clear whether this company was related to the Albuquerque Water Works Company, or was simply borrowing the name.

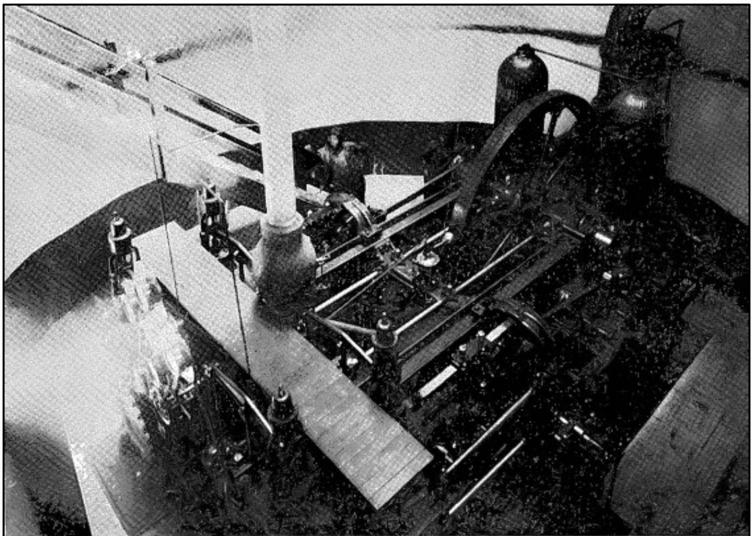
On February 1, 1886, Mr. Woolston, the contractor's manager of the water-works construction, summarized the facts about the water system for the Albuquerque Evening Democrat. There were 5-1/2 miles of distribution piping, 50 double fire hydrants, and 36 driven wells at the pumping station (only 26 were actually in place, according to a February 22 article). The driven wells (as distinguished from the 20-foot diameter excavated well) were 60 feet deep, tapping the "third water," below two "rock" strata. Bedrock would not actually have been found in the well, and the "rock" would presumably have been a bed of sand with some carbonate cementation within the valley-fill sequence. The 20-foot diameter well had seemingly not reached the projected depth of 50 feet as described in the plan of early 1884, or if it had, the flow that could come into it through the bottom was not sufficient to supply the system. Mr. Woolston did point out that the water was clear and soft, and sufficient to provide a half-million gallons per day; the supply was said to be increasing rapidly, perhaps because pumping from the wells had improved their performance, and he expected the supply would be more than doubled in two months.

The summary went on to admit that the reservoir "leaks a little," but would be repaired at once. The Gaskill pump was guaranteed to raise "125,000,000 lbs. of water, one foot high, with 100 lbs. coal." A 3-hour test had been carried out two days earlier at 180 pounds per square inch water pressure, running "eight streams to an elevation of from fifty to seventy-five feet." These streams would have been the flows from fire hydrants. He also reported that "[n]o pipes bursted. Eight or ten sprang leaks at joints, which will be repaired at once."

The "duplex compound pump" had two sets of steam cylinders, each set consisting of a high-pressure cylinder, which then fed its exhaust to another, low-pressure cylinder, and two water cylinders.

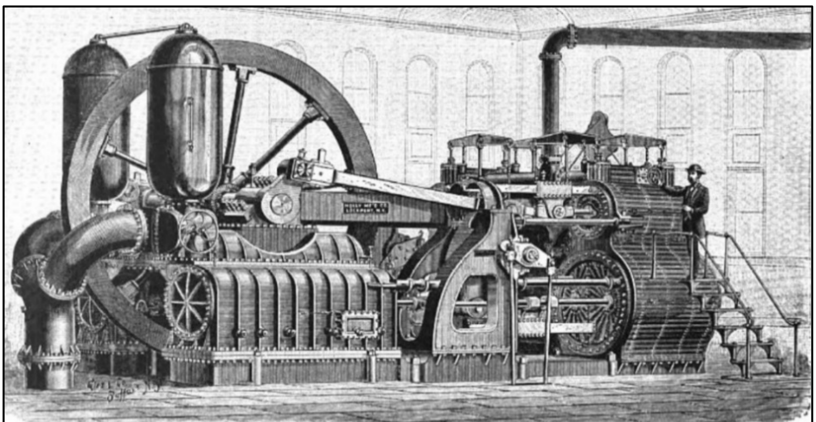
A "scribbler" for the Albuquerque Morning Democrat (January 22, 1886) visited the water works and expressed his awe at the pumps, "for there are two of them …the Gaskell [sic] duplex compound pattern, and they certainly are beauties," and at the "room in which these monster machines are being kept, [which has] stained glass windows, vaulted ceiling elegantly decorated and handsome enough for a lady's boudoir of the middle ages." Were there two Gaskill pumps, or only one? Although the scribbler makes the point that he "understands almost everything else on earth better than machinery," he could surely have counted the monster machines accurately; on the other hand, the earliest Sanborn map, that for 1891, indicates only one pump, as does the 1893 map. The 1898 map describes two pumps, one Gaskill duplex compound and one Laidlaw-Gordon duplex compound. It seems possible that there had been two pumps from the beginning, one in primary service and one to provide redundancy, which the Sanborn surveyors didn't count.

The pump itself was in a pit (Figure 4), to reduce the suction lift required to raise water from the wells; at Albuquerque's elevation, the practical suction lift, accounting for the net positive suction head required at the pump intake, would not be much more than 7 feet. A clearer picture of a similar pump is shown in Figure 5. The pump was probably in the small brick building near the corner of Washington (Tijeras) and Broadway, as shown on the Sanborn map for 1891 (Figure 6). The pump discharged into a 14-in. pipeline beneath Broadway that fed the water mains, and also into a 14-in. line under East Copper Avenue that conveyed water eastward to the reservoir on the mesa. On the UNM campus, the water line to the reservoir was 10-in. pipe, and lay to the north of the Main Building, now Hodgin Hall, approximately along what is now Redondo Drive. An 8-in. main under East Central Avenue came later. The height of the reservoir provided a system pressure of something more than 90 psi (pounds per square inch) in the water mains in town—ample for firefighting.



PUMP PIT ALBUQUERQUE WATER SUPPLY CO.'S PLANT

Figure 4. The Holly System Gaskill pump, in its pit at the Albuquerque Water Works in about 1905 (from Weinzirl, 1905, p. 9). A clearer picture of a similar pump is shown in Figure 5.



THE GASKILL HORIZONTAL COMPOUND PUMPING ENGINE.

Figure 5. An illustration of one model of the Gaskill pump, similar to the Albuquerque Water Works pump (https://alchetron.com/Birdsill-Holly). A man (at the top of the steps) is shown for scale. One set of high-pressure and low-pressure steam cylinders is visible on the right, and the two water cylinders are on the left with the flywheel between them. The pump's suction pipe is rising from the floor at the far left.

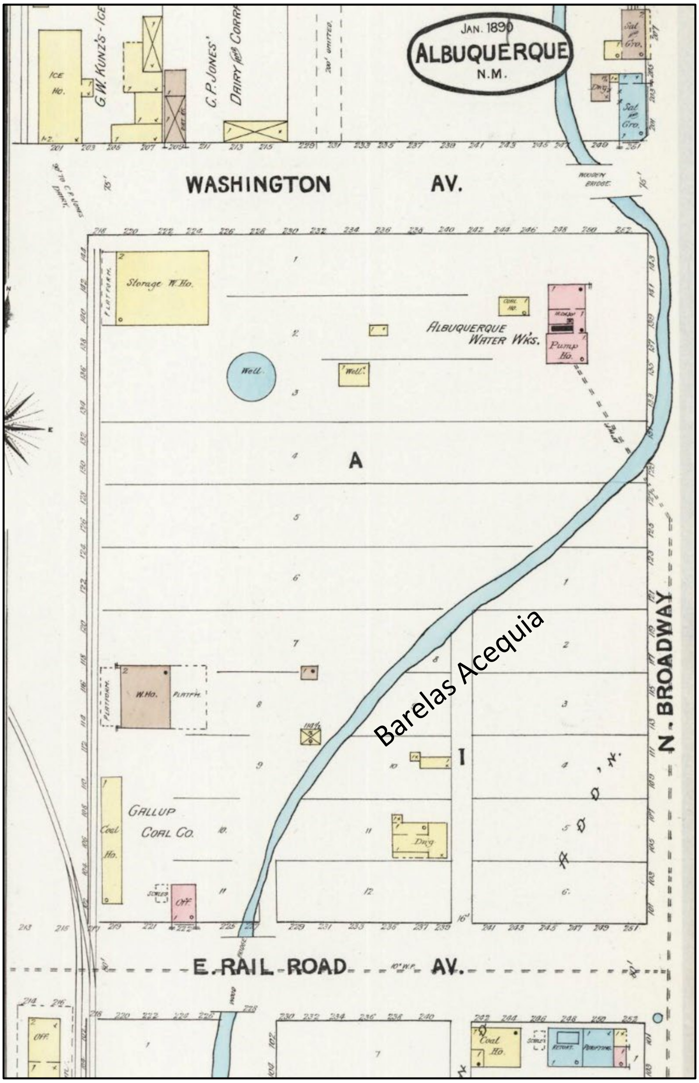


Figure 6. The Albuquerque Water Works in 1891 (excerpt from Sanborn map, January 1891), along Washington Avenue (now Tijeras Avenue) between Broadway on the right and the railroad tracks along the left side of the map. The layout would have been the same as it was at the completion of the system in early 1886. The round, blue feature in the western part of the tract is the well. The pumps were in the small building (color-coded pink to represent brick construction) next to the Barelas Acequia (label added) and North Broadway. Library of Congress, Geography and Map Division, Sanborn Maps Collection.

Everyone was excited about the advent of a public water supply, and the leading newspapers were watching the water works closely. The Albuquerque Journal had published an article on February 28, 1886, accusing the Water Works Company of building the reservoir on "a sand foundation," and improperly using tar in the construction, to which the Evening Democrat replied by way of a strongly worded defense by G.F. Gray (Albuquerque Evening Democrat, March 2, 1886). The Journal article also expanded on problems around the driven wells, alluded to above, quoting an unnamed informant to the effect that some of the "points" did not in reality reach even 40 feet, much less the claimed 60 feet. A test of the pump had shown that, after 36 hours of pumping into the reservoir, water was leaking out as rapidly as it was pumped in. The controversies continued; a few months later, rumors were circulating that the reservoir contained only 10 inches of water—the Albuquerque Morning Democrat of July 20, 1886 said "[p]ersons who have lately visited the reservoir say that there is hardly one foot of the liquid in the big basin"—but investigation by a delegation of leading citizens found about 10 feet (Albuquerque Journal, also July 20, 1886).

Although the reservoir had been completed in August 1884, it had not been in service until the rest of the system could be readied for service, and some repairs appear to have been necessary when that time came. The Albuquerque Evening Democrat of February 28, 1886 announced that the reservoir would be finished within six days, "three weeks at the furtherest, no preventing Providence," and the entire system ready to turn over to the company. Mr. Woolston said he would guarantee that a newspaper laid on the bottom could be read from the surface. On March 9, the reservoir was "being filled with clear crystal water (Albuquerque Evening Democrat, March 9, 1886)." By May 14, the engineer of the water works, J.P Greene, "a thoroughly skilled workman in his business," was releasing water from the reservoir because it had overflowed. The water company had "fixed up the ground surrounding the works [that is, the pumping plant] in nice style, having set out a number of trees and otherwise beautified the place (Albuquerque Journal, May 14, 1886)."

On May 21, 1886, Mr. Woolston formally turned over the completed system to the Albuquerque Water Works Company. The Albuquerque Journal (May 22, 1886) opined that "[n]o town in the west can boast of better water works or better water than they have brought us." F.L. Pearce was appointed manager of the works, in full charge during the absence of A.A. Grant. Pearce would be accepting applications for water service beginning on June 1. W.K.P. Wilson was now President of the company (Albuquerque Journal, May 28, 1886). By June 13, customers were taking so much water that, at a pumping rate of one million gallons per day, the reservoir was filling "but slowly," and the company was thinking about "the propriety of putting in water meters for all large consumers and charging all such by the quantity of water consumed (Albuquerque Journal)." The customers must have been billed at a flat rate.

It was only a few days before some other benefits of the new reservoir were recognized. Although the reservoir had been fenced, the Albuquerque Journal (June 2, 1886) pointed out that "persons who have investigated the matter [say] that tramps and lewd persons are in the habit of bathing in the water works reservoir. Some action should be taken…to prevent the outrage and punish those who perpetrate it."

Albuquerque's growth was rapid, and the economic prospects were very promising. The Albuquerque Journal (June 22, 1886) began to support a proposal by Charles Marriner to construct a new canal and reservoir system to provide irrigation water on the east mesa, expecting that many "small farmers will purchase their supplies of Albuquerque dealers, and our city will thus be rendered prosperous." Nothing seems to have come of the proposal.

In contrast to the optimistic early projections, supply problems continued. By October, the company was expecting that "[u]pon the arrival of Mr. Grant it is contemplated to increase the number of wells at the water works, and it is estimated that the outlay of six or seven hundred dollars…will give a greater capacity than the demand will be for years to come (Albuquerque Journal, October 12, 1886)."

The problem with supply, which continued for many years (there were 39 wells in this same location by 1902), was attributable to the basic design of the system, which in turn was largely governed by the limited technology of the time. The great Gaskill pump could push 2,000 gallons per minute up to the reservoir, almost 200 feet higher, but neither it nor any other pump could lift water by suction more than about 7 feet given Albuquerque's elevation. A pump would have to be down within the well, below the water level and pushing water upward, to deal with this problem, and although such pumps were available, they were expensive and complicated. The system relied upon a plentiful supply with a water level, even during heavy pumping, only a few feet below the level of the pump itself. This meant that the pump would be installed in a pit excavated almost to the water level in the wells, and that the combined inflow to the wells be great enough that the amount of drawdown would not exceed a very few more feet. To achieve this condition, more and more wells, or "points," were added, all making water available to the original 20-foot diameter "well." A further complication, clearly understood from the beginning, was that the quality of the uppermost water was not very good, and even though it would have increased the capacity of the system to allow it to flow into the well, it was excluded from the well by the masonry lining.

Another reason that the wells were all so close together is that any reliable pump, whether at the surface like the Gaskill pump or down-hole, was steam-powered, and therefore had to be near the boiler. Where the depth to water in the well was too great for suction lift and there was thus no choice but to use a down-hole pump, there also had to be a boiler and associated facilities—or a windmill, and the University's first well was pumped with a windmill. This fundamental problem continued until the advent of down-hole turbine pumps, as will be discussed in the following section.

There are hints in the newspapers that the water company was attributing some of the water shortage to waste on the part of customers, but "a well-posted water consumer assures The Journal that the waste of water reported by the water works management is not the fault of consumers, but that the reservoir leaks badly and the water mains in many instances are also leaky (Albuquerque Journal, June 13, 1886)." On the other hand, the company had its fans. The Albuquerque Journal of May 1, same year, included a paid advertisement with the message "Water vs. Dust. The water company is sending out excellent water now with a force of 93 pounds to the square inch and is selling it cheap…," and goes on to say "…while I am putting in hydrants and street washers at the lowest possible figures consistent with good work." The fan was Solon E. Rose, whom we will meet again as a contractor for the water company. The Journal was itself a fan, as would be expected given the newspaper's ownership; about a year later (May 24, 1887), the Journal told its readers that "[w]ater rates of the Albuquerque Water Company are so popular that every business house and residence should be supplied with the company's clear well water."

The reasons for the location for the water works and the first wells have not been discovered, but the site would have offered a highly productive aquifer in the form of the shallow alluvium of the inner-valley floodplain, and a very shallow depth to water. Choosing wells rather than a dam on the Rio Grande would have made economic sense, and wells would have been more likely to survive the fairly large and frequent floods. If the intended source of water had originally been the Barelas Ditch, which reached the town at Tijeras and Broadway, the location of the water works there would have offered the minimum pipeline distance into the town.

The railroad had already drilled or dug wells at the future site of the depot about a quarter-mile to the south—locomotive water would have been needed as soon as trains began to arrive—and thus had explored the possibilities. By January of 1891, the Sanborn map shows a "windmill pump" and a tank on railroad land between First Street and the railroad tracks about 500 feet south of Railroad Avenue, and a well and pump house with a boiler about 90 feet further south. By 1924, the railroad's water system included wells numbered up to Well 9 (Bjorklund and Maxwell, 1961, table 2), and there may have been more.

The natural chemical quality of the water from the original shallow water-works wells would have been acceptable under today's standards, although not as good as water from deeper in the aquifer. The first analysis appears to have been made in about 1895; it indicated a total dissolved solids concentration of 21.23 grains per gallon, equivalent to 363 mg/L (milligrams per liter) as it would be expressed in the units used today (see Weinzirl, 1905, p. 5). The potential for contamination would have been another matter, however; the wells were in the town's industrial corridor along the railroad, and there were nearby residences, all of which presumably had privies that contributed directly to the shallow groundwater. The C.P. Jones dairy and corral were on the north side of Washington Avenue (now Tijeras Avenue), just across the street from the water works in 1891, and by 1898 there was a wool-scouring mill on the northwest corner of the water-works block, only a few tens of feet from the large well. A lot of sodium or potassium hydroxide is likely to have been used in the scouring process, and the wastewater, including the greases removed from the wool, may very well have been disposed of on-site. Fortunately, the wool-scouring mill was gone by the time of the 1908 Sanborn map.

The Barelas Acequia, which provided irrigation water along the eastern side of the inner valley, ran along the west side of Broadway south of Washington (Tijeras), which crossed it on a wooden bridge, then curved to the southwest across the block that included the water works (Figure 6). The acequia would have provided recharge to the shallow groundwater at the water works, and on some occasions when the wells could not meet demand, the company diverted the Barelas Acequia directly into the big well—with unhappy consequences.

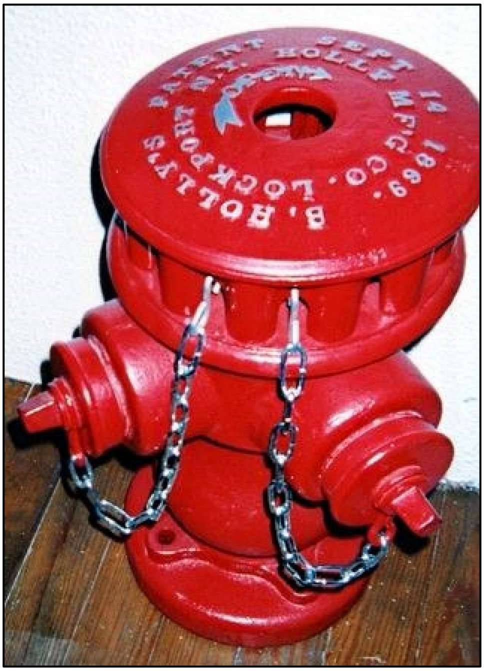


Figure 7. A Holly System fire hydrant (Jon Szpakowski, firehydrant.org, used by permission). There were single and double hydrants.

The Holly Manufacturing Company built machinery and provided pipe and accessories (Figure 7), including fire hydrants, for 117 American cities between 1863 and 1887,[5] and, although Holly apparently did not recognize the Albuquerque water works as one of its systems, the company sold a great deal of equipment to the water company. The Holly system was designed for "direct pressure" operation, in which the pump(s) operated continuously to maintain pressure in the water mains, so that no reservoir at an elevation high enough above the service connections to provide water under adequate pressure, was required. The Albuquerque Water Works, on the other hand, built the large reservoir on the mesa to maintain a supply.

The reservoir, until it was decommissioned a few years ago and replaced by a new Physics, Astronomy and Interdisciplinary Science building on the UNM campus, was at the northeast corner of Yale Boulevard and Redondo Drive, about

[5] http://www.waterworkshistory.us/tech/Holly/HollySystems.htm

350 feet east of the University's own, much smaller, reservoir (Figure 8), and eventually surrounded by University land.

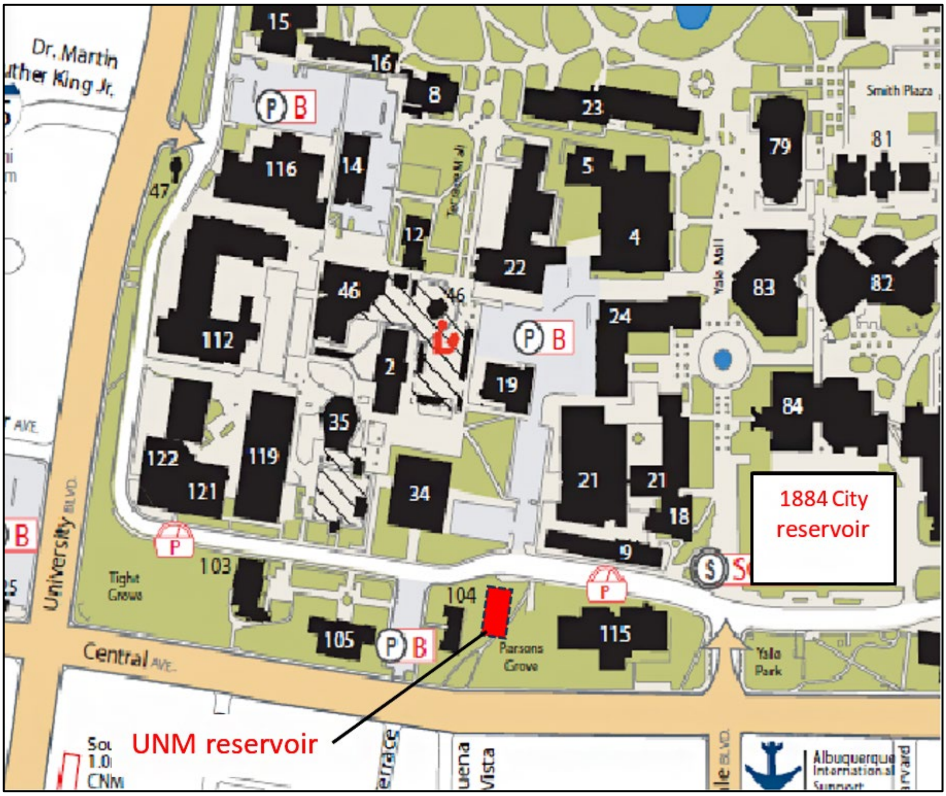


Figure 8. Excerpt from a recent map of the UNM campus showing the 1884 city reservoir and the approximate location of the former UNM reservoir.

The reservoir was regarded as a mixed blessing. It provided reliable pressure for the system and held a large fire-fighting reserve, and made it possible to operate the water-works pump only during the day rather than constantly, as would have been necessary without the large storage, but the water sometimes became undrinkable. Weinzirl (1905, p. 16) tells us that, "…firstly, the water in the reservoir is not regularly emptied, hence it partakes of the nature of stagnant water; secondly, an open reservoir is subject to infection by typhoid and other bacteria, and at best furnishes a favorable breeding place for algae (so-called green moss of pools) which, while harmless in themselves, yet decompose and give the water a putrid odor and flavor." Weinzirl goes on to describe the solution to the water-quality issue—periodic treatment with a very low concentration of copper sulfate, and regular draining of the reservoir—so that, after a "slight epidemic of typhoid" in November

1904, by June 1905 the water "was free from algae and perfectly clear, a condition never before seen by the writer during eight years of observation," and had no bad flavor or odor. The typhoid epidemic may have been caused by drinking water from individual wells, rather than the water system's mains.

By mid-1887, the water system was well established and looked very good on paper, but some fundamental problems, particularly the disappointing capacity of the groundwater source at the water works, had been revealed that would continue to plague the water company for years to come.

Growing, But with Growing Pains

After about a year of operation, on June 18, 1887, the Santa Fe Daily New Mexican reported that the Albuquerque Water Company system had a capacity of 3,000,000 gallons per day, roughly equivalent to the 2,000 gallons per minute rated capacity of the Gaskill pump (assuming constant operation), and dramatically more than would be needed to supply the estimated demand of 125,000 gallons per day. Both the New Mexican's article and the water company seem to have been serenely confident of the ability of the great well to provide enough water to keep up with the great pump. Even so, the water company's operations were not going smoothly, and Angus Grant seems to have been called upon to pay some of its bills himself.

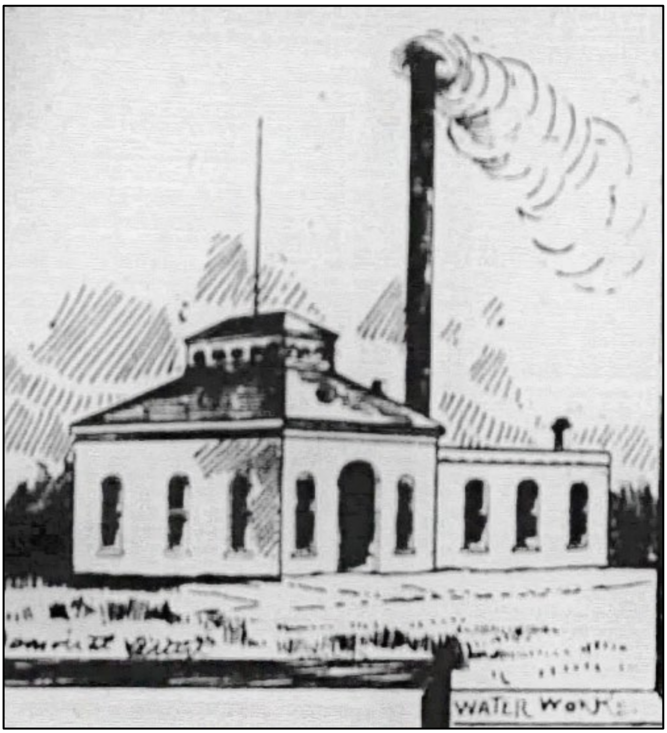


Figure 9. Sketch of the water works building, Albuquerque Journal, October 3, 1889.

Grant, and his brother L.A. Grant, sued the Albuquerque Water Company to recover damages for breach of contract, and on October 7, 1887, obtained a judgment against the company in the amount of $9,832.82 plus costs and interest. To satisfy the judgment, the Sheriff offered all of the assets of the company for sale.

These assets included the franchise, the land and buildings, the equipment, the reservoir, 73 fire hydrants (of which 50 were in use), "6-1/2 miles of water mains, one No. 3 Gaskill compound condensing pumping engine, one 150-horsepower steel boiler, one steam boiler pump, and miscellaneous tools and supplies (Albuquerque Journal, January 6, 1888)."

The Albuquerque Water Company ("Consolidated" seems to have been dropped from the name) operated until late 1888, "…when, having become heavily involved in debt, all its property, including its franchise, was sold by the sheriff at public sale (Albuquerque Journal, May 19, 1905)." The purchaser appears to have been Grant himself, or a group that he controlled. The same article continues, "[i]n 1890 the property passed by sale to the Water Supply company, again a Grant-controlled corporation. At the time of the sheriff's sale and at the date of this transfer, there was an outstanding bonded indebtedness of the old company amounting to $110,000, which was a first lien upon all the property of the Water Works. The new company refunded this indebtedness by a new bond issue of like amount, viz: $110,000, dated October 1, 1890, due in twenty years… bearing 6 per cent interest…" This new water company, the fifth, was the Albuquerque Water Supply Company (Business ID No. 12,302). Its date of incorporation is not given in the Secretary of State's records, but 1890 seems probable.

In mid-summer 1889, the water supply was meeting demand, although a large part of the water was being used in irrigation—there would have been gardens in many residents' yards—and demand would have been high. The Albuquerque Journal (July 12, 1889) reported that "as soon as the rainy season sets in the reservoir will be thoroughly cleaned and repaired." There were concerns as to the quality of the water, and especially the condition of water in the reservoir. In June of 1889, the City Council asked "Dr. Eally, city physician" to investigate the potential for contamination, and the doctor reported that "I can see no grounds for an objection, as far as location of the water works plant is concerned, at this time. There is no immediate or surrounding source from which these wells can be contaminated. The only possible point to have any fear of would be the marsh swamp near and just east or southeast of the Rankin Brewery [later the Southwestern Brewery and Ice Co., on the east side of the railroad between today's Roma Avenue and Lomas Blvd., about a quarter-mile north of the wells]. To benefit the town at large and remove a possible source of contamination, especially during the hot, dry summer months, the council should compel the owners of these lands to drain by open ditch the entire swamp… (Albuquerque Journal, June 1, 1889)." Dr. Eally also examined the reservoir and found "no foul, decaying or unhealthy matter in or about the tank."

He did, however, report that "green scum…does exist to a limited extent…on the surface of the water, which could be removed "once in two or three months." The doctor's standards may not have been particularly high; two months later, the Board of Health made a report, which was adopted by the Council, recommending that "the reservoir of the water company be emptied and cleaned at the earliest date possible, as the water it contains is not fit for household uses (Albuquerque Journal, August 8, 1889)."

Santa Fe was having similar problems with its reservoir on the Santa Fe River above the city. The Albuquerque Journal of September 3, 1889 tells us that "… the only reservoir which the water company maintains has been constantly filling up with sand and goat manure, and that the water that lodges there soaks up impurities …from hundreds of goats and sheep on the one hand and a thick green scum on the other."

About this time, there were forces at work that later would have implications for the water supply in the Rio Grande Valley. At the behest of business interests in the West, the U.S. Geological Survey was contemplating a survey of the possibilities for irrigation reservoir projects, and the Albuquerque newspapers were all in favor. A brief note in the Albuquerque Journal of March 18, 1888 reported that the "reservoir convention at Denver on Thursday was largely attended, and from the degree of interest manifested in the movement, it is plain that the necessity of a system of reservoirs for the reclamation of arid lands in the west, will be forcibly brought to the attention of Congress." But there was opposition in Washington to the funding that would be necessary. Congress authorized the project late in 1888, although the appropriation was reduced to $100,000 (Albuquerque Journal, September 16, 1888). The movement for irrigation projects led to the Rio Grande Project in the Rio Grande Valley of southern New Mexico (the Elephant Butte Irrigation District), and adjoining Texas.

The water company's billings were a continuing subject of complaints. It would appear that the rate for residences was based on the land area that might be irrigated, at one cent per square foot for "the entire space enclosed and also for the house upon the premises." The Council received petitions requesting that the rates be regulated in various ways (Albuquerque Journal, May 16 and 23, 1889).

By August 1889, unfortunately, the big well seems to have failed to keep up with demand; the problem was attributed to a long drought. The river continued to carry water, however, and for a time, the Barelas Acequia, which crossed the water-works tract, was diverted into the well and the water pumped up to the reservoir, "giving people Rio Grande ditch water in a very roundabout way, and of a quality that aroused great indignation." The solution was to "drive" a well, that is, to drill a well with cable tools while driving casing from the surface, within the existing large well. Rose & Bro. drove the new well 36 feet below the bottom of the existing well, and water "forced itself up and ran over the pipe, falling into the well, from whence it pumped into the city's reservoir (Santa Fe Daily New Mexican, August 23, 1889)." The phenomenon was deemed a discovery "of greatest importance to New Mexico," although of course the water level in the new well would have been similar to that of the existing well if it had been drilled from the land surface, rather than from the bottom of the existing well. It did increase the yield of the existing well significantly. The population was growing fairly rapidly, reaching 3,285 by the 1890 census, and the new demand each year would have put a strain on the system.

The 1891 Sanborn map shows that the distribution system now included a 10-in. water main in Railroad (now Central) Avenue, and 5-in. mains in Copper and Gold Avenues, and in First, Second, and Third Streets, Arno Street, and Broadway south of Railroad Ave. At that time, the system largely served the commercial properties; residences typically had their own shallow wells. In that same year, however, development began to spread onto the higher ground east of the railroad and the inner valley, where hand-dug individual wells would be impractical, but beyond the water company's system. Martin Stamm began to sell lots in his Terrace Addition, between Central and Hazeldine and eastward to Buena Vista, around the present-day Central New Mexico Community College (CNM), and later still farther east to include the Silver Hill neighborhood as far east as Yale Boulevard. He was not able to persuade the water company to serve the area, and drilled a well himself (Albuquerque Historical Society).[6]

Further serious problems with the water system occurred in 1892. An article in the Las Vegas Free Press (June 23, 1892) reports that "statements of prominent citizens…as well as of leading representatives of the fire department, are to the effect that there is no water either in the reservoir, the wells or the pipes of the water company, the water famine being so serious that the residents of the Highlands have for several days been without sufficient water for ordinary domestic purposes. Should a fire break out under the conditions at present existing the most disastrous consequences would inevitably result…" Eighteen ninety-two was the first year for precipitation and temperature records in Albuquerque, and it was a hot, dry year, with 6.0 in. of precipitation as compared with the long-term average of 8.4 in., and

[6] https://albuqhistsoc.org/SecondSite/pkfiles/pk213neighborhoods.htm.

that would have contributed to the failure of a groundwater supply if the wells themselves were too few and too shallow to keep up with demand.

More and deeper wells seemed to be the answer. By April 1892, a new well was being drilled to a contract depth of 200 feet or more (Las Vegas Free Press, April 9, 1892), and the drilling of more wells, although shallower, continued into the next year (Santa Fe Daily New Mexican, April 24, 1893). In the spring of 1893, Mr. Ropes, the company's engineer, announced the start of a new 60-foot well, and expressed the position that the company "confidently expected that an abundance of pure, soft water will be obtained from this source to meet the demands of the city for many years to come (Albuquerque Weekly Citizen, April 8, 1893)." The article emphasized the point that all surface water would be excluded from the well, so that there would be no contamination from sewage. The underlying problem—the fact that all of the wells were in the same place, and to some extent functioned as a single, if larger, well—would continue to haunt the management of the system for years to come.

Things still were not going well, however. In late 1893, the City Council voted to sue the water company (and also the gas company, controlled by Grant) to cancel its franchise. Shortly before November 21, 1893 (Albuquerque Journal), Grant notified the council that, unless the company had a lawful franchise and contract with the city, it would cease to furnish water and close down its works on November 23. He also demanded immediate payment of all the moneys due for maintenance of the fire hydrants, and water that had been supplied. The City contemplated seeking an injunction to keep the system in service. On December 17, however, the Albuquerque Journal reported that "the court has decided the company has a franchise," and that "the company is here to stay and we can't drive it out, even though we might be disposed to do so."

In February of 1894, under the headline Big Water Deal, the Santa Fe New Mexican (February 8, 1894) announced that Capt. J.S. Day and Julius M. Howells, respectively the superintendent and chief engineer of the Santa Fe Water & Improvement Co., had arranged an agreement in which the Municipal Investment Co. of Chicago, which controlled the Santa Fe system and 26 others around the country, would purchase the Albuquerque system. The deal was subject to the extension of the franchise for 25 years; the City Council passed an ordinance granting the extension, and setting a special election for ratification by the voters. The deal was not consummated, and the company did not change hands.

There were other troubles. In October 1897, Folger Potter, the son of Mrs. Rena Potter, drowned in the reservoir. His mother sued the water company for $5,000, contending that the fence around the reservoir was in bad condition, and that the sloping concrete lining was "slippery from the deposits from the water," perhaps a subtle reference to the reservoir's algae problem. The company defended itself on the grounds that "it was not bound in law to guard the reservoir from children at that place (Albuquerque Citizen, June 15, 1903)." The court disagreed, and according to the Las Vegas Daily Optic (January 26, 1898), the judgment was in the amount of $25,000. The award seems to have been appealed, however, and on June 17, 1903 the Optic reported that Mrs. Potter's suit had been thrown out of court.

It was perhaps ironic that the landmark properties of the two principal founders of the water company, instituted largely for fire protection, could not be saved from fire. Among A.A. Grant's enterprises in Albuquerque was the Grant Building, an office building and opera house on the northwest corner of Third Street and Railroad (Central) Avenue, built in 1883. Several stores occupied the ground floor, and a 1,000-seat auditorium was on the second. The building caught fire in June of 1898, and the usefulness of the water company's fire hydrants was tested, as shown in Figure 10. The efforts of the volunteer fire department were not enough, however, and the building was destroyed. It was rebuilt, although without the opera house (New Mexico ImagePast.com). The same thing had happened in the previous year to the Armijo House, built by another principal owner of the water company, Mariano Armijo, across Railroad Avenue from the Grant Building (Bryan, 2006, p. 163). It was an adobe building, according to the Sanborn maps, and was destroyed in late 1897.

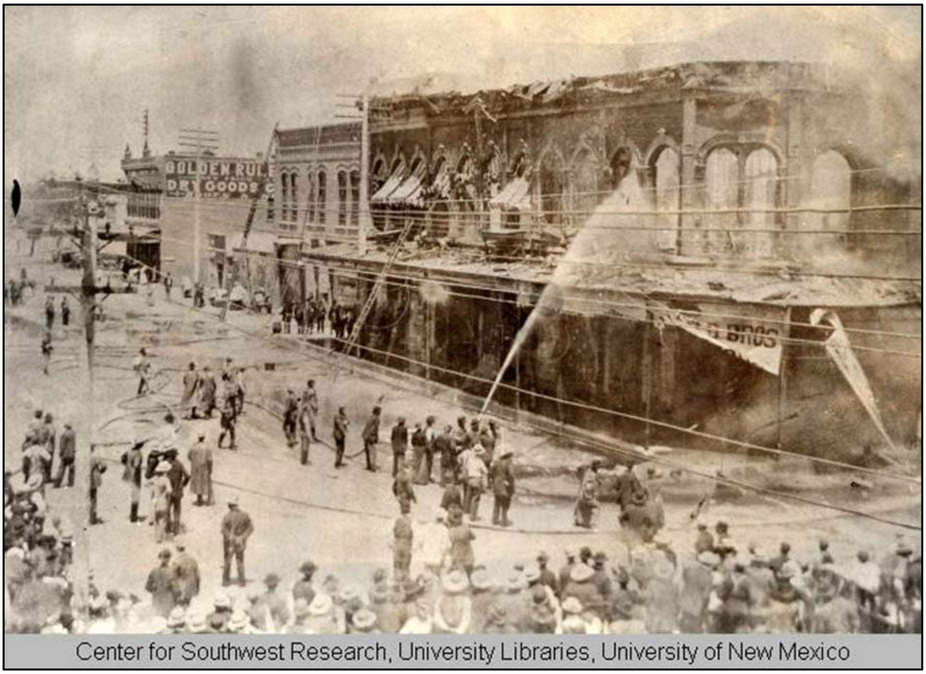


Figure 10. Fire at the Grant Building, corner of Third Street and Railroad (Central) Avenue, June 1898 (Cobb photo, Wm. A. Kelleher Collection, Center for Southwest Research, UNM Libraries).

By 1898, a second pump, this time a Laidlaw-Gordon duplex compound, had been added at the water works, raising the pumping capacity to 4.5 million gallons per day, and there were now 100 fire hydrants (1898 Sanborn map). The map shows two large wells; although there is no mention of the deeper drilled or driven wells within the large pits, more may have been added.

The County Commission on January 17, 1899, accepted a proposal by the water company to extend service to the court house, which was then near Old Town at what is now Central Avenue and San Pasquale, and the jail, a little farther west at about the corner of today's Central and Rio Grande. The pipeline would be about 3,500 feet long, and the cost of the pipe was estimated at $1,200. The company proposed that the County itself furnish both the money and the labor to carry out the work, under the water company's supervision, to be reimbursed by receiving credit for "one-half of all the moneys earned on the line until such credit amounts to the money expended by the county." After that, the line would become the property of the water company (Albuquerque Citizen, February 9, 1899).

Although the water system was expanding, new private wells and windmills were common on into the early 1900s, and many real-estate advertisements included them. Newspaper articles frequently mentioned water-supply improvements at residences. A typical brief piece in the Albuquerque Citizen on July 19, 1900 described the large well, windmill and 30,000-gallon tank at Mrs. C.T. Brown's residence. J.W. McQuade's well, near the intersection of Tijeras Road and High Street, about a half-mile east of the railroad station and outside the water company's service area, has an intriguing story. "As water was a scarce article in that vicinity," it was drilled to successively greater depths, and at 138 feet a strong flow was found. Although the well had a 12-foot Aermotor windmill pump, the well would fill a large elevated water tank even when the windmill was still, suggesting a flowing artesian well (Albuquerque Journal, December 9, 1892). The situation was anomalous, particularly under the conditions of 1892. Unfortunately, neither the water supply from the well nor the best efforts of the firemen, who laid about 1,000 feet of fire hose from the nearest hydrant, at Tijeras and Walter, were able to save the house from a disastrous fire less than four months later (Albuquerque Weekly Citizen, March 18, 1892).

In 1899, the Santa Fe Pacific Railway was contemplating a reservoir of its own "to store the waste water from the water works pipeline (Albuquerque Citizen, April 11, 1899)." An engineer had located "almost a natural site for a reservoir on the top of the mesa east of town," and it was thought that 30 million gallons of storage, far more than the capacity of the water company's reservoir, could be developed. It is not clear what this wastewater might have been; overflow from the water company's reservoir could always be prevented by pumping less water into it, and it may be that the railroad simply wanted to salvage water that the water company drained from the reservoir when it needed cleaning. It is not likely that such a reservoir was ever built; the railroad built a much smaller reservoir, adjoining the yards, in 1919.[7]

In early 1900, an irrigation canal was under construction, funded largely by the landowners it would serve, to supply water to 12,000 acres upstream from Albuquerque and another 8,000 acres below the town. The project would presumably replace or augment part of the network of acequias, although the newspaper article describing it (Albuquerque Citizen, January 29, 1900) does not discuss the location of the canal. This may have been an early effort to develop what became the Middle Rio Grande Conservancy District two decades later.

[7] National Park Service, National Register of Historic Places.

The population in 1900 was 6,238. The long drought that began in or before 1892 continued, and by early 1900 the reservoir was again empty (Albuquerque Citizen, February 22, 1900) because of the combination of increased demand due to the lack of rain, growth of the population, and lowering of the water table in the wells. The newspaper thought that a heavy rain would fill the reservoir, but of course the reservoir had no catchment, and could be filled only by pumping from the wells. Things improved, though, and by September, after a summer of rain (and a total of 9.8 inches for the year), the water in the reservoir was nine feet, three inches deep, less than two feet below its maximum capacity (Albuquerque Journal, September 6, 1900). Unfortunately, the water itself had some problems. As early as April 1901 the Albuquerque Citizen (April 10, 1901) reported that "the reservoir of the Albuquerque water works has not been cleaned out in three years. It is foul, and needs the attention of the Board of Health." On May 7, however, the same paper announced that the company was installing a new electric motor—presumably for another pump—and that "as the wells have been deepened it is believed there will be no scarcity hereafter."

Angus Grant died, in Los Angeles, in 1901. Thereafter, his Albuquerque interests were administered by Daniel A. Macpherson, who had been Grant's personal representative in Albuquerque since 1899. Macpherson was a nephew, also a Canadian, who had been with Grant Brothers Construction Co. in Los Angeles since 1887.

The performance of the water company continued to be controversial, and had become a political issue as well as a bone of contention between the Journal-Democrat, which supported the water company, and the Albuquerque Citizen, which didn't. The City Council formed a committee—two Democrats and one Republican—to look into the company's activities, and found major problems, among them that the "accumulation of surface water and pouring the same into our water supply…makes bad water." The report also mentioned that the runoff associated with the Albuquerque Wool Scouring Mill, which was in the western part of the same tract as the water works, was part of the "filthy water" entering the water company's wells (Santa Fe New Mexican, April 9, 1902). Another committee of several physicians reported similar findings to the Board of Health.

The Bearrup and Edie wool-scouring mill, later the Albuquerque Wool Scouring Mill, was an important industry, and had been on the western end of the water-works tract since 1884 (Albuquerque Journal, June 6, 1884), although its negative influence on the water supply seems not to have been recognized at the time. The wool-scouring mill was built about the time that planning for the groundwater supply had begun, but about two years before the water company's plant was actually completed and went into production.

The Journal-Democrat attacked the Council's committee, and was answered by an article by A.B. McMillan in the Citizen (May 1, 1902) in which blame for the troubles was assigned to the water company for failing to take the necessary steps to "draw only from the seventy-foot strata which all agree is good water." McMillan was a member of the committee, as were Frank McKee and H.E. Rogers.

As a related issue, the community was lobbying around that time for the establishment of a military post near Albuquerque, and there was concern that the negative report on the water supply might jeopardize the chances. By early 1903, the city physician was able to say that "the water furnished the city by the Albuquerque Water Supply company is pure and excellent," but the article went on to say that all the benefit of a good and pure water supply may be wholly neutralized by a bad sewer system (Albuquerque Morning Journal, February 18, 1903). The sewer system was certainly a problem from the general public health perspective.

The 1902 Sanborn map (Figure 11) described a great deal of capital improvement at the water works. In addition to the two duplex compound pumps, with a combined 4.5 million gallons per day capacity, there was a new Deane electric pump providing an additional 1.5 million gallons per day, and there were more wells. The map shows one large dug well with 30 bored wells in the bottom at the site of the smaller of the two earlier dug wells; it is shown in a frame building over the well, but not covering it entirely. This would presumably be the 65-foot dug well with 25 pipes driven to 35 feet, or 100 feet depth below ground level, mentioned by W.T. Lee in 1907. There were also eight, 6-in. bored wells in the "passage" shown as a building on the map; there is no indication of their depths, but these are likely to be the eight, 291-foot wells mentioned by Lee. The original large well, near the west side of the tract, is not mentioned in the map explanations, and may by then have been transferred to the Albuquerque Wool Scouring Mill at the west end of the tract, which was supplied by "well and city water." The scouring mill had two storage tanks, one of them elevated. The maps indicated that there were 109 double fire hydrants, and a total of 21 miles of water main in the water system.

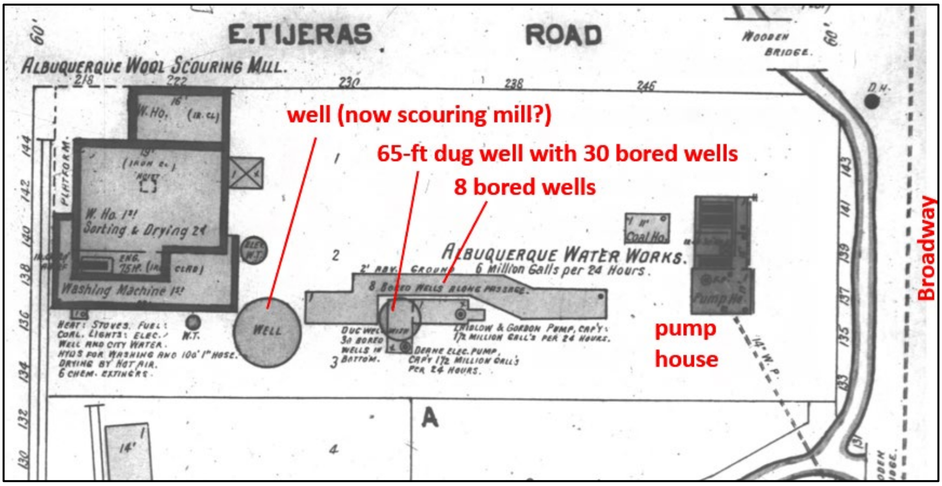


Figure 11. Excerpt from the 1902 Sanborn map, with labels in red added. The street along the north side of the water-works tract is now "E. Tijeras Road." This black-and-white image is from a microfilm version of the map that became available many years ago. Library of Congress, Geography and Map Division, Sanborn Maps Collection.

The McMillan committee published a detailed description of the water works—and its failings in terms of contamination—in the Albuquerque Citizen (October 13, 1902). The "passage" was actually a ditch, 15 to 20 feet deep, 15 feet wide at the top and 6 feet wide at the bottom, and 165 feet long, between the wool-scouring mill and the water works pump house. The committee found that "the sides and ends of this ditch are protected from caving by heavy timbers and boards, and [it] is covered with boards. The covering, owing to shrinkage, leaves spaces between the boards...from which the sand dirt and filth can readily sift into the ditch." Although the water company had asserted that the supply was entirely "from the seventy-foot strata," the committee found that surface water and shallow groundwater could enter both of the large wells, although they had been "walled with stone," and also through the "decaying timbers which support the walls of the ditch." In particular, they noted that "the filthy water which seeps into the ground about the wool scouring mills must eventually find its way into the city water."

The water company continued to add new wells, although always in the same place. In April, 1903, the company announced that, along with the eight wells described by the 1902 Sanborn map, an experimental 12-inch well would be drilled to 750 feet, starting within a few days. Although the company continued to assert that the then-current supply was ample to meet the city's needs, the company wanted to prepare for future growth, and provide water of "absolute purity

(Albuquerque Morning Journal, April 15, 1903)." Weinzirl (1905, p. 7) reported that the well was completed, to 704 feet, in July 1903. W.T. Lee, of the U.S. Geological Survey (1907, p. 34), gives the depth of the "12-inch double steel-cased" well as 710 feet. Both authors give sample-description logs (Lee's is shown as Figure 12); the two logs appear to have been prepared by different geologists, but are remarkably similar, even accounting for the difference in reported depth. The casing was perforated only below 350 feet, so that only the better-quality water would be produced. The well made 600 gpm with 18 feet of drawdown.

Record of the city waterworks well at Albuquerque, N. Mex.

	Feet.
Soil	0– 10
Sand and coarse gravel	10– 35
Clay	35– 40
Sand and coarse gravel	40– 71
Cemented sand	71– 75
Clay	75– 80
Cemented sand and bands of "sandstone"	80–179
Sand and gravel	179–185
Clay	185–189
Cemented sand and clay	189–243
Yellow clay	243–292
Cemented sand	292–320
Yellow clay	320–362
Sand and clay	362–386
Shale and sand	386–397
Cemented sand	397–442
Yellow clay	442–456
Cemented sand	456–471
Sand and clay	471–487
Clay, sand, and gravel	487–572
Quicksand	572–614
Clay and cemented sand	614–710

Figure 12. Sample-description log of the first deep well at the water works, drilled in 1903 (from Lee, 1907, p. 35).

This first deep well was drilled, or more correctly driven, by E.C. Proctor of Los Angeles. The 12-in. thin-walled "stovepipe" casing came in 3-foot lengths, and in two slightly different diameters so that alternating joints could be telescoped over each other, leading to the "double-cased" configuration described by Lee. The pipe is likely to have been 10-gauge (9/64-in.) wall thickness, forming a casing just over 1/4-in. thick (see e.g., Schwalen, 1924, p. 4). The casing was pulled downward by hydraulic jacks, acting against two large horizontal timbers buried about 10 feet below land surface (Albuquerque Morning Journal, May 10, 1903), while the "mud scow" loosened the material and acted as a bailer to remove it, or a cable-tool bit broke up larger rocks or boulders below the casing so that it could be removed by a bailer or sand pump. The inner and outer casing joints typically were "united" by denting them with a pickax. The perforations in the casing, to allow the entry of water, were probably made after the well had been driven to total depth using a tool called a Mills Knife to slice vertical slots through the double steel casing.

The water company, having bought another pump with a capacity of 3 million gallons per day, raising the total capacity to six million, told the Santa Fe New Mexican that the supply was now practically unlimited, and "absolutely secure for some years to come (June 9, 1904)." Even though 1904 had been very dry—1902 through 1904 had been another drought—and the company had "had difficulty in supplying the large increase in demand which comes with the season of grass growing and street sprinkling,"… but now "finds itself confronted with more water than it can take care of." Now the problem of the moment was that the reservoir was overflowing and water was running to waste (Deming Headlight, July 20, 1904).

On March 1, 1905, Grant's administrator, Daniel Macpherson, completed the sale of the water works system to a group consisting of M.W. Flournoy, W.R. Whitney, Frank A. Hubbell, W.H. Gillenwater and A.B. McMillen, all of Albuquerque, all owning equal one-fifth interests (Albuquerque Journal, May 18, 1905; Anderson, 1907). The Roswell Daily Record called the sale one of the largest deals that had occurred in Albuquerque.

The fraught financial history of the company is summarized in a long "Statement of Water Supply Company" in the Albuquerque Journal of May 19, 1905, in support of a petition for an extension of the franchise that was then pending before the City Council. The company's indebtedness included the $110,000 bond issue of 1890, to retire the debt of the predecessor company at the time of the Sheriff's sale, that would come due in October 1910, and a second issue of $75,000 that Grant was able to secure only with great difficulty in 1892 that would be due in 1913, only three years later. But the current franchise would expire on March 7, 1919. The statement summarized the rapid growth of the city, with an estimated population of the new town of 1,500 to 2,000 in 1885, and 3,000 to 3,500 in 1890. The Santa Fe railroad had made extensive improvements in 1901 through 1903, important businesses had been established, and the number of children in the schools had increased from 660 in 1892 to 1,800 in 1905. The statement also made the point that "no dividend has ever been declared or paid on the stock of the Water Supply company." The company foresaw great opportunity, and strongly desired to participate in it beyond 1919.

On the other hand, the public and at least some newspaper editorial writers, notably those of the Albuquerque Citizen, had been thinking since before the turn of the 20th Century that the city should own the water system. The Albuquerque Morning Journal, in contrast, shared some stockholders with the water company, and was not pressing for municipal ownership. The question was much in the news in 1905. The Journal thought the company's request for an extension of its franchise was entirely reasonable, but W.S. Strickler of the Bank of Commerce, and owner of the Citizen, was highly critical of the company, and of what he considered the extremely favorable terms of the franchise contract (Albuquerque Journal, June 21, 1905). M.W. Flournoy, one of the owners of the water company, was an officer of a rival bank (Albuquerque Citizen, October 6, 1907, ad). The Citizen was in favor of a municipally owned system, and opined that a "new system of water works would be the best thing for the Duke City," but added, perhaps ominously, that "it would cost but little more to build a new plant than it would to buy the old one at a fancy price (Santa Fe New Mexican, January 13, 1906)."

In April of 1906, the voters were asked to approve a $300,000 bond issue to purchase the system, but, led by the Taxpayers Party, they declined—by a vote of 446 to 380 (Albuquerque Journal, April 4, 1906). The Journal took the position that most of those who voted on the issue were real-estate owners; many people who voted for candidates in the election did not vote on the water-system question. A committee of business leaders[8] had examined the company's books, and determined that, for the year ending March 1, the receipts had been $36,175.08, of which $5,548.31 had been paid by or was still due from the City for fire-hydrant rentals, and the expenses (exclusive of taxes and interest) had been $7,684.90. After some further analysis, taking debt service into account, the article in the Journal (April 1, 1906) concluded that "[t]he City then, owning this water works plant, could at once make a direct and straight cut of one-fourth in the present water rates, upon which this $30,000 annual gross income is collected, and still leave to the City a safe balance of net profits for emergencies." As an extra justification for purchase by the City, the article pointed out that the City could use its "$50,000 of extra bonds" to make extensions of the water system that would almost immediately add large sums to the annual income. These arguments were not enough.

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[8] George Brewer, owner of a fire-insurance agency; Melville Summers and John Moore of the John M. Moore Realty Co.; E.H. Dunbar, "a real-estate man and one of the pioneers of Albuquerque;" and D.S. Rosenwald, "a member of the Rothenburg & Schloss Cigar Co. and a pioneer of Albuquerque."

As part of the debate over municipal ownership, the Albuquerque Morning Journal (February 18, 1906) carried a long analysis by A.S. Riffle, a consulting engineer employed by the City Council after the question of the purchase of the system for $250,000 [sic] had been presented to the voters, on his detailed inspection and evaluation of the water system. Mr. Riffle examined the construction and condition of the works, verified the materials in place, and estimated the remaining life of pumps and pipelines; he praised the company representatives, and the people he had interviewed on both sides of the municipal-purchase issue, but his valuation of the company was not given in the newspaper article.

A few days later, the Albuquerque Journal (March 7, 1906) published a long and detailed manuscript under the headline "Engineer Discusses the Water Works System on Basis of its Value as an Investment for the City," signed only by "A Constructing Engineer." The wide-ranging contents told the public about water systems in general, going back to Roman times, and the details of the Albuquerque system, which he assured the citizens justified their great pride and confidence. On the other hand, the credibility of the work is marred to some degree by an improbable tale describing the value of the high-pressure stream that can be provided from a fire hydrant in a properly engineered water system. In the story, a fireman (presumably not in Albuquerque) rescued a baby from an upper floor of a burning building, even though access by the stairs had been blocked by the fire; he signaled the crew on the ground to direct a stream within reach of a window, then with the baby in one arm, "he circled the stream with the other arm, and throwing his leg around it (the stream) descended with ease and safety to the street…" The story was clearly intended as a spoof, but it isn't so clear what message was intended.

There were sweeping changes in the water works between 1902 and 1908, as reflected in the Sanborn maps. In 1908, the "Holly force pump" (the Gaskill pump) with bore and stroke dimensions of 13 in. x 24 in. x 13 in., presumably the high-pressure steam cylinder diameter, the stroke, and the water cylinder diameter, respectively, was now in a new concrete-block building on the western side of the tract next to the railroad tracks, about where the larger of the dug wells had been, and the wool-scouring mill was gone—which would have been a relief to anyone concerned about the quality of the City's water.

Although the water company was improving its facilities significantly, it still was not serving the new developments on the East Mesa. In 1906, the busy developer D.K.B. Sellers established University Heights, which extended south from Central Avenue, from Yale Blvd. east to Girard, and which he described as the "coming aristocratic section of Albuquerque." As with Martin Stamm's earlier subdivisions, Sellers drilled wells to serve University Heights. One of the wells was near the corner of Carlisle and Coal Avenue; the two-story-high water tank at the site still exists as part of the house at 319 Carlisle SE (Albuquerque Historical Society).[9] Sellers' subdivision was not far from the water company's reservoir, about a mile, but at the well location was about 100 feet higher. It would have been possible to pump water up from the reservoir, but as things developed, Sellers' system presumably enjoyed much better water quality than the water company could have provided.

By mid-1907, the Albuquerque Wool Scouring Mill had moved to a tract along the railroad just north of Mountain Road (Albuquerque Citizen, April 15, 1907), and by the end of the year was about to double in capacity, and become the center of the wool industry in the southwest, through the purchase of the Tucumcari Scouring Mills (Albuquerque Journal, December 10, 1907). The Tucumcari plant was converted to a cotton gin (Tucumcari News and Tucumcari Times, November 9, 1907). The new site of the Albuquerque mill had been part of a tract of City land, and rather ironically, the City later drilled many new wells on the adjoining property, although by that time a sewer system was in place to take away the wastewater.

Now the constraint on the scouring mill's activities was the inadequacy of the sewer system and the cost of screening the wastewater before it could be discharged. The December 10, 1907 article quoted J.M. Wilkinson of the Albuquerque mill as saying, "when you consider that in scouring six and a half million pounds the tremendous amount of dirt we have to handle, you can see what we are up against." The City Council took note, and by mid-1908 had hired a consultant, Dr. Samuel M. Gray, to report on the kind of system needed to meet the requirements (Albuquerque Citizen, June 6, 1908). Within two days, Dr. Gray "told the city fathers some things about the city's sewage system that caused each paternal brow to take on a grave expression." Many pipes were broken and leaking, and the wool-scouring mill, the Albuquerque Gas plant, and the Santa Fe Railway shops were largely responsible for the choked condition of the sewer mains (Albuquerque Citizen, June 10, 1908).

As of the 1908 Sanborn map, the second large duplex compound pump, a Laidlaw-Gordon pump, 12 in. x 18 in. x 12 in., had been added (Figure 13). The Deane electric pump described in 1902 is not mentioned, but with the Laidlaw-Gordon pump the total capacity was 4.5 million gallons per day. The brick building

[9] https://albuqhistsoc.org/SecondSite/pkfiles/pk213neighborhoods.htm.

on the east end of the tract, formerly the pump house, was no longer shown as a pump house. The "passage," the ditch described by the McMillan committee as the source of much of the contamination, was gone. There were 22 miles of 4-in. to 14-in. water lines, and 139 double fire hydrants.

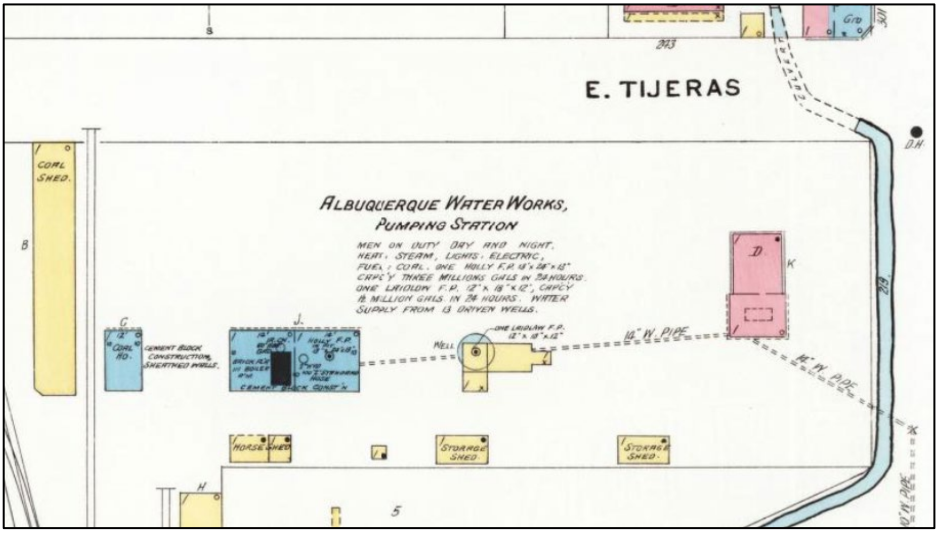

Figure 13. Excerpt from 1908 Sanborn map of the water works, showing the changes described in the text. Broadway is at the right side of the map, and the railroad is shown by the double line on the left. Library of Congress, Geography and Map Division, Sanborn Maps Collection.

The source of water in 1908 was described as 13 driven wells; the map shows only the large dug well near the middle of the tract, with the Laidlaw-Gordon pump in a frame building partially over the dug well. One of these wells must be the deep well mentioned by Weinzirl (1905) (Figure 14) and Lee (1907). According to Lee, there were nine wells in 1907, so some new ones must have been drilled in 1907 or 1908. The building housing the wells is missing in 1908.

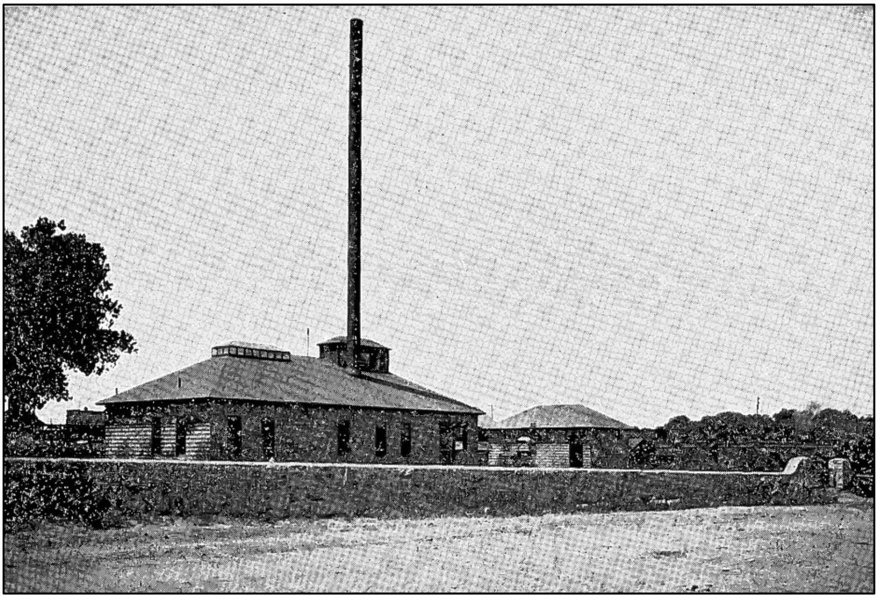

Figure 14. The new water works buildings in about 1905 (Weinzirl, 1905, follows p. 4), showing the boiler and pump house with the tall chimney at the left, and the coal house, next to the railroad, on the right. Tijeras Avenue is in the foreground.

Albuquerque's population in the 1910 census was 11,920, somewhat short of the estimate of 16,000 given on the 1908 Sanborn map. Presumably the map simply repeats a number given to the Sanborn surveyors by officials of the City or the water company.

The growth of the system by the time of the 1913 Sanborn map had resulted in a total of 25 miles of water mains, and 213 double and triple fire hydrants. The average daily production was given as 1,350,000 gallons, equivalent to 1,513 acre-feet per year.

Clyde Tingley was elected alderman in 1916 (the city charter was amended in late 1917 to provide for the City Commission and city manager form of government that then prevailed until 1974), and he at once began a drive by the City to buy the water system. Henry Westerfield was the mayor. Control of the Water Supply Co. was in the hands of shareholders A.B. McMillen and Frank A. Hubbell, and they insisted on an 8-percent net annual return. The water company had generally been unwilling to extend service to new subdivisions until the customers were already in place and the cost could be recovered rapidly, a policy that was assumed by many citizens to retard the growth of the city (see Simmons, 1982, p. 363). As William A.

Keleher (1983, p. 123), put it, the management of the company "had no concern with establishing and maintaining good relations with the consumers, seemingly going out of their way to antagonize citizens." Keleher (p. 127 et seq.) describes the developments that ensued.

> Soon after Mayor Westerfield had taken office, the council authorized the execution of a buy and sell agreement between the city and water company. Among other things, the agreement provided for arbitration as to price. Assuming the arbitrators fixed a price of more than $400,000, the city would have the right to refuse to buy. The city named Black and Veatch, Kansas City engineers, as its arbitrators. James N. Gladding, one-time Albuquerque city engineer, was designated to act for the Water Supply Company. The arbitrators fixed $453,591 as the reasonable value of the property. The city refused to buy. Mayor Westerfield, on behalf of the city, announced in a newspaper interview that the city would promptly begin to build an entirely new, modern plant.
>
> Well aware of the powers of the city to build an entirely new plant…and recognizing that its own franchise to sell water in Albuquerque would expire in a few months, the Water Supply owners decided to throw in their chips. The City of Albuquerque had won in the biggest poker game then in town.

The City issued bonds for the purchase of the water works, but the validity of the bond issue was in question because the City's charter itself was attacked as being unconstitutional. The New Mexico Supreme Court entered an opinion on July 10, 1918 sustaining the validity of the bonds, although it did not rule on the constitutionality of the charter. The Court did advise the City that it should "have its charter legalized by the coming session of the legislature (Albuquerque Morning Journal, July 11, 1918)." The City paid $400,000 for the system, and took title on July 20, 1918 (Albuquerque Journal, August 5, 1918). The water system was now securely in the hands of the City of Albuquerque, and the water-supply policy changed dramatically.

The City's System Now, and a New Expansion Policy

A detailed land-use map of the valley, the 1917 Rio Grande Drainage Survey, showed that the city was expanding to the east, and also illustrated the extent of the high-water-table problem that was limiting development in the inner valley. The area south of Central Avenue and west of Eighth Street, all the way to the river, was mapped as "alkali" land, as was almost everything south of Bridge Blvd. and west of Broadway in the south valley. Almost all of the lands north of today's Mountain Road, all the way to Montaño Road, were in cultivation, but with patches of marsh land.

The City made major improvements in the system over the six years following the purchase, probably the most important being several new well fields, described below, which the private water company had never been inclined to pursue. Extending water mains to serve paying customers was one thing, but extending pipelines for no better reason than to connect to outlying wells was another, and the water company seems to have preferred to continue struggling with the wells at the original water works.

In mid-1919, not long after the City bought the system, the Sanborn map described the source of supply as "13 wells, 65 ft to 708 ft deep," all in the same place at the water works. Water continued to be pumped to the reservoir by the Holly (Gaskill) and Laidlaw-Dunn steam-powered pumps. There were 26 miles of water mains, and 238 fire hydrants; an average day's water use was estimated at 1.4 million gallons. The water pressure in the downtown area, at Second Street and Central Avenue, was measured at 95 psi. The ever-optimistic Sanborn map estimated the population at 23,000; the U.S. Census of 1920 showed a population of 15,157.

The implied per capita water use of 92 gallons per day (based on the census population) may not have been much different from recent figures, although it has been much higher. Per capita water use increased over time as landscaping and water-using amenities became more prevalent, reaching an all-time high, probably in 1995, at 251 gallons per capita per day. Since then, effective conservation measures have reduced water-use very significantly, and it has been in the 130s in recent years and is projected to be around 110 gallons per capita per day—not dramatically more than the number in 1919—by 2037 (ABCWUA statistics). The per capita use in 1919 may actually have been higher than the current goal because the census population would have included people and businesses that had their own wells and were not water-system customers.

Another major improvement to the system, much to the annoyance of the University, was an expansion of the reservoir in 1923. Keleher (1983, pp. 124-125) tells the story of the quarrel between Dr. David Spence Hill, President of the University, and Edwin B. Swope, Chairman of the City Commission. The two men met at the reservoir for a friendly discussion of the "most direct method of 'getting rid of the reservoir,'" so that the growing university campus could include the reservoir tract, but the conversation degenerated into a name-calling contest. The outcome was that the old reservoir was demolished, but a new and larger one was built in its place, on land that should have been acquired by the University. The footprint of the original reservoir was about 1.13 acres, but it was only 12 feet deep; the new one wasn't much larger in area, about 1.35 acres, but it was 22 feet deep; it had a capacity of about 9.7 million gallons, roughly double the old one. The University eventually got rid of the reservoir, but not until almost 100 years later; the reservoir was filled and leveled in late 2017 to make way for a new University building.

By the time of the 1924 Sanborn map (Figure 15), the city was beginning to take a recognizable shape, although expansion was of course largely to the east, and still had not crossed the Rio Grande to the west. Old Town was not actually within the Albuquerque city limits at the time, but a 4-in. water main extended along the former Railroad Avenue, renamed Central Avenue by 1924, into Old Town, and there was a fire hydrant on the west side of the plaza.

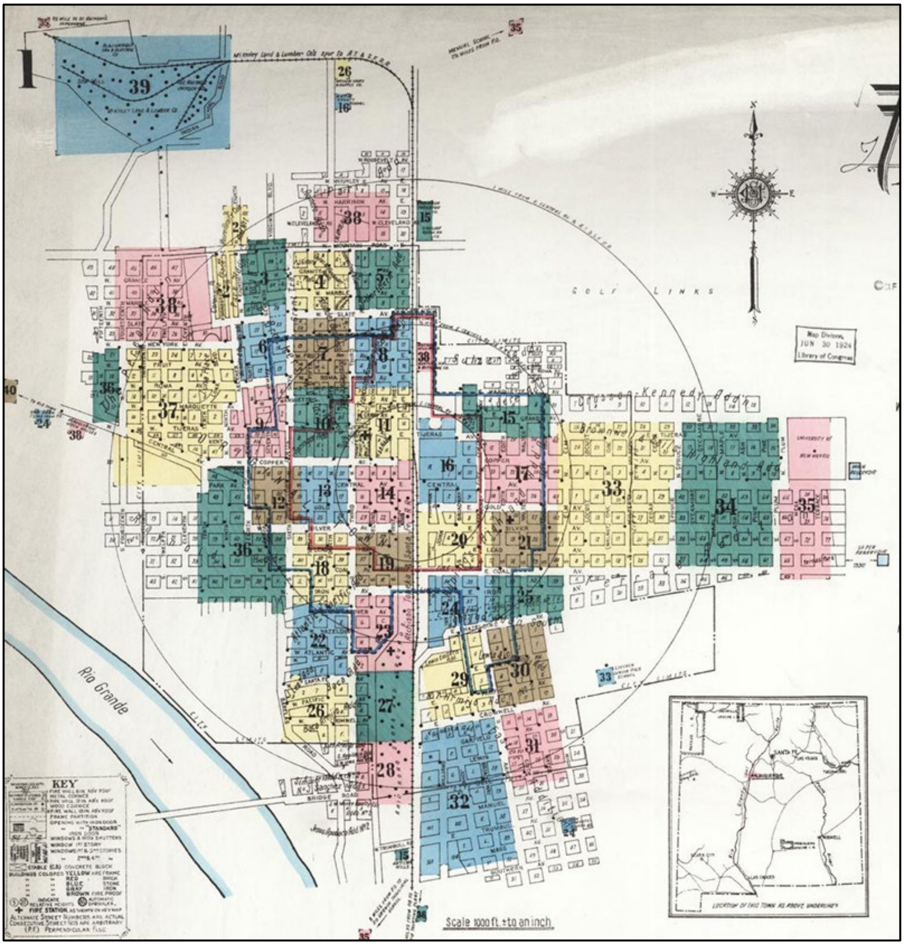

Figure 15. Excerpt from Sanborn index map for 1924. Color-coded areas represent individual detailed map sheets. The University of New Mexico occupies the large pink block at the eastern edge of the city, and the Main Reservoir is the small blue box just to the east of it; the Upper Reservoir in Burton Park is to the south of the Main Reservoir, at the eastern edge of the map. Old Town is not shown on the index map, but is represented on Sheet 40 as indicated by the small square at the west edge of the map. The red and blue boundaries are the "inner" and "outer" fire limits, respectively. Library of Congress, Geography and Map Division, Sanborn Maps Collection.

By 1924 (according to the Sanborn map), the original large well was now augmented by 30 driven and drilled wells ranging from 60 feet to 708 feet deep, and there were three auxiliary pumping stations with their own well fields. One of these was along north Broadway, with two 8-in. wells, 60 feet deep, operated by a motor-driven pump with a capacity of 400 gpm. This presumably was a centrifugal suction pump powered by an electric motor. A second station was along the railroad tracks between Marble Avenue and Mountain Road. Here there were seven wells, five with 8-in. casing and two with 12-in. casing, all 65 feet deep, and operated by a motor driven pump with a capacity of 750 gpm. It is likely that both of these pumping stations and all of the wells associated with them were in the tract now occupied by the main Post Office, between Broadway and the railroad on the south side of Mountain Road; at some point, the tract became a City equipment yard. Wells continued to be drilled on this tract, which came to be part of the Main Plant well field. One of the wells drilled in 1922, Main Plant Well 3A, about 300 feet south of Mountain Road and 400 feet west of Broadway (and thus directly under today's Post Office building), was still in service in 1960 (Bjorklund and Maxwell, 1961, p. 73).

The third auxiliary pumping station was at Fifth Street and Mountain Road, probably near the northwest corner, on City property that is today the Johnny Tapia Community Center. The well there was 77 feet deep, with 28-in. casing, reduced at some depth to 12 in. The pump had a capacity of 1,000 gpm.

It would appear that water from the auxiliary well fields was collected at the water works at Tijeras and Broadway, and the same two large steam-powered pumps at the water works (the electrically driven pumps described on earlier maps are not mentioned) pushed water up to the newly enlarged reservoir, now called the Main Reservoir, at Yale and Central. The water system's service area in 1924, based on the distribution of fire hydrants shown on the Sanborn map, covered almost all of the area within the city limits. The map also shows successively smaller areas within the city limits labeled "outer fire limit" and "inner fire limit;" it is not clear what these distinctions meant, but presumably referred to the capacities of the fire hydrants and the capabilities of the Fire Department.

Albuquerque's expansion to the east beyond Broadway was uphill, and before long the new additions beyond Martineztown and Huning Highlands had reached high enough elevations that the Main Reservoir did not provide enough water pressure. A second reservoir had been built by 1924 on the east mesa, in what is now Burton Park at the corner of Kathryn Avenue and Carlisle Boulevard, to serve customers at the higher elevations east of Mulberry Street, just east of today's I-25. This Upper Reservoir also was concrete-lined, and had a capacity of 3,250,000 gal. The Upper Reservoir was about 150 feet higher than the original Main Reservoir at Yale and Central, which itself was about 215 feet above street level in the downtown area. Two electric booster pumps at the Main Reservoir, with 500 gpm and 300 gpm capacity, moved water to the Upper Reservoir.

Of course, as Albuquerque continued to grow and occupy more and more of the East Mesa, elevations were higher and higher and it became necessary to develop the system of pressure zones that began with the new Upper Reservoir. By the time the city reached the foot of the Sandias, the elevation difference between the highest and lowest customer connections was roughly 1,500 feet (equivalent to about 650 pounds per square inch water pressure), and there are now 12 pressure zones. The zones are inter-connected, but with pressure-reducing valves to prevent excessive pressures in zones below them.

The system in 1924 included some 29 miles of steel, and 2 miles of cast iron water mains, ranging from 4-in. to 14-in. diameter; all of the mains installed after the City's purchase in 1918 were 6-in. or larger. There were 275 double and triple fire hydrants, and the estimated demand was 2,500,000 gallons per day.

It would appear from the description on the 1924 Sanborn map that the various wells at the outlying "pumping stations" were not equipped with deep-well turbine pumps in the wells themselves, but that water was produced by electrically driven suction pumps at the surface. However, by the mid-1930s, electrically powered pumps, which would require no boiler to provide steam, and with a turbine pump deep in the well driven by a shaft from the surface, so that water could be raised from almost any depth, had become available (Figure 16). Such pumps would allow for placement of wells wherever it would be convenient, so that the supply would not have to be so concentrated at and near the water works and its large boiler plant.

The turbine pumps had come on to the market slowly. The first deep-well turbine pump was made by P.K. Wood, in Los Angeles, in 1897, but it was very inefficient and the Wood Company was short-lived. The Byron Jackson Company, also of Los Angeles, built its first deep-well turbine in 1901, and Mahlon Layne (soon to become the famous pump maker, Layne and Bowler) began to manufacture them in Houston in 1904. Many others came into the market in the 1920s; the pumps came into general use in the 1930s, and the numbers of irrigation wells with turbine pumps grew dramatically after World War II.

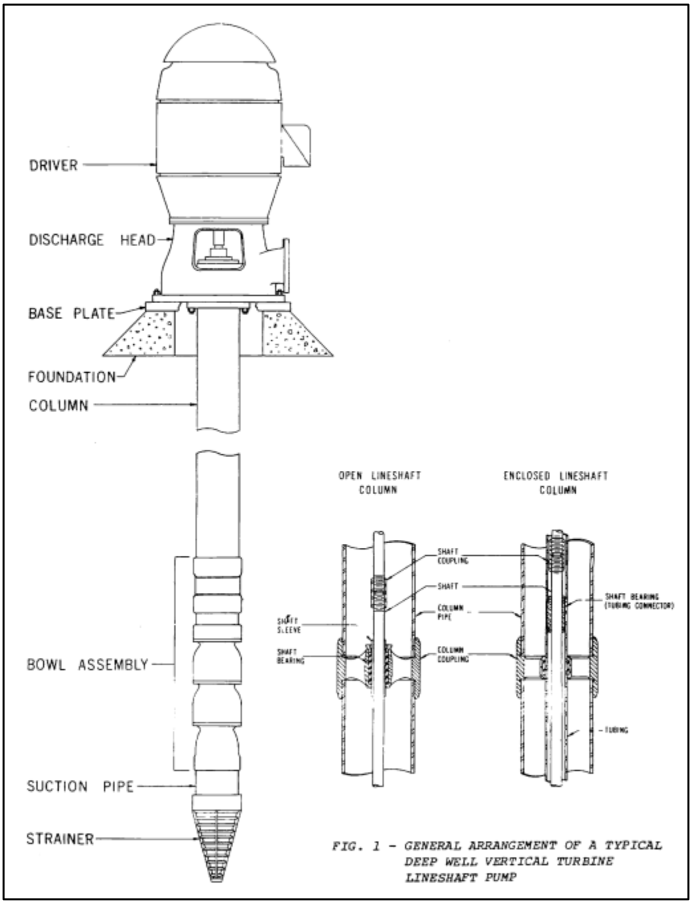

Figure 16. Diagram of a vertical turbine pump (from Layne Deep Well Turbine Pump Manual[10]).

It is not clear when the first such pumps came into use in the Albuquerque system. The first wells outside the shallow-water-table area along the Broadway corridor weren't drilled until 1950, but it seems very likely that some or most of the wells in the extended Main Plant well field would have been equipped with down-hole turbine pumps simply because the water table would have been declining due to the increasingly heavy pumping. The new pumps would allow for production of much more water from the existing wells, because the pumping water levels in the wells could be far deeper than the maximum suction lift.

[10] https://www.pentair.com/content/dam/extranet/web/nam/aurora/manuals/48579-layne-deep-well-vertical-turbine-lineshaft-pumps-iom.pdf

Reclaiming the Albuquerque Landscape

Although perhaps not an important element of the city's water supply system per se, the surface water in the valley ultimately provided the supply, either in the form of recharge to the groundwater system or directly, and the valley's irrigation system played a central role in shaping the geographic development of the city and its surroundings, and is worth some discussion. After 1880 the flooding and waterlogging problems in the valley continued and worsened. The flood of 1884, just as the city was beginning, may have been the worst in the valley's history—and the new water works was right in its path. A dike was built at Alameda in 1885 to prevent the river from re-entering the old, low channel down the eastern side of the valley, between Fourth Street and the railroad tracks, and inundating the new city, but the dike was breached in 1891 and again in 1904.

The area of irrigated land in the Middle Rio Grande, which would be sufficiently well-drained to serve as well for urban expansion, had decreased from a peak of about 125,000 acres in 1880 to 38,850 acres in 1889. The drainage survey in 1917-1918 (see Figure 17 for an example) showed that much of what is now the valley area of Albuquerque was "alkali" land, unsuitable for building because the water table was very close to the surface. If the trends continued, Albuquerque as it then existed, both Old Town and the new city, would have been in increasing danger of waterlogging and flooding, and growth would have been largely restricted to the East Mesa. A solution was desperately needed.

A petition was filed with the District Court in late 1923 to create a reclamation district to solve the problems, under a statute newly enacted by the New Mexico Legislature (Albuquerque Journal, December 29, 1923). Although the needs for flood prevention, drainage of swamp lands, and efficient delivery of irrigation water were clear to all, there were strenuous protests on the grounds that the individual farmers would not control the conservancy district and could not afford the assessments, and that the district was being organized to benefit not the farmers, but "people who see a chance for business advancement (Albuquerque Journal, December 15, 1923)."

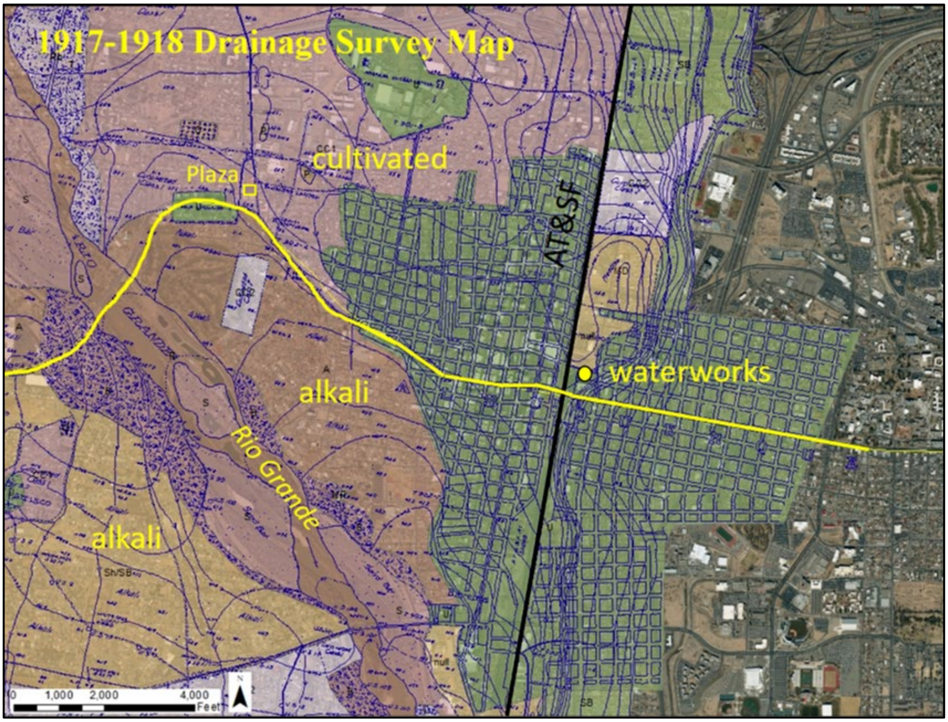

Figure 17. Excerpt from the 1917 Rio Grande Drainage Survey map showing the built-up area of Albuquerque in green, with cultivated lands in light brown and seeped "alkali" lands in darker brown. The yellow line highlights Central Avenue, and Old Town plaza is the yellow box near the upper-left corner. The old Fair Grounds is shown as the green area on both sides of Central Avenue just west of the plaza.

The difficulty facing the farmers was that, under the then-existing acequia system that supplied irrigation water to farms, the farmers themselves provided the labor to maintain the small-scale ditches and (often temporary) diversion dams, and costs were minimal. The water itself came to the irrigators without cost. The large-scale works of a conservancy district, on the other hand, would involve enormous construction costs and large annual operation and maintenance bills.

The Middle Rio Grande Conservancy District (MRGCD) was organized in 1923, but the controversy between the farmers and the proponents of the district continued, and prevented work from beginning, until a series of conferences organized by the Albuquerque Journal resulted in an agreement between the Middle Rio Grande Farmers Association and the MRGCD Board in January of 1930 (Albuquerque Journal, January 24, 1930). Federal funds had already been secured.

Work on the project in Albuquerque began in early 1930. On February 19, the Albuquerque Journal carried an article describing the dragline excavators—four large and eight smaller—that were about to be shipped to town, and quoted J.L. Burkholder, the District's chief engineer, as estimating that 25 million cubic yards of earth would be excavated in constructing the canals, drains, diversion dams and levees. Flood control for Albuquerque was a first consideration in the construction work, which was to begin with a celebration at the new Rio Grande bridge and continue with the drain ditch and a 10-foot-high levee, from the new bridge for 12 miles up the river to the bend in the river north of Alameda.

The MRGCD applied to the State Engineer on May 27, 1930, for a permit to appropriate the waters of the Rio Grande "by means of the El Vado Dam, and 198,110 acre-feet are to be stored in the El Vado reservoir and there used for storage to supplement the natural flow of the Rio Grande during the irrigation season, for the use and benefit of lands" within the MRGCD (legal notice, Albuquerque Journal, June 20, 1930). Work on the dam was to begin in early 1931. During the first six months of construction in the summer of 1930, over 70 miles of drainage canals and 50 miles of flood-control levees had been built. The project was expected to affect about 132,000 acres in the valley, of which about 45,000 acres were in cultivation (Albuquerque Journal, October 30, 1930).

"By 1935, the Conservancy District had built the storage dam at El Vado and the diversion dams at Cochiti, Angostura, Isleta, and San Acacia to manage its water. The Conservancy had also dug 17 miles of new drainage and irrigation canals, and incorporated another 214 miles of existing canal into the system. Nearly 200 miles of riverside levees and a system of jetties and checks alongside the river protected against floods (MRGCD website)." Much of the valley, including much of the land that became part of Albuquerque, had been restored to use. Figure 18, "before" and "after" views from approximately the same vantage point, shows the success of the drainage system in lowering the water table and making the land usable again.

Not all of the investment in the MRGCD came from Federal funds. Albuquerque Progress, in its June 1943 issue, reported that by that time the railroad had provided about $1.7 million to the project in addition to the taxes it paid to the County and State.

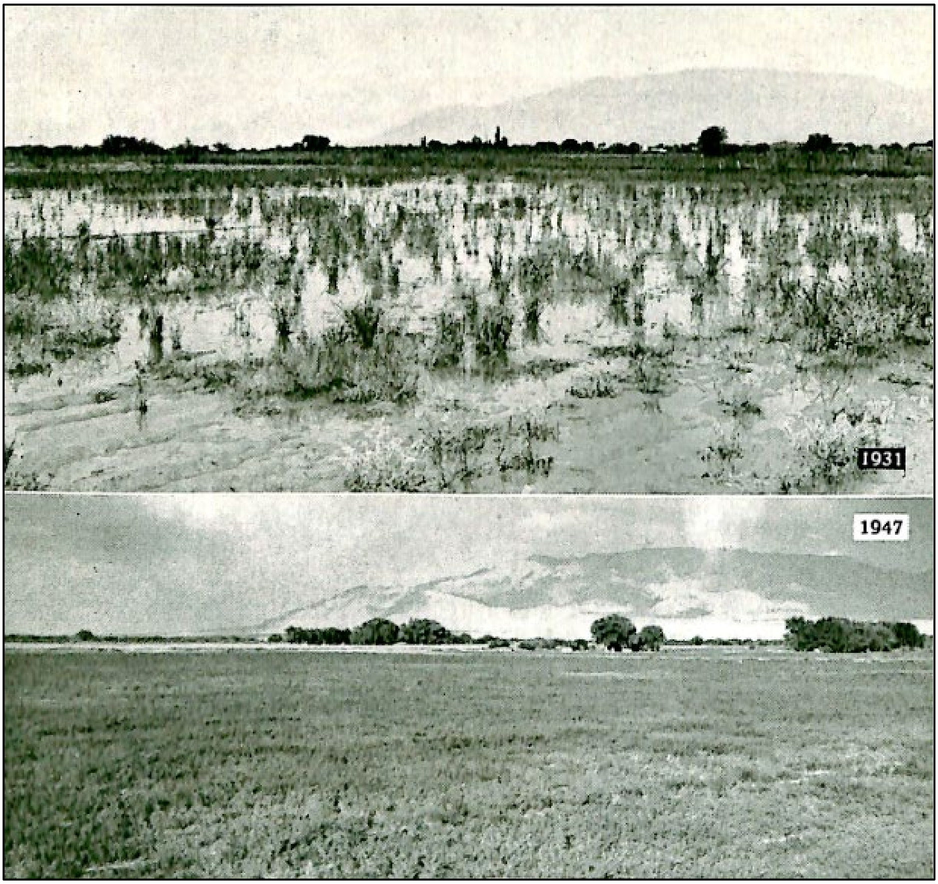

Figure 18. Views across the valley from approximately the same location in 1931 and 1947, illustrating the effect of the MRGCD drainage system in making land available for use (from Albuquerque Progress, December 1947; both images, Albuquerque Museum).

The December 1947 issue of Albuquerque Progress reported that the Conservancy District operated and maintained some 730 miles of irrigation canals, and 342 miles of drain ditches. The total investment had reached $11 million, and farmland under irrigation had increased from about 45,000 acres to 82,000 acres; but unfortunately, "the problem of the silting and rising river bed has returned…and the spring flood danger has increased to a new and more dangerous point. Increased water use and decreased water supply has created a serious situation in late summer for the past two years." The Bureau of Reclamation and the Army Corps of Engineers were formulating new flood control and water conservation plans, and new Federal funds were being sought.

The Congressional Flood Control Acts of 1948 and 1950 provided the needed federal help to MRGCD, and the Bureau of Reclamation spent more than $35 million to repair all of the district's dams and to channelize 127 miles of the river so that it could carry high flows more efficiently. The Army Corps of Engineers spent another $40 million on flood control reservoirs and levees, including the construction of a new dam at Cochiti that created the present-day Cochiti Reservoir. The district taxpayers' financial obligation for repayment to the Bureau of Reclamation was limited to $15.7 million—the cost of rehabilitating the irrigation works, which has been paid in full (from MRGCD website).

A large land area up and down the valley, on both sides of the river, had been made available for Albuquerque's growth.

The City's New Treatment Plant and Well Fields

The City's pumping plant at the Tijeras and Broadway site was mostly replaced in 1928 with a new treatment plant (Albuquerque Journal, January 13, 1929, several articles and advertisements). The treatment system, described by the Journal as the most modern in the West, had a capacity of 6 million gallons per day, and an average daily production of 1.5 million gallons; the cost was $175,000. The treatment system included processes to remove iron, soften the water, and disinfect it. Most of the cost of the plant would have been related to iron-removal and softening, which presumably were thought necessary because of some "hard-water" wells.

There were now three major components at the water works—a boiler and pump house, a filtration and softening plant, and a building housing a concrete settling tank (Figure 19). The plant operated 16 hours a day, five days a week, to maintain the supply of finished water sent to the Main Reservoir. R.L. Cooper, the City Manager, with Black & Veatch, consulting engineers from Kansas City, designed it, and the contractor was E.J. Marchant of Albuquerque. Clyde Tingley (Figure 20) was mayor at the time. The bond issue for the new plant was $164,700.

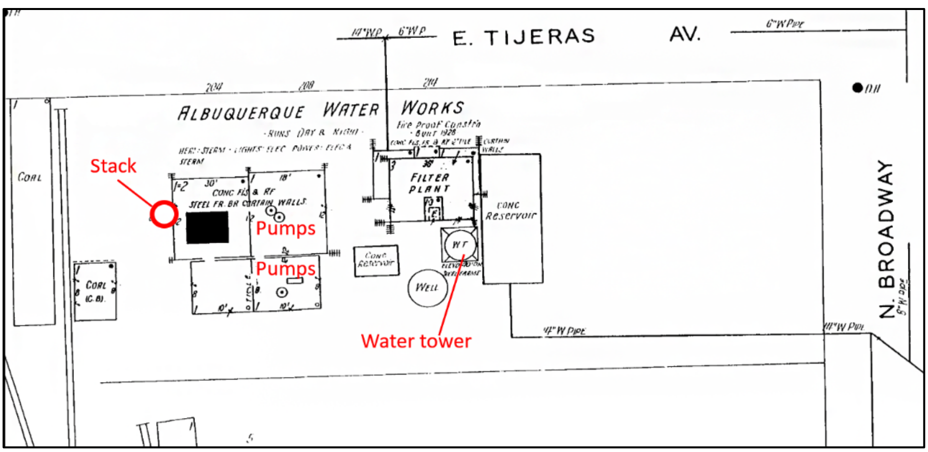

Figure 19. Sanborn map of the new water works, 1931. The boiler and pumps had been moved to the west end of the tract where the wool-scouring mill had been (red labels added based on 1947 map). Library of Congress, Geography and Map Division, Sanborn Maps Collection.

Figure 20. A later picture of Mayor Clyde Tingley, at his desk in 1945 (Albuquerque Museum).

The new buildings, along Tijeras Avenue between Broadway and the railroad, were in Pueblo style (Figure 21). The supply of water continued to come from the array of wells along the Broadway corridor, and was pumped into the filtration plant by a new Allis Chalmers pump (Figure 22), still steam powered, with a capacity of 4 million gallons per day. According to the page-one article in the Journal, two standby pumps, one with an electric motor and the other the old 3-MGD Gaskill pump, were there in case of emergency, but it seems more likely that they continued in their former roles, pushing water up to the main reservoir from the settling basin at the plant.

The filtration plant included a 22-foot deep, 17-foot diameter lime mixing tank; after a residence time of 10 minutes, the water went to the 85 by 35-foot, 15-foot deep, settling tank and then to a third tank in which alum was introduced to coagulate the iron in a floc. The water then passed through a sand filter tank and into a reservoir under the building. The system also included a chlorination process, but that was not in routine use. It would "remove all B [sic] Coli in case these germs should ever be found in the water (Albuquerque Journal, January 13, 1929)." In contrast, today's deep-well water is not thought to require softening, but all of the municipal supply is chlorinated.

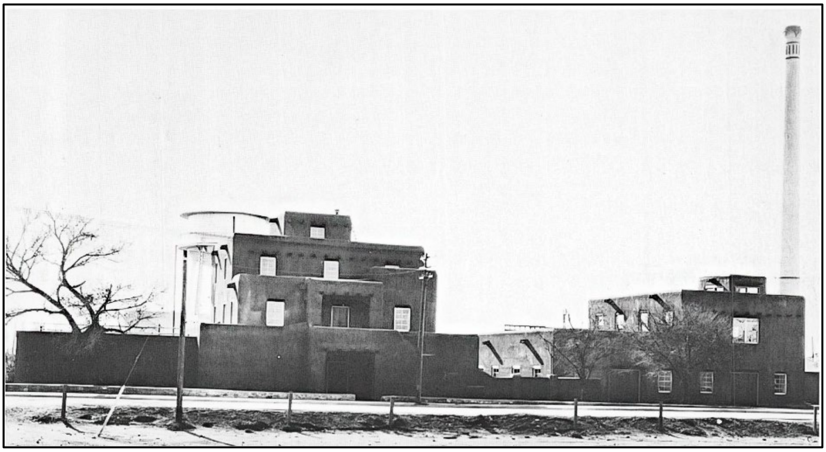

Figure 21. The main plant from the north side of Tijeras Avenue about 1930. The filtration plant is the larger building just left of center, and the boiler occupied the taller of the two buildings at the right, with its tall stack at the right-hand edge of the photo. The pumps were in a pit beneath the shorter building between the filtration plant and the boiler house (Albuquerque Museum).

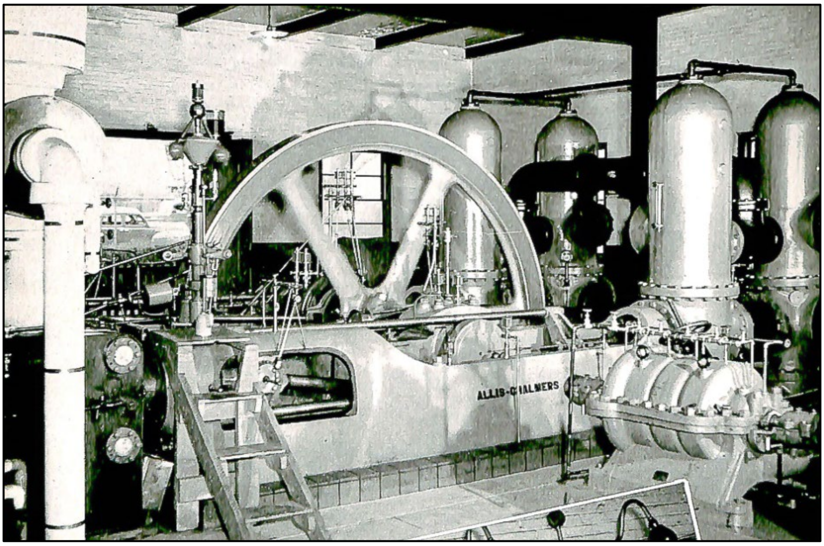

Figure 22. The steam-powered Allis Chalmers pump at the Main Plant, installed in 1928 (from Albuquerque Progress, June 1947; Albuquerque Museum).

Neither Old Town nor Barelas were within the City limits in 1930, and neither had access to city water or sewer, but the completion of a new bridge across the Rio Grande on Central Avenue was expected to lead to an increase in traffic and "a little boom" for Old Town that would justify annexation (Albuquerque Journal, January 10, 1930). The residents of North Albuquerque—that is, along Fourth Street north of Indian School Road—also were outside the City limits, and clamoring for water service, a major issue in the City Commission election of 1930. Democrat Clyde Tingley was the incumbent and Chairman of the Commission, the de facto Mayor, and seems to have favored extension of the water mains into the Huning Castle Addition east of the Country Club, where "there isn't a house," according to his detractors (Albuquerque Journal, March 29, 1930). The Tingley ticket included contractor Charles Lembke, also an incumbent, and E.N. Boule, a businessman whose father-in-law happened to be in charge of the water department. Henry Coors, on the other hand, promised that "if the People's ticket is elected we will first put sewers and water where there are houses and not in some subdivision where real estate men can get rich off the taxpayers' money (Albuquerque Journal, March 29, 1930)." Tingley won. He also promised to spend $300,000 on utilities for the North End.

By 1931, the Sanborn maps reflected some further expansion of the supply. The "1 large well at pump house with 30 driven points 60 feet to 200 feet" probably represented one 708-foot well and the 30 shallower drilled or driven wells at the original plant. There were four wells at Broadway and Mountain Road, and two wells at Broadway and New York Avenue, roughly today's Lomas Boulevard; all of these were probably on the current Post Office tract. There were now two wells at "E. Marble Ave. and Bernalillo Road;" Bernalillo Road on the Sanborn map was an extension of Edith Blvd. The well at Fifth Street and Mountain Road had been augmented by three additional wells. Curiously, in 1931, rather than being equipped with pumps as the wells had been in 1924, the wells now were "so connected that they flow into main well at [the] pumping station by siphon when water level is drawn down to operating level." The pumping capacity was now 10,250,000 gallons per day, with two steam-powered and one electric pump. The two reservoirs were still as they had been described in 1924, and there were 65 miles of 4-in. to 14-in. water mains and 400 fire hydrants. Water consumption was averaging about 2.5 million gallons per day, or 2,800 acre-feet per year.

Although most of the wells were very shallow, less than 100 feet deep, the City had augmented the "soft-water" supply from the 708-foot well drilled in 1903 with four more such wells by 1933. According to Bjorklund and Maxwell (1961, table 1) one of these, then called Main Plant No. 1, was near Broadway and Mountain Road in the (then) City equipment yard, and was 433 feet deep. Main Plant No. 2 was near Broadway and Granite in the equipment yard and was 442 feet deep, and Main Plant No. 3 was in Wells Park at Fifth Steet and Mountain Road, and was 550 feet deep. All three were drilled in 1932 by John F. Wolking, whose own equipment yard was conveniently located at the corner of Fifth Street and Marble Avenue. The original deep well, drilled in 1903, no longer existed at the time of Bjorklund and Maxwell's report.

The fourth soft-water well, Main Plant No. 4, was at the actual Main Plant at Broadway and Tijeras, and also was drilled by Wolking, presumably in 1933.[11] It may simply have replaced the 1903 well. The fourth well had an electric pump, presumably a lineshaft turbine pump, although that was not mentioned. The Albuquerque Journal of July 1 and 22, 1933, also reported that "the City has about 25 hard-water wells but doesn't use them all. The other three soft-water wells make 500, 800, and 1,000 gpm; the new one is tested at 1,000, may make 2,000—can supply even peak demand." The total depth of the fourth well had been planned to be 700 feet, with 275 feet of screen (Albuquerque Tribune, May 11, 1933), but it was actually drilled to 716 feet and perforated below 286 feet, if the description of Soft Water Well No. 4 in Albuquerque Progress of June 1947 refers to the same "fourth well" that was discussed in 1933 newspaper articles. The other deep wells reportedly each had 150 feet of screen. Figure 23 is the description of the cuttings brought to the surface as the well was drilled.

The U.S. Geological Survey topographic map of 1934 (Figure 24) shows that the city had expanded eastward beyond Girard Blvd., and was beginning to be built up for a few blocks past Carlisle Blvd. and along Ridgecrest Drive, so that some residences were almost at the elevation of the Upper Reservoir in Burton Park. To provide adequate pressure, and storage for fire flows, the city built a third reservoir near the Veterans Administration Hospital at the east end of Ridgecrest Drive south of Gibson Boulevard. The reservoir may have been a steel tank on the surface, the first of a great many to be built in later years, rather than a lined excavation as were the original Main Reservoir next to the UNM campus and the Upper or Burton Reservoir. The 1934 topographic map clearly shows the first two as excavations, but does not show a reservoir near the hospital.

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[11] Bjorklund and Maxwell give the drilling date as 1932, but the contemporary newspaper account is more likely to be correct.

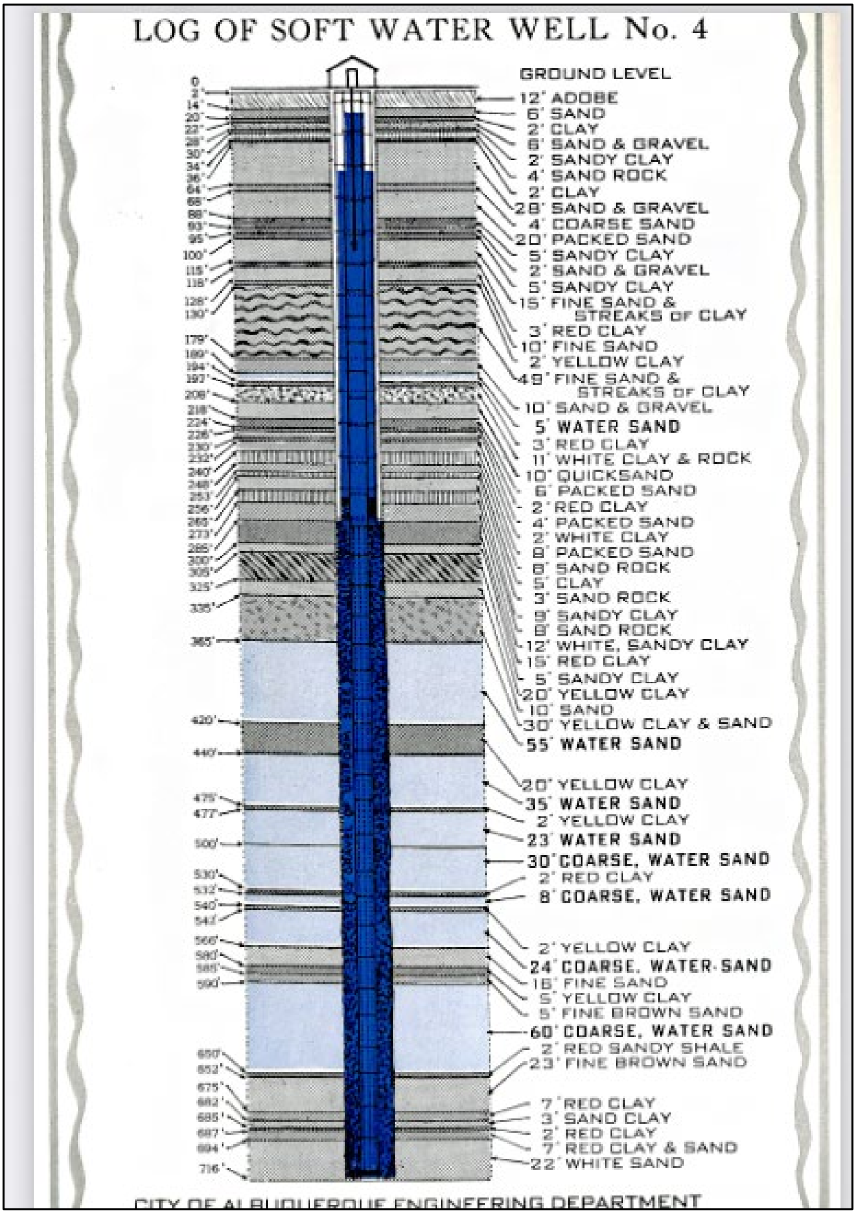

Figure 23. Driller's log of the strata penetrated by "Soft Water Well No. 4" at Tijeras and Broadway in the Main Plant well field, presumably drilled in 1933 (from Albuquerque Progress, June 1947). The well was cased through the water-bearing sands and gravels above 286 feet to exclude the shallower poor-quality water.

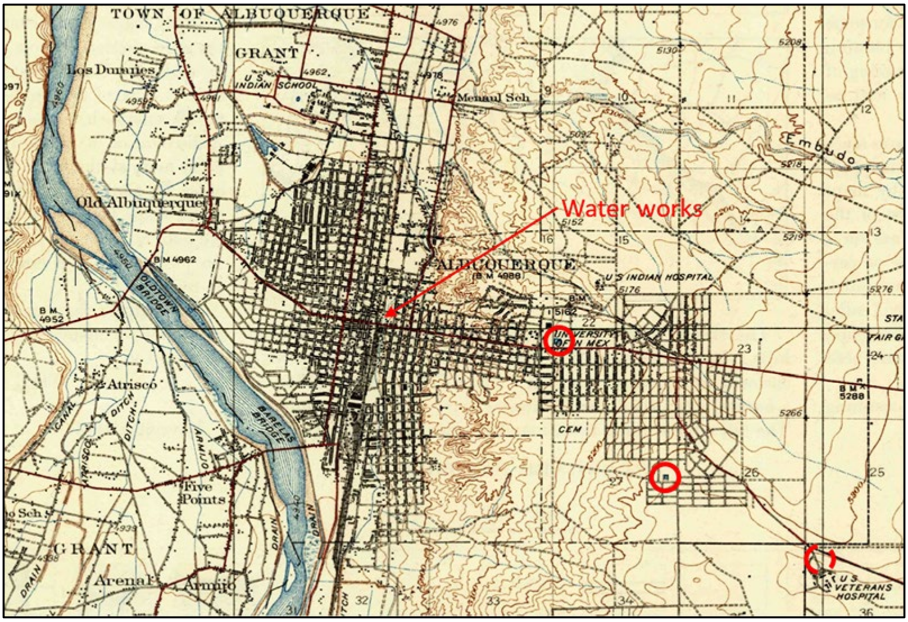

Figure 24. USGS Albuquerque topographic map of 1934, showing the Main Reservoir on the UNM campus and the Upper or Burton Reservoir to the southeast (solid red circles), and the approximate location of the reservoir near Veterans Hospital (dashed red circle). The location of the water works is indicated by a red arrow.

There were now three pressure zones, each with its own reservoir above it (by the 1980s the system had 12 pressure zones between the Rio Grande and the foot of the Sandias, and eight zones between the river and the far west mesa on the west side). The veterans' hospital was opened in 1932.[12] The original buildings were at about the same elevation as the city's reservoir, and the water supply for them would have been pumped from the reservoir. The hospital drilled its own 1,000-foot well in 1956 (Bjorklund and Maxwell, 1961) and installed its own water system in 1957, although by then the City system had expanded much farther to the east and could have continued to supply it. The City's reservoir near the hospital, not the same as the Ridgecrest Reservoirs in the present-day system, has not been in service for many years.

Bjorklund and Maxwell (1961, p. 30) indicate that there were six wells in service in 1933, counting the many drilled and driven wells at the main pumping plant, which they termed a "battery," as a single well. It would appear that some of the

[12] https://www.va.gov/new-mexico-health-care/about-us/history/

wells enumerated on the 1931 Sanborn map were already out of service, although they may have continued to exist.

Charles Lembke became Mayor in 1935, and was able to report to the Albuquerque Rotary Club on September 19, 1935 (Albuquerque Tribune) that in 1934 the water system had delivered 815 million gallons to 7,162 connections, generating revenue of $209,715—and had shown a profit of $131,155. At that point, the water department had an accumulated surplus of $159,074.

The financial situation was dramatically better than it had been during the privately owned Water Company days, but some customers were not happy with the rates. The University of New Mexico was one example. In early 1933, the University asked the City for a reduced rate, but was rebuffed and the University's Engineering Department was looking into putting the long-unused, on-campus well back into service (Albuquerque Journal, July 4, 1933). Many other large water-users continued to expand their own supplies. Also in 1936, for example, the Alvarado Hotel, a part of the railroad's complex, drilled a new 60-foot, 12-1/2 in. diameter well for "air-cooling the buildings," that is, for operating the swamp coolers. The drinking water and water for other uses was already being provided by 500-foot wells at the railroad shops (Albuquerque Journal, June 25, 1936).

The railroad had built its own reservoir in 1919, along Commercial Street at the southeastern end of the complex. It was a large cistern, partly below grade, measuring 32 feet by 182 feet and with a concrete, shallow-pitched gabled roof. The Sanborn maps indicated that the reservoir was 6 feet deep, which would lead to a capacity of 261,000 gallons (if the walls were vertical). There were also three above-ground tanks, along with one of the wells, and a small treatment plant just north of the reservoir (National Park Service, National Register of Historic Places).

The City's water-operations surplus funds would soon be put to good use. In November of 1936, City Manager Charles Wells (after whom one of the City well fields in the northeast heights would be named much later) reported to the City Commission that another new deep well would be needed to meet the summer demand in 1938. Although the existing wells had been adequate for the summer of 1936, and probably would get the City through the summer of 1937, they might not suffice for the summer after that. The Commission had received a letter from the National Tube Company, the supplier of most of the pipe for the water mains, that the prices of pipe would be increasing by 10 percent, and after Wells' report, the Commission directed him to buy as much pipe as he could foresee a need for before the price increase went into effect (Albuquerque Journal, November 25, 1936). The

City had already purchased a house and five lots at Fifth and Mountain, "near a deep water well" already in the system, for $6,000 as a site for future wells (Albuquerque Tribune, May 25, 1936). Figure 25 is an aerial view of the water works and the tract to the south of it between Broadway and the railroad.

Figure 25. The Albuquerque water works in 1936, with buildings and a water tower on the right-hand side of the image. Broadway is in the foreground, and Tijeras Avenue is just out of the picture on the right (Albuquerque Museum).

As the system developed, beginning about 1935 new wells were added at an average rate of a little more than one well per year. Bjorklund and Maxwell (1961, p. 30) assembled the records, and the results, both the numbers of wells in service and the annual total amounts pumped, are shown in Figure 26. Many wells were added to the city system in the late 1940s in the new Candelaria well field near Broadway and Candelaria Blvd., and in the new San Jose well field along Broadway south of Gibson Blvd.

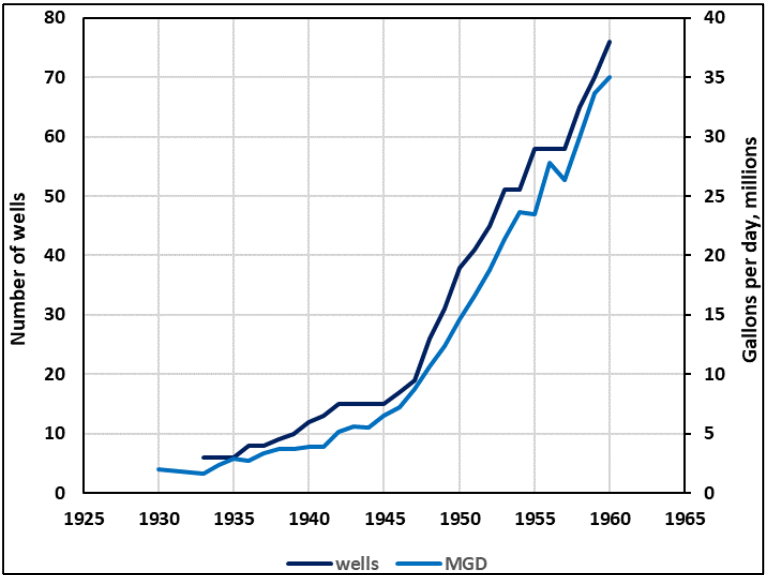

Figure 26. Cumulative number of City-owned supply wells by year, and average daily pumping from City supply wells in millions of gallons (MGD), 1930-1960. From Bjorklund and Maxwell (1961, p. 30). The graph does not appear to include the shallow wells at the Main Plant, some of which were still in service in the 1930s and 1940s.

Although the water-quality benefit of drilling deeper wells was recognized, some new wells were still very shallow. For example, and to illustrate the water-quality distinction between the shallow and deep wells, the City brought in a "big soft water well at shallow depth of 98 feet" at Broadway and Mountain Road in 1937. The hardness of the water was reported as 6 grains per gallon, whereas the hardness of water from other shallow wells had typically been 12-1/2 or 13 grains, and even up to 20 grains per gallon. In contrast, water from the deep "soft-water" wells, 400-500 feet or deeper, typically had 7-1/2 grains per gallon hardness (Albuquerque Journal, June 26, 1937). "Grains per gallon" is an obsolete measure of chemical concentrations in water, and to put those numbers into the milligrams per liter units in use today, we multiply by 17.1. Hardness is a measure only of the concentration of calcium and magnesium ions in the water, and is not to be confused with total dissolved solids concentration.

During the late 1930s, a proposed plan to divert the Jemez River near San Ysidro and pipe water into Albuquerque was much in the news, almost as much as the proposal to install parking meters. One wag noted that "maybe a mathematician could figure which bobs up oftenest here, the parking meters or the Jemez water project (Albuquerque Journal, May 15, 1939)." In 1936, the City retained Black and Veatch, the Kansas City engineering firm, to give an opinion on the project. Black and Veatch thought that the City had an ample supply for the future in the form of groundwater, and that it could be developed at less cost than the Jemez project (Albuquerque Journal, November 22, 1936), although some people thought that, over time, it would be less costly to operate than the system of wells, and it would supply better-quality, that is softer, water.

The initial cost of the project would be $2,250,000 to $3,000,000, and the federal Public Works Administration (PWA) had approved a grant for $1,200,000 (Albuquerque Journal, June 29, 1938). The surface-water supply would also have the virtue of indefinite renewability, which may not have seemed important at the time, but it would be today.

The City in 1938 hired Greeley and Hansen Engineers, from Chicago, to study the idea, and their conclusion was that over a 30-year period, the Jemez project would supply the city at lower cost, a total of $5,489,850, which would compare with $6,652,280 for the continued operation and improvements to the existing system without water-softening treatment, or $7,312,250 if treatment were included (Albuquerque Journal, September 1, 1938).

A little later in 1938 the grant approval was rescinded by the PWA because Texas had objected on the grounds that the project would affect the flow of the Rio Grande by diverting water from its tributary, the Jemez River (Albuquerque Journal, September 24, 1938). The Rio Grande Compact, allocating the flow of the river among the states of Colorado, New Mexico and Texas, was negotiated in 1938, and although it did not take effect until May 31, 1939, Texas was in no mood to countenance a potential threat to compliance by New Mexico. The newspaper articles do not tell us whether the estimated costs included the purchase of water rights, or whether the New Mexico State Engineer had commented on the proposed project.

Even though the PWA grant was no longer available, the Jemez project discussions continued, although there seems to have been little enthusiasm on the part of the public. In their report, Greeley and Hansen had calculated that there would be little savings in the first 10 years, which was a significant negative in the eyes of the City Commission (Albuquerque Journal, April 26, 1939), and that water rates would be no lower. On September 8, 1939 (Albuquerque Journal), City Manager Charles Wells announced that "we've been going ahead expanding our water system with additional wells for months. We had stopped considering the Jemez job long ago."

In early 1938, the outstanding bonds for water supply, the reservoir and reservoir improvements, water-main extension, and water-works improvements totaled $953,000, of which about 42 percent was for "water supply," presumably well drilling (Albuquerque Journal, March 2, 1938). During the fiscal year ending June 30, 1938, the Water Department had an operating profit of about $76,000, based on revenues of $272,878, and the Department's earnings had been sufficient to meet the need for extensions and replacements so that no new bonds had been issued since 1930. About seven miles of new water mains and one new well had been added to the system that year (Albuquerque Journal, October 2, 1938).

The system seems to have fallen behind again in supplying demand in the late 1940s. The June 1947 issue of Albuquerque Progress reported that lawn-watering had been limited to alternate days in the summer of 1946, but that the condition was temporary and not due to lack of water supply. Seventeen deep wells were in service, and the addition of pumping capacity at the Main Plant (called the Tijeras Station in the article) had been delayed by deferred delivery of equipment that had been on order for a long time. The demand for 1947 was estimated at 2.9 million gallons per day. The system then had more than 400 miles of water mains, and served more than 13,500 connections, about 2,500 of which were outside the city limits. The investment in the water system had risen from $406,046 in 1920 to $2,492,368 in 1947. An addition to the Main Plant was under construction, as shown in Figure 27.

The late 1940s were dry, and as had happened often before, the system was still not able to keep up with summer demand. In the summer of 1948, lawns and other landscaping north of Central Avenue could be irrigated only on odd-numbered dates, and south of Central only on the even-numbered dates—although a rain on August 4 was enough for City Manager Wells to declare a "holiday" and allow unrestricted watering on the next Sunday (Albuquerque Journal, August 6, 1948).

After the end of the 1940s, the new wells were widely distributed, as they now conveniently could be with the availability of turbine pumps that could raise water from depths far beyond the theoretical suction lift. The actual extent of the aquifer, in terms of both area and depth, would certainly have been of great interest to the City's water-planners, and remarkable new information about it became available in the late 1930s. The evolution of understanding of the aquifer is discussed in the next section.

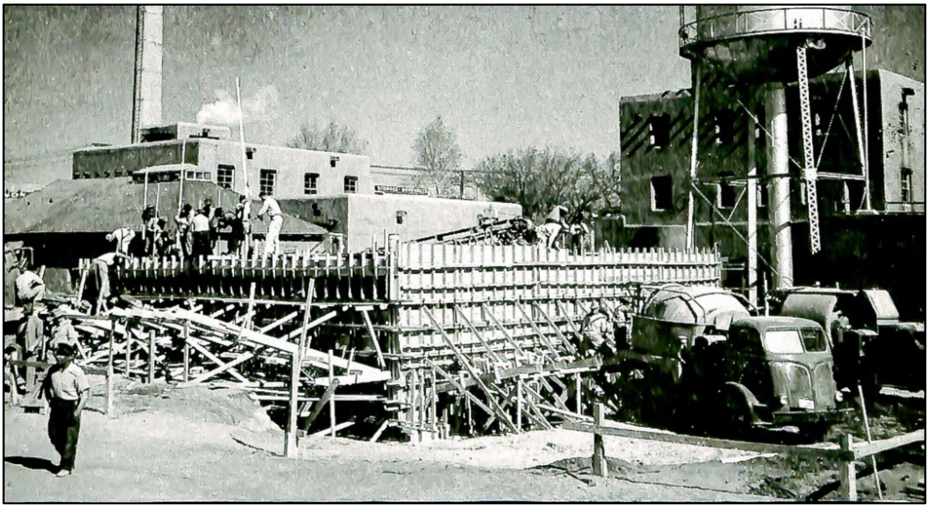

Figure 27. The Main Plant in the summer of 1947, with the building housing the boiler and the "big pumps" on the left, the 1928 filtration plant on the right behind the water tower, and a new addition under construction in the foreground (from Albuquerque Progress, June 1947; Albuquerque Museum, gift of Albuquerque National Bank).

Slowly Discovering a World-Class Aquifer

By the end of the 1960s, the aquifer beneath Albuquerque was understood to be a highly permeable, water-saturated body of valley-fill sediments extending from the Rio Puerco valley to the foot of the Sandias, and to sea level or below, all the way from somewhere north of Bernalillo to south of the Valencia County line (see e.g., Bjorklund and Maxwell, 1961; Kelley, 1977). Research has continued since then, and the picture has been modified since 1960, but the basic configuration of a highly productive aquifer, extending to several thousand feet under the entire city and beyond, has been confirmed. The City drilled three test wells to depths below 3,000 feet in the northeast heights in the late 1980s,[13] and found good-quality water in relatively permeable beds at those depths. The deepest drilling in the valley has been the Shell Oil Isleta No. 2 oil test,[14] about 2 miles northwest of Isleta Pueblo, which reached 21,266 feet without drilling out of the valley-fill sediments.

What eventually was recognized as a vast potential groundwater resource began to be understood only slowly, and the businessmen, city officials, and engineers that managed the water system can be forgiven for not realizing that it existed: the geologists didn't see it either. Albuquerque's situation in a very deep rift, filled with alluvial sands, gravels, and clays—and water—had not been understood until wells went deeper, and were drilled farther from the water company's original Main Plant well field. Just as importantly, the sources of the water in the aquifer, and the quality of that water and the ways it changed during its passage through the ground, began to be recognized.

Maj. W.A. Rankin was many years ahead of his time in recognizing the possibilities for groundwater under the east mesa. In 1895, he was negotiating the purchase of a drilling rig with which he proposed to drill a 1,000-foot well on his east mesa ranch; he also was expecting to drill wells for other homesteaders on the mesa. At that time, there were reportedly three wells on the mesa, belonging to "Messrs. Sulzer, Lamparter, and McCowan (Albuquerque Journal, May 5, 1895)." The same article praised the water available at 200 to 250 feet as unsurpassed in quality, and adequate for irrigating from 5 to 10 acres from each windmill well. The author of the article speculated that "with a hundred or so windmills and engines pumping water on the thirsty soil of that district it would not be long until the

[13] Thomas No. 5, near Wyoming and Montgomery; Charles Wells No. 5, near San Mateo and I-40, and Love No. 8, at Pennsylvania and I-40.

[14] API No. 30-001-20003.

landscape would be dotted with some of the most thriving orchards, gardens, and beautiful homes to be seen in the southwest." There seems to be no record of Maj. Rankin's well.

Clarence L. Herrick, President of the University of New Mexico from 1897 to 1901, was a geologist (and also a comparative neurologist).[15] He published a geologic study and map of the Albuquerque topographic sheet in 1900 (Herrick and Johnson, 1900, p. 183), and gave his opinion that the shallow aquifer tapped by a few wells on the east mesa "does not extend much below the water level in the river." Herrick and Johnson described two wells on the mesa, which may have been among the three mentioned in the 1895 Journal article; one of these wells was "rather south of east and about four miles from the city," and was 370 feet deep, the lower 25 feet of which was a water-bearing zone. That location would be at about the longitude of San Pedro Blvd., some distance south of Central Avenue. What appears to be a dike around an oval reservoir of more than 30 acres appears on both the 1934 aerial photo and the 1934 USGS East Albuquerque topographic quadrangle, just south of Central Avenue and east of Wyoming Blvd., but it would be about 5.8 miles east of the railroad tracks. Another well "not more than 2 miles east of town" was reported by Herrick and Johnson to be 214 feet deep. This may have been Martin Stamm's Terrace Addition well near Carlisle Blvd. and Coal Avenue, discussed in an earlier section, although that would be about 2.5 miles east of the railroad. Clearly, neither of these two old wells penetrated more than a few feet or tens of feet into the aquifer, and gave no hint of a great thickness of saturated valley fill.

Herrick and Johnson (p. 186) did, however, conclude that the Albuquerque Basin was a down-dropped block, formed by a displacement on a number of faults, and that some thickness of geologically young sediments had been deposited "in this sunken area."

The University of New Mexico drilled its first well in late 1903 (Albuquerque Journal, May 4, 1903). It was 240 (or 250) feet deep, with 6-in. casing, and was originally pumped with a windmill. The well is shown on the 1908 Sanborn map about 220 feet east-northeast of the northeast corner of the Main Building, now Hodgin Hall, just north of what is now Redondo Drive (Figure 28). The windmill can be seen behind the trees to the right of Hodgin Hall in an early photo (Figure

[15] Herrick was a particularly well-prepared educator. In addition to his capabilities in geology and neurology, University records indicate that he was Professor of Psychology, Philosophy, and Biology.

29). The 1908 map shows an 8-hp electric motor, which may have powered a pump jack, and the depth to water in the well was about 200 feet. The University had its own reservoir about 480 feet east of Hodgin Hall, where Parsons Grove, just west of the Communication and Journalism Building, is today. This well also tapped only the uppermost fringe of the aquifer.

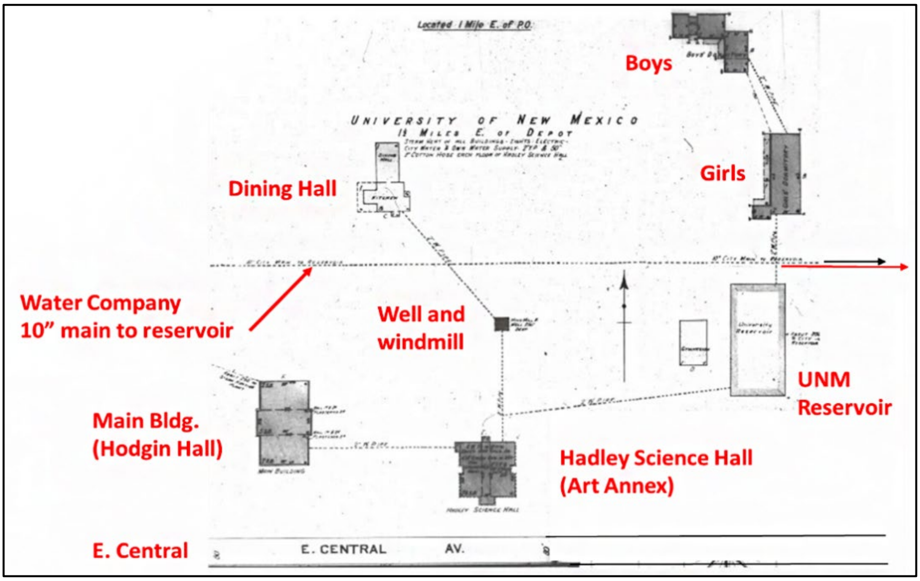

Figure 28. Sanborn map of the UNM campus, 1908, with red labels added, showing University well and reservoir. Hodgin Hall is the only one of the buildings still in existence. Library of Congress, Geography and Map Division, Sanborn Maps Collection.

Figure 29. View of the UNM campus from about the corner of today's University Blvd. and Central Avenue. Hodgin Hall is to the left, the now-vanished Hadley Hall to the right, and the windmill over the University well between them (photo from Center for Southwest Research, UNM Libraries).

Another UNM professor, the bacteriologist and chemist John Weinzirl, studied the city's groundwater supply and the water-quality issues with the water system, and published a paper in 1905. His principal interests were in the prevention of water-borne disease by proper management of the water system, and in the chemical characteristics of the water itself, such as hardness and the concentrations of sodium, magnesium, and sulfate, and their health effects.

Weinzirl's investigation related to water quality also included a study of the directions of flow in the aquifer, and the sources of chemical constituents, which in turn led him to consideration of the configuration of the aquifer itself. He drew a cross-section from the Rio Grande eastward through the City's well field, the University's new well, and the Military Well (discussed below), all the way across the East Mesa to the Sandias (Figure 30), showing the position of the water table and the depths to the "first," "second" and "third" water levels, or water-bearing intervals, in the City's 1903 deep well. Weinzirl's dashed line showing the position of the "Granite Walls," in effect the bottom of the aquifer, is tentative to say the least, and he did not venture a guess as to the depth to bedrock under the city.

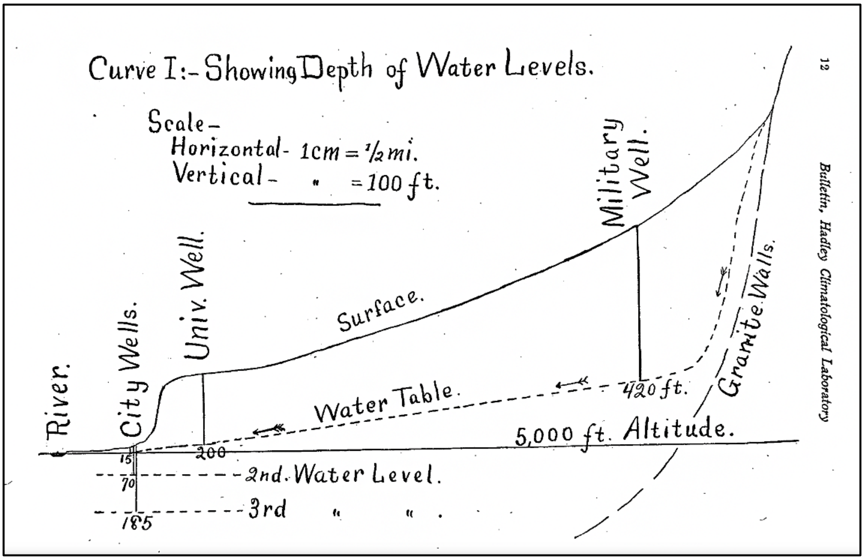

Figure 30. Weinzirl's (1905, p. 12) cross-section from the Rio Grande on the left to the foot of the Sandias on the right, showing the position of the water table in wells on the East Mesa. The "Granite Walls" presumably represent the bedrock surface beneath the valley-fill sediments that constitute the aquifer.

Weinzirl's report includes chemical analyses of water from the river; from the water system representing a composite of all the wells; from the University's new well; and from the Military well, which he summarized graphically as shown on Figure 31. All of the water-company wells were more than 70 feet when the report was written in 1905, but some were as shallow as 20 feet deep when the composite sample was collected in October 1904 (p. 17-18; see Figure 32). Weinzirl also published the earliest analysis of the water from the public supply as sampled in about 1895, and an analysis of water from the Water Supply Company of Albuquerque's 1903 deep "soft water" well (Figure 32). Weinzirl recognized that the chemical characteristics of the river water and the "mountain" water represented by the sample from the Military well were significantly different, and that the water from the city system's wells was a mixture of both. The mountain water was the better of the two, and "we may say that, if the supply of mountain water is positively known to be fully adequate to meet any demand that is likely to be made upon it, then it may be somewhat the more desirable of the two; but if the quantity is uncertain, then the valley … source becomes in general the more satisfactory," because of its "inexhaustible" nature (Weinzirl, 1905, pp. 15-16). He concluded that the aquifer beneath the East Mesa was recharged by runoff from the west face of the Sandias, and the aquifer in the inner valley was recharged by river water. He may not have recognized that, under the natural conditions that prevailed before irrigation began in the valley, the river was actually a groundwater drain, and that the water at shallow depth in the inner valley resembled river water because of recharge from irrigation ditches and irrigated farmland.

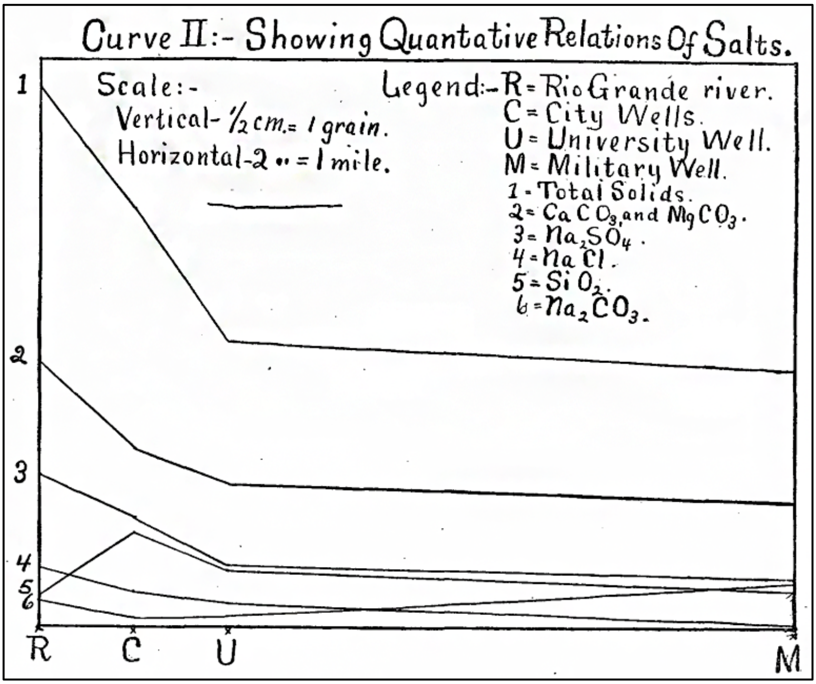

Figure 31. Weinzirl's (1905, p.13) graphic summary of water analyses for the Rio Grande, the City system, the University's 1903 well, and the Military well. The horizontal scale is distance from the river to the Military well, and the letters R, C, U, and M represent the respective wells; the vertical scale represents concentrations of major chemical constituents in grains per gallon. This reproduction is not at the same scale as the original; the vertical axis range is from zero to approximately 24 grains per gallon, and the horizontal axis represents roughly 9.5 miles.

Weinzirl's sampling also showed that the deeper water beneath the inner valley, and produced from the 1903 "soft water" well was indeed softer, in terms of calcium and magnesium concentrations, than the shallow groundwater, even though the total dissolved solids concentrations were similar, if not somewhat higher in the deeper water. The two analyses are reproduced in Figure 32.

A, 1903 "soft water" well

Sodium Chloride	1.03 grains per U.S. gal.
Sodium Sulphate	5.25 grains per U.S. gal.
Sodium Carbonate	1.71 grains per U.S. gal.
Calcium Carbonate	3.71 grains per U.S. gal.
Magnesium Carbonate	1.70 grains per U.S. gal.
Iron and Aluminum Oxides	.25 grains per U.S. gal.
Silica	4.92 grains per U.S. gal.
Cryst. Water, etc	.18 grains per U.S. gal.
Total solids	18.75 grains per U.S. gal.

B, 1904 composite system sample

	Parts per 1,000,000	Grains per U. S. Gal.
Sodium Chloride	25.34	1.48
Sodium Sulphate	78.49	4.58
Sodium Carbonate	5.89	.34
Calcium Carbonate	103.95	6.06
Magnesium Carbonate	24.68	1.44
Iron and Aluminum Oxides	1.20	.07
Silica	67.20	3.92
Total	306.75	17.89
Total residue heated to 150°C. for 1 hr.	304.00	17.72
Free Ammonia	trace	trace
Albuminoid Ammonia	.13	.0076
Hardness (by soap method)		7.19°

Figure 32. Water analyses (A), for the 1903 deep "soft water well," sampled in July 1903, and (B) of a sample taken in late 1904 from the distribution system and representing a composite of all of the producing wells (Weinzirl, 1905, pp, 6 and 8). Although the total dissolved solid concentrations are similar, the hardness of the system composite would be significantly higher.

As part of his discussion of the water system, Weinzirl described the long-standing issues related to stagnation of water in the reservoir, a "difficulty … encountered by all cities having such reservoirs, the trouble becoming so pronounced during the summer months that the water is largely abandoned for drinking purposes," but he concluded that draining and cleaning every three months, and a 1 part per million copper sulfate treatment to kill algae, if and when needed, would solve the problems (p. 16).

Kirk Bryan was born in Albuquerque in 1888, did his Bachelors in Geology at UNM, and went on to become a Yale Ph.D. and a distinguished Harvard professor. His Bachelors-degree paper (Bryan, 1909, pp. 6-7) provides a log of the 1903 "soft water" well and summarizes the geology of the valley as it was then known.

Bryan reasoned, from geologic evidence, that "…there existed at Albuquerque a deep trough…that it was erosional and caused by a strong through-flowing river seems evident…" The trough is now understood, not to be an eroded canyon that had been partly refilled with sediment, but rather to be a very complex down-dropped zone created by tectonic forces, bounded on the east at the foot of the Sandias by faults, and on the west by the many faults of the Rio Puerco fault zone (see, e.g., Kelley, 1977). The rift has indeed been filled with sediment by a through-flowing river, which has been blocked naturally at times so that lakes have formed, then re-connected by the river. Erosion has cut a few hundred feet back down through the accumulation of sedimentary beds, but recent geophysical studies indicate that the Rio Grande trough beneath Albuquerque contains some 6,000 to

10,000 feet of river-borne sediments (see, e.g., Grauch and Connell, 2013, fig. 5), the actual thickness varying from place to place.

A military post was proposed by Albuquerque boosters on the East Mesa and, probably in 1904, a well was drilled about seven miles east of town to supply it (Weinzirl, 1905, p. 10). It is not clear who actually owned the well or how it was financed. If the well was near the then-existing road that ran directly east from the Railroad Avenue railroad crossing, the location would have been somewhere close to present-day Central Avenue near Eubank Blvd. The 1934 aerial photo shows a cleared tract of about 13 acres just north of Central and about half-way between Eubank and Juan Tabo Blvds. that may have been the site. The depth to water in the Military well, as it was known, was 420 feet (Lee, 1907, p. 34), roughly 130 feet above the level of the Rio Grande, and the well itself must have been deeper. The water was of excellent quality, with 197 ppm (parts per million, equivalent to milligrams per liter) total dissolved solids. The military post never materialized.

In 1906, the members of the Commercial Club discussed a "proposal to plant some 640 acres in winter wheat on the mesa east of the city, at the Military well, and give the Campbell dry farming system a thorough test (Albuquerque Citizen, Aug. 1, 1906, p. 5)." The yield of the well must have been promising, although farming under the Campbell system would not have required irrigation because the scheme relied on specific soil treatments to retain the natural precipitation. The principles of the system were deep plowing in the fall, subsurface "packing" with an implement Campbell had designed, light seeding, thorough cultivation before and after seeding, and summer fallowing, with thorough tillage (which he called "summer culture") during the fallow period. Campbell believed his system would make family farming feasible on the Great Plains (see, e.g., Encyclopedia of the Great Plains, "Hardy Webster Campbell").

As late as 1921, N.H. Darton, the pioneering geological explorer of the West for the U.S. Geological Survey, thought that the Sandia Mountains were part of the eastern limb of an anticline, and that the Rio Grande valley to the west of the Sandias was a broad syncline in which the succession of bedrock units was present. He recognized the faults along the west front of the Sandias, but did not understand that they dropped the bedrock block of Rio Grande valley by many thousands of feet, and he apparently did not know about either the Military well or the water company's deep well (Darton, 1922, p. 220), and so did not know that many hundreds of feet of valley-fill sediments had been found to be present.

The dawning of the understanding of the Rio Grande valley as a very deep, fault-bounded and sediment-filled rift probably came in the late 1930s. The Norins Realty Co., of Los Angeles, bought and subdivided about 5,700 acres of the Elena Gallegos Grant, and in 1931 platted North Albuquerque Acres. Presumably as part of the sales effort, because each of the small lots was sold with an undivided interest in the oil and gas under the entire tract, Norins kept an oilfield drilling rig going for five years, from 1935 to 1940, drilling two test wells.[16] The first was near today's Beverly Hills Avenue just east of Louisiana Blvd., about 0.9 mi almost due south of the Sandia Hotel and Casino. It was drilled in 1935 to 575 feet, and was converted to a water well. The second test was about 2,000 feet south of Paseo del Norte and 700 feet west of Wyoming Blvd. in what is now the Palomas Park subdivision. Although it was a failure as an oil well and was not completed as a water well, it did demonstrate that the valley-fill sands and clays, potential aquifer material, were at least 5,024 feet thick, the total depth drilled.

The nature of the aquifer, as well as its extent, was better understood as wells were drilled. The shallowest beds in the valley-fill aquifer were very weakly consolidated, and the well-construction methods of the time were not effective in preventing sand from entering a well during pumping. Pumping led to serious land subsidence around some of the City's wells. The City declined to allow an easement in an alley for a building-owner to drill a well to supply an air-conditioning system, presumably with evaporative coolers, because, according to City Manager Charles Wells, "there is a definite danger of heavy withdrawals of sand from water wells causing nearby buildings to settle," and "the land has settled for 100 feet in diameter about one of our City wells. The settled space is large enough to throw a boxcar into it. Of course this well is where no damage could be done to buildings (Albuquerque Journal, September 16, 1938)." The City did not want to incur any liability by allowing others to drill wells on City property.

In contrast to the shallow, river-reworked alluvial sands and gravels, the beds at depth in the valley fill include conglomerate, sandstone, siltstone, shale, and lava flows, all full of water. Part of the sequence of these beds was originally named the Santa Fe marl by Hayden (1869); the geologic unit is now called the Santa Fe Group, with many subdivisions, and is the subject of an extensive literature (see, e.g.,

[16] See N.M. Oil Conservation Division records, Norins North Albuquerque Acres No. 1, API No. 30-001-00505 and Norins North Albuquerque Acres No. 2, API No. 30-001-05005.

Connell, 2008). Hayden described the surface exposures of the "Santa Fe marl" but did not recognize the great thicknesses that exist in some parts of the rift.

The valley-fill aquifer contains an enormous volume of water. In 1977, geologist (and Albuquerque realtor and state representative) Philip R. (Bob) Grant—no relation to Angus Grant—published the remark that the volume of recoverable fresh groundwater in the Albuquerque subregion is around 70 percent of the amount of water in Lake Michigan (see, e.g., Albuquerque Tribune, April 12, 1977). That remark was seized upon by Albuquerque boosters to support a claim that we had a more-or-less endless water supply, and sometime later, the City's advertising materials even changed lakes to make the number bigger. The comparison was made to Lake Superior, which is, of course, more than twice as large as Lake Michigan.

Once it became clear that Albuquerque's water supply is in fact limited, not by the total volume of water in the ground, but by the amount of water we can take under the terms of New Mexico's interstate compact with Colorado and Texas, Bob took some criticism for what seemed to be an outrageous statement. But Bob was right. In the first place, the calculation of the amount of water, 2.5 billion acre-feet, which looks like a supply that would last for thousands of years, had been made two years earlier by the U.S. Geological Survey, and Bob simply translated their number into something people could visualize and compare with Bernalillo County's groundwater pumping at the time, around 95,000 acre-feet per year (Sorenson, 1977, p. 17). And the "Albuquerque subregion" that the USGS and Bob were referring to encompassed the whole Rio Grande valley from the Colorado line to Elephant Butte, not just Albuquerque itself. The water the USGS estimated was, and largely continues to be, in place in the aquifer. Unfortunately, it cannot be pumped at any meaningful rate without diminishing the flow of the Rio Grande, and the Rio Grande Compact sets a strict limit on that, as will be discussed in a later section.

Geologists' understanding of the aquifer as of 1960 is shown in the block diagram below (Figure 33), from the comprehensive report by Bjorklund and Maxwell (1961).

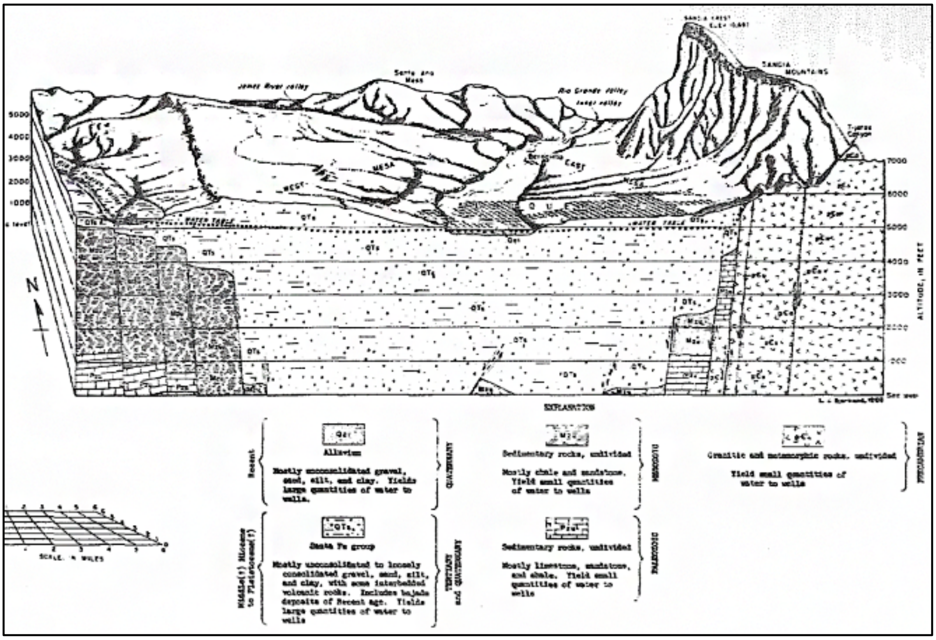

Figure 33. Block diagram from Bjorklund and Maxwell (1961, p. 9), illustrating the aquifer as geologists understood it in 1960. The Rio Puerco is at the left side of the diagram, and the Sandia Crest is at the right. The older part of Albuquerque, in the inner valley of the Rio Grande, is in the center. The bottom of the diagram is at sea level. The label "QTs" denotes the Santa Fe group, "mostly unconsolidated to loosely consolidated gravel, sand, silt and clay, with some interbedded volcanic rocks…[y]ields large quantities of water to wells," which is the valley-fill aquifer. A very thin layer of alluvium, also an aquifer, overlies the Santa Fe group. All of the other geologic units shown in the cross-section have relatively low permeability.

A more recent estimate of the volume of water in the aquifer in the Rio Grande valley between Cochiti Lake and San Acacia (a few miles north of Socorro) can be gleaned from the input files associated with a digital groundwater-flow model prepared by the U.S. Geological Survey and the Office of the State Engineer (see, e.g., Barroll, 2001). Down to about 1,560 feet below the original water table, the aquifer contained around 460 million acre-feet of water; there is, of course, much more water at greater depths.

Breaking Free from the Main Plant

The first wells outside of the Main Plant well field, which by then included the wells at the Main Plant itself at Broadway and Tijeras, the wells in the City equipment yard at Broadway and Mountain Road, and the group at Fifth Street and Mountain Road, were drilled in 1948, in the new Candelaria well field (Bjorklund and Maxwell, 1961, table 1). There were four of them, ranging from 278 to 578 feet deep, on the north side of Candelaria Road between Edith Blvd. and the railroad, and each was capable of producing 1,000 gallons per minute. Next, in 1949, came five wells in the San Jose well field, clustered near Broadway south of Gibson Blvd. These also were relatively shallow, with depths of 306 to 510 feet. Most of the 1948 and 1949 wells had 14-in. steel casing, and all were drilled by Howard Sheets, another local drilling contractor.

Until 1950, the system relied entirely on wells along the Broadway corridor and the wells in the group at Fifth Street and Mountain Road, and all of the water passed through the treatment plant and was pumped up to the main reservoir at Yale and Central, then to the Upper Reservoir in Burton Park, and from there to the reservoir near the Veterans Hospital. The entire distribution system was then supplied from these three reservoirs. The conceptual design was illustrated in the July 1947 issue of Albuquerque Progress (Figure 34). The Sanborn maps as late as 1942 indicate only a few small built-up areas on the west side of the Rio Grande, and no fire hydrants are shown; it would appear that the water system did not yet serve any area west of the river.

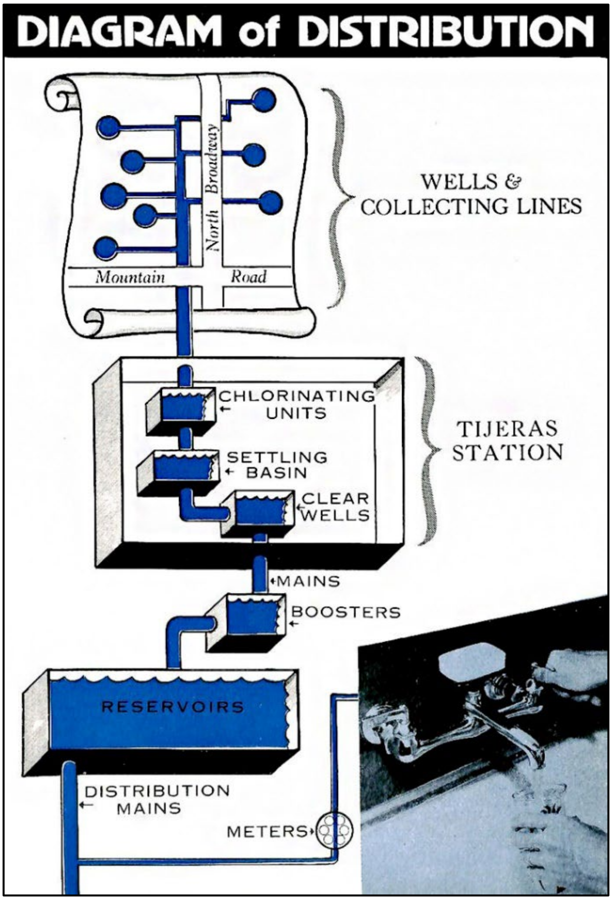

Figure 34. The basic configuration of the water system in the late 1940s (from Albuquerque Progress, June 1947).

Although the City had built a water-softening plant in 1929, the groundwater pumped from deeper wells is safe to drink as it comes out of the ground and needs no treatment, although it is considered "hard," in the sense that it contains relatively high concentrations of calcium and magnesium, and all water in public supply is chlorinated to suppress bacterial growth. Even today, there is no treatment other than chlorination (and since resumption in 2018, fluoridation to minimize tooth decay). Thus, there was no compelling water-quality reason to continue to pass the city's entire supply through the Main Plant, and the explosive post-war expansion of population and demand required a different approach.

In the early 1950s for the first time, wells were drilled on the mesa east of the Broadway corridor, and on the west side of the Rio Grande, and after chlorination, the water went directly into the distribution system rather than to the Main Plant. The first wells outside the Main Plant well field were in the Bel Air well field near Menaul Blvd. and San Mateo, discussed below, and in the Atrisco well field along Atrisco Drive south of Central Avenue on the west side of the Rio Grande. Now, rather than depending on a central treatment plant, the system evolved toward a pattern of "trunk" water mains with distributed well fields and the associated reservoirs. The reservoirs took the form of large, reinforced-concrete or steel above-ground tanks. The new configuration of the system was illustrated in the June 1955 issue of Albuquerque Progress (Figure 35), which showed one well field with its reservoir, along with a pumping station and connection to "other reservoirs," referring to the cross-connections that allowed for flexibility in delivery of water throughout the system.

Between 1950 and 1960, with the system no longer constrained by the need to pass the entire supply through the treatment facility and pumping station at the Main Plant, and the wells limited to the Broadway corridor, the City drilled the first well in each of 10 new well fields scattered throughout the service area, as shown in Table 1. The depth to water was, and is, very shallow in the inner valley, between the low bluff above Martineztown on the east, and the bluff along the west side of the Rio Grande on the west; but beneath the mesas on both sides of the valley, the land surface rises more steeply than the slope of the water table toward the river. For that reason, wells on the East Mesa needed to be deeper to reach the water, and then to penetrate enough thickness of the saturated aquifer to provide an adequate supply.

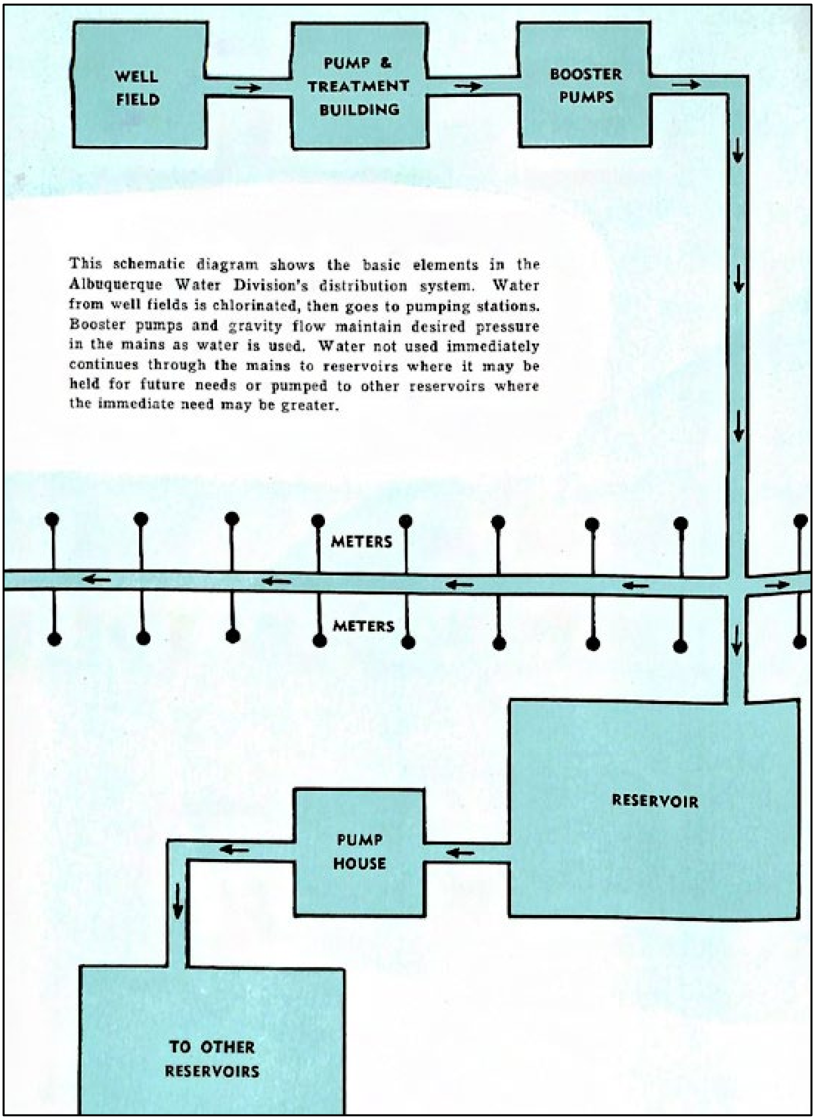

Figure 35. The post-1950 configuration of the water system, showing one of the several well fields, each with a reservoir and cross-connection to other reservoirs (from Albuquerque Progress, June 1955).

Table 1. The growth of the City system: new well fields between 1886 and 1960.

Well Field	General Location	Year of first well	Depth of first well, feet	Number of wells in 1960
Main Plant	Tijeras and Broadway	1886		22
Candelaria	Candelaria and Edith	1948	578	4
San Jose	Broadway between Gibson and Rio Bravo	1949	306	7
Atrisco	Atrisco between Central and Bridge Blvd.	1950	558	14
Bel Air	Menaul and San Mateo	1950	376	3
Duranes	Rio Grande between Menaul and Candelaria	1950	1,000	7
Burton Reservoir	Carlisle and Gibson	1955	1,000	1
Love	Lomas between Eubank and Lomas	1955	1,170	5
Griegos	Rio Grande and Griegos	1955	824	5
Lavaland	west end of Mountain Road	1956	184	0
West Mesa	Central and Bridge Blvd.	1959	1,180	1
Leyendecker	Montgomery between San Mateo and Louisiana	1959	1,000	4
Thomas	Montgomery and Wyoming	1959	1,092	4
Vol Andia	Montgomery and Carlisle	1960	972	6

As the system grew, trunk water mains were laid in the principal east-west streets, connecting well fields and their associated above-ground reservoirs, and smaller mains were laid under the north-south arteries. The water mains between the Main Reservoir and the distribution network that originally centered on the Main Plant well field continued to be a major connection in the system. By the time of a Metcalf and Eddy Engineering map prepared in 1987, there were as many as seven individual pipelines ranging from 14 in. to 36 in. diameter in part of the route paralleling Central Avenue between the Main Plant and the Main Reservoir.

The first foray onto the East Mesa, in the near northeast heights around San Mateo and Menaul, did not begin as a City project. In August of 1952, the City took over a water system and three wells from Harvey Golightly, the developer of the Bel Air Subdivision, which was bounded by Carlisle, Candelaria, San Mateo, and Menaul, and which had been annexed in 1951 (Albuquerque Journal, July 1, 1952; Kelly, 1982, p. 352). The developer may have been a little too cost-conscious in terms of drilling depths. The three 1950 wells in what became the Bel Air well field (Figure 36) were 376 to 402 feet deep, and the depth to water was about 215 feet in one of the wells when visited in 1957 by Bjorklund and Maxwell (1961, p. 73). These wells would have had limited lives before the water column in a well was too short to accommodate the drawdown during pumping. On the other hand, the Bel Air wells, once tied into the City system, were expected to relieve "water pressure shortages" in the then-existing City pipeline network, which by then had been extended far into the northeast heights. As it turned out, the City had already made an "off-the-record deal" with the Bel-Air Co., negotiated by City Commission Chairman Clyde Tingley, to tie into the then-private wells to relieve pressure shortages in the area north of Candelaria Road (Albuquerque Journal, August 8, 1952). Many more wells would be needed in the northeast heights, but no more were drilled in the Bel Air field.

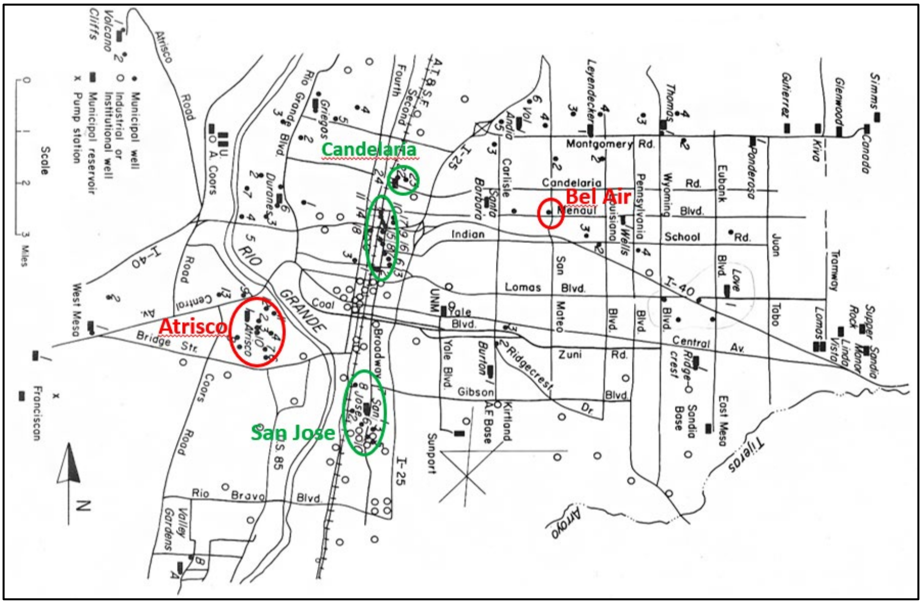

Figure 36. Map showing the 1948 and 1949 Candelaria and San Jose well fields in the Broadway corridor (along with the older Main Plant wells), in green, and the Bel Air and Atrisco well fields first developed in 1950, in red. The map is from Kelley (1969), with well-field labels in color added. As published, the map was oriented with north to the left, rather than the more conventional "north up," and has been rotated.

The first well in the Duranes field, on Indian School Road about 1,400 feet east of Rio Grande Blvd., was drilled in 1950 to 1,000 feet. It was the first in the Albuquerque system to reach that depth, and was tested at 2,400 gpm. The depth to water at that location, close to the river, was only 22 feet (Bjorklund and Maxwell, 1961, p. 72). The reinforced-concrete reservoir for the Duranes well field is shown in Figure 37.

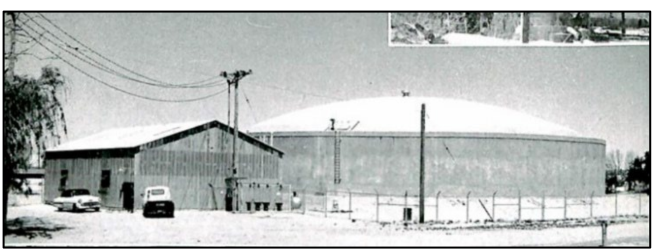

Figure 37. Reservoir, and well-field pumping station and chlorination plant in Duranes well field (from Albuquerque Progress, June 1955).

Four wells were drilled in the Atrisco field (Figure 38) in 1950, and by 1960 there were 14 wells serving customers on the west side of the river. The first four were 368 to 558 feet deep, with 14-in. steel casing, but of course the water levels were very shallow because of their locations near the river. The aquifer there is highly permeable, and each of the four original wells was tested at 1,000 gpm.

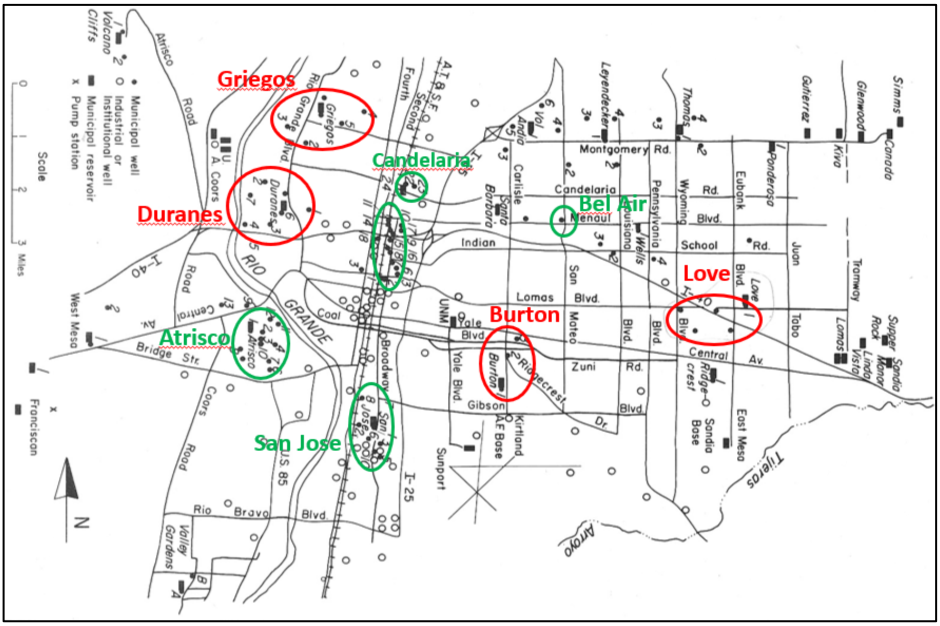

Figure 38. Map showing the Burton, Love, Duranes, and Griegos well fields added in 1953 through 1955, in red, along with older well fields, in green. The map is from Kelley (1969), with well-field labels in color added. As published, the map was oriented with north to the left, rather than the more conventional "north up," and has been rotated.

The Albuquerque Historical Society describes the rapid development of the East Mesa in these words:[17]

> In 1950, the city was rapidly annexing land east and north of its borders, and subdivisions were spreading toward the mountains. That year the Saturday Evening Post wrote of Albuquerque, "New houses go up in batches of 50 to 300 at a time and transform barren mesas before you get back from lunch." In the four years between 1946 and 1950 the city's area tripled. In 1950, Sam Hoffman built the 800-home Hoffmantown Addition north of Menaul and east of Wyoming. In 1953, Ed Snow's Snow Heights Addition followed directly south. In 1954, Dale

[17] https://albuqhistsoc.org/SecondSite/pkfiles/pk213neighborhoods.htm

Bellamah's 1,600-home Princess Jeanne Park, named for his wife, was built between Lomas and Indian School and from Eubank to Juan Tabo. In the early 1950s Bellamah also built the Kirtland Addition just west of the airport.

The rapid expansion of Albuquerque after World War II brought a corresponding increase in the demand for water, primarily on the mesa east of the older part of town. In contrast to the conservative approach of the former privately owned water company, namely adding water mains only when the customers were in place, the city was now striving to extend service, and plan far ahead even though it had not been able to meet demand fully.

It is clear from a glance at the 1954 USGS topographic maps, which were based on 1951 aerial photography, that new subdivisions in the northeast heights were anything but orderly accretions to the existing city and the water system, but appear instead to have been randomly distributed all the way to the foot of the mountains. The City created a Planning Commission in 1949, and the City Commission passed a zoning ordinance in 1953 that set new rules and regulations for subdivision developers. Some veteran politicians, including Clyde Tingley, warned the new "progressive" officials on the City Commission that this checkerboard pattern of growth would be costly to the city unless developers were required to share at least some of the costs of expanding city services. After several years of haggling over various proposals and enduring intense lobbying by builders, the City Commission finally voted in 1953 to assess developers some of the costs for water and sewer extensions and service hook-ups. The historian Robert Wood estimates that between 1954 and 1958 the city installed 190 miles of water lines and paved 157 miles of new roads. As a result, home prices rose significantly in the 1950s, although this did not seem to significantly affect home ownership. (This is mostly paraphrased from Greater Albuquerque Association of Realtors, The History of Albuquerque, Chap. 4).

Although it had not been keeping up with the rapid increase in demand in the eastern part of the city, by 1953 Albuquerque had "caught the vision," and was moving ahead with a 15-year master plan of well-drilling, and construction of water lines, reservoirs and sewers, that was estimated to cost $20 million. R.H. McDonnell, an engineer with Burns and McDonnell in Kansas City, told a meeting of the Rocky Mountain Section of the American Water Works Association that the City was about three years behind in infrastructure development, and that two or three years would be required to catch up. He also made the point that water rates would probably have to be increased (Albuquerque Tribune, September 22, 1953).

One symptom of the water department's difficulties in catching up with the demand was the fact that public-health officials had been urging the City to cover the open Main Reservoir and Burton Reservoir, but without results, since 1948. There had been algae and dust problems, and even an outbreak of worms, but "each time money is available for the work, the city has simply grown so much they have to use the money to get water to new sections," according to Charles Caldwell of the State Department of Health (Albuquerque Tribune, August 11, 1953). It was finally accomplished in early 1955 (Albuquerque Journal, January 21 and April 15, 1955).

Another formidable obstacle was the drought of the 1950s, which led to greater demand for water largely because so much was needed for the landscaping around all of the new houses. The drought could be said to have begun with the somewhat below-average precipitation of 1945 through 1947, but 1949 was a good year, and the serious trouble began in 1950. Precipitation in all of the years 1950-1956 was significantly below normal, and 1956 was the worst of all. There were occasional breaks—the City's "gleeful" water manager, Walter Blume, reported that rain on July 15, 1953 had apparently brought a temporary end to the latest city water crisis, and that the next day the water department had not received a single call complaining of low pressure (Albuquerque Tribune, July 16, 1953)—but that was still only half-way through the drought. Lawn-watering restrictions were in place until late August of 1953, but, although there were complaints of low pressure (e.g., Albuquerque Journal, April 26, 1956), well-drilling and waterline construction seems to have caught up with demand, and restrictions were not imposed in the summers of 1954, 1955, or 1956.

At the end of 1953, the firm Gordon Herkenhoff & Associates came into being (with the dissolution of the short-lived partnership of Herkenhoff & Turney, two famous names in the New Mexico engineering community), and began its long history as the City's water-system design and construction engineer (Albuquerque Journal, December 16, 1953). An early success was the automation of the well operations in 1955; before that, operators manually started and stopped the pumps at each of the wells as reservoirs emptied and filled. By 1956, Walter A. Webster, formerly with the Army Corps of Engineers, had joined Herkenhoff and was one of the engineers most involved with the automation and rapid development of the system.

Until 1953, Kirtland Air Force Base had relied on the City system for its water, but in that year "the hard-pressed city water system will get one source of relief," as

Kirtland announced that it had completed a new 1,100-foot well, and was planning another well for 1956. Kirtland expected to be independent of the City. Sandia Base already had six wells of its own by then, and relied on the City system only for four residences and two "sentry houses (Albuquerque Tribune, July 11, 1953)." Sandia had also depended on the City until 1949, when it contracted with Roscoe Moss Co. for its first three, 1,000-foot wells (Albuquerque Journal, June 29, 1949).

The 1954 topographic map, based on aerial photos taken in 1951, shows two large storage tanks at the east end of Lomas Blvd. as it existed at the time, close to an intersection with Central Avenue and what is now Tramway Blvd., near the mouth of Tijeras Canyon. One of the tanks, the Sandia Manor reservoir shown on Figures 36 and 38, was at an elevation of 5,962 feet, at the foot of the Sandia Mountain slope; the other and larger tank was one of the Lomas Reservoirs shown on the same maps. The Lomas trunk was already in place, and by mid-1952, a 125,000-gallon "accumulator tank" had been installed near Supper Rock—the small hill (formerly marked with the "U") near the east end of Copper Ave. at the foot of the mountains (Albuquerque Journal, May 14, 1952).

A Dick Kent aerial photo of 1965 (Figure 39) shows three new reservoirs in Glenwood Hills at the eastern end of Montgomery Blvd. and the Montgomery trunk, with only a few houses in sight.

Figure 39. Aerial photo taken in April 1965 showing early development in Glenwood Hills, and (from left to right) the new Simms, Glenwood, and Kiva reservoirs, all above-ground reinforced concrete tanks. Dick Kent photo, DK08622B4A, courtesy of Historic Albuquerque, Inc.

By 1954, the annual supply had jumped by a factor of three, from the 2.9 billion gallons in 1947 to 8.7 billion gallons (Albuquerque Progress, June 1955). Peak demand on a hot summer day reached 320 gallons per capita. There were now over 449 miles of pipeline, and 38,320 meters, up from 13,688 in 1947. The investment in the system had grown by more than six times, from $2.5 million in 1947 to $15.5 million. The City's Water Division had 143 employees.

The City added an average of about four wells per year between 1945 and 1960 (see Figure 26). New well fields, and their associated reservoirs, were located where development was occurring. One, or a few, wells drilled to establish each new field were augmented with additional wells as time went on. By 1960, there were 77 wells in service in 12 fields (Bjorklund and Maxwell, 1961, p. 29), and another six wells had been added in a new Vol Andia well field in 1960, but were not yet in service at the end of the year. The Main Plant field continued to contribute, although the "battery" of wells within the original large excavated well at the Tijeras and Broadway pumping-plant site was no longer used for water supply, but had been converted to a sump into which the city water mains could be drained when necessary for repairs.

The wells drilled in the 1950s typically had 16-in. or 18-in. steel casing. Many were drilled by the Roscoe Moss Co. of Los Angeles and constructed with Moss-patented well screen manufactured by forming downward-facing louver-shaped openings into pipe that itself is made from spiral-welded steel coil. At some point, a copper-bearing steel, more resistant to corrosion than mild steel, came into use. All of the wells were equipped with lineshaft turbine pumps, with electric motors, and water was pumped either to a local reservoir or directly into the distribution system. The wells on the East Mesa were typically around 1,000 feet deep, with the deeper wells in the far northeast heights where the depth to the water table was greatest, and typically were tested at more than 2,000 gpm. Figure 40 shows the well fields that were initiated in 1958 through 1960, and the names and locations of the reservoirs as they were in the late 1960s.

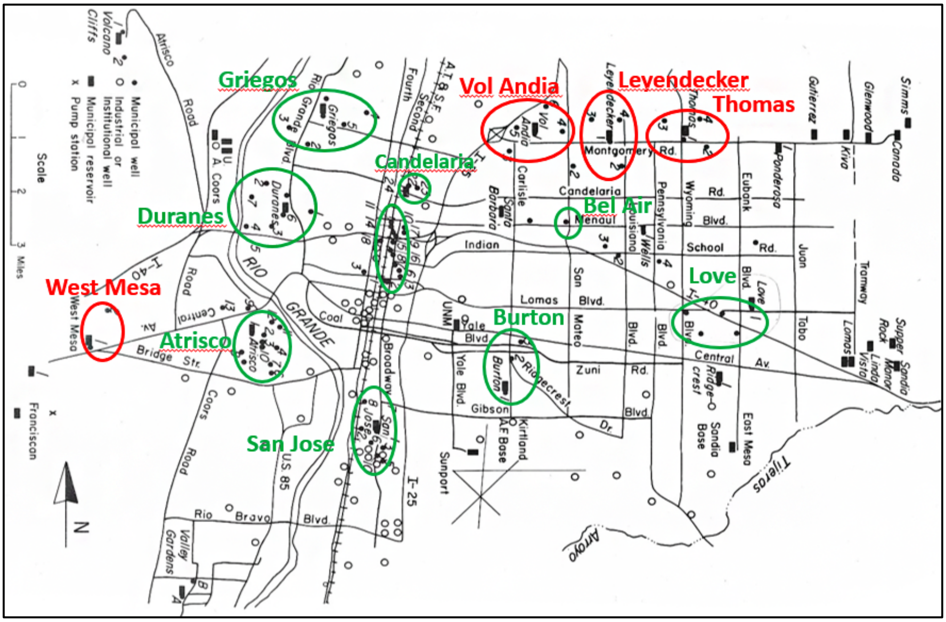

Figure 40. Map showing the Vol Andia, Leyendecker, Thomas, and West Mesa well fields added in 1958 through 1960, in red, along with older well fields, in green. The map is from Kelley (1969), with well-field labels in color added. As published, the map was oriented with north to the left, rather than the more conventional "north up," and has been rotated.

Pumping from the aquifer, in areas away from the river and therefore without the rapid recharge to the groundwater by seepage from the river, began to lead to lowering of water levels in wells. Probably the earliest map showing the elevation of the water table beneath the Albuquerque area was prepared by C.V. Theis in 1936 (Theis, 1938). Theis was one of the leading developers of quantitative groundwater science, and had published the seminal Theis equation for estimating the drawdown of water levels around a pumping well (Theis, 1935). He worked in the U.S. Geological Survey office in Albuquerque. T.E. Kelly, also a hydrologist with the U.S. Geological Survey and later a consultant in Albuquerque, referred to that map, and to a water-table map by Bjorklund and Maxwell (1961) representing the conditions in 1960, to draw a contour map showing the amount of water-table decline over the 24 years between the Theis and Bjorklund-Maxwell studies (Figure 41). The most apparent areas of decline were around the Public Service Co. (now PNM), wells serving the Person Generating Station at Broadway and Rio Bravo (now out of service), the wells supplying the Veterans Administration hospital and the (then) Sandia Base, and the new City wells in the Atrisco and Love fields. Before 1936, there had been little effect on the water table due to Albuquerque's pumping, except for very local drawdown in and around the Main Plant wells; and even up to 1960, although drawdown had spread throughout the east mesa, the drawdown had been very small as compared with the situation in later years.

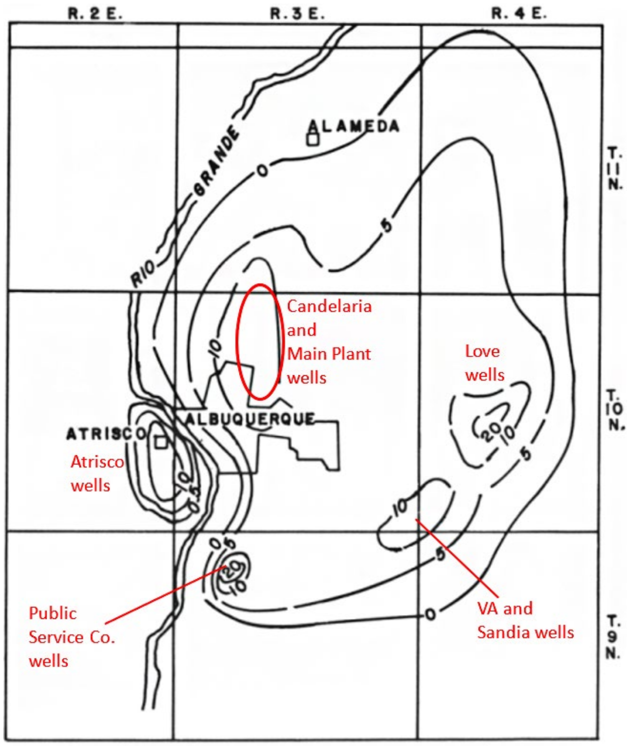

Figure 41. Contour map showing change in groundwater levels in the Albuquerque area between 1936 and 1960. The contours are in feet (from Kelly, 1982, fig. 4; scale and red labels added).

Construction under the master plan was progressing nicely until 1956 when another speedbump appeared, in the form of an order by the State Engineer that required some Rio Grande surface-water rights to be either dedicated to the State Engineer or, later, transferred into the City's portfolio of rights and in effect retired, and no new wells were drilled in 1957 or 1958. The State's new groundwater administration for the Rio Grande Underground Water Basin, and the uproar that resulted from the State Engineer's order, will be discussed in the next section.

Steve Reynolds Takes Charge

The New Mexico Territorial legislature had enacted a water code in 1907 that established the prior-appropriation, "first in time is first in right," doctrine, under which the first person to put water in a stream to beneficial use acquired a right that would be fully supplied first in case of shortage, then came the next-oldest right, and so on, but the code applied only to surface water. The 1907 act also established the office of the Territorial Engineer, later the State Engineer, to administer water rights. The State Constitution, as of statehood in 1912, incorporated the same system.

Groundwater development was not regulated at all under the 1907 law. By 1931 it was clear that groundwater should be regulated to protect existing well-owners against the effects of new pumping, at least in some parts of the state, and the prior-appropriation scheme was extended to apply to groundwater, but only in particular basins that would be defined and "declared" by the State Engineer. Outside of those "declared underground water basins," wells could still be drilled and pumped without regulation but within a declared basin, a new appropriation of groundwater could be done only under a permit from the State Engineer—and more importantly, the permit would be subject to the requirement that an existing water right, generally a surface water right, be obtained and either dedicated to the State Engineer, or assigned to the new well, in the amount of the effect on a river's flow that would be attributable to pumping from the new well.

Albuquerque's water supply situation took an important turn in 1956 when the State Engineer put significant limits on the City's ability to develop groundwater. The State Engineer had been worried about the effect of City pumping on the flow of the Rio Grande, and the City had a clear interest in the longevity of the aquifer; in 1955 the State Engineer contracted with the U.S. Geological Survey Water Resources Division office in Albuquerque to do two comprehensive water studies. The first was a description of the geology and hydrology of the aquifer, including water quality, with an inventory of the water wells that existed at the time (Bjorklund and Maxwell, 1961), and the second was a quantitative analysis of the decline in water levels in the wells, and the contribution of the river to the groundwater system as a result of pumping from the wells, based on the first study (Reeder, 1967).

The State Engineer's concern had to do with the Rio Grande Compact, a contract entered into by the states of Texas, New Mexico, and Colorado, that allocates the flows of the Rio Grande among the three states. It was signed in 1938, in the Palace of the Governors in Santa Fe, after years of negotiation and one temporary compact, and was intended to allay the concerns of Texas and New Mexico over the rapid development of agriculture in the Colorado part of the drainage basin. Littlefield (1999) gives a good summary of the history of the Compact.

The water being taken by Colorado farmers was causing reduced flows in New Mexico, and was responsible for some of the troubles of the late 19th and early 20th Centuries discussed in an earlier section. Reduced flow in New Mexico, of course, threatened downstream Texas. After signature by the representatives of the three states and approval by their legislatures, the Compact was approved by Congress in 1938 and thereafter had the force of Federal law. Rights to Rio Grande water that were already established by 1938 almost certainly exceeded the supply in most years.

Under the terms of the Compact, Colorado's required deliveries to New Mexico at the state line are calculated, on a sliding scale, based on the measured flows at four stream gages near the headwaters. Similarly, New Mexico's deliveries to Texas are determined by the flows that pass the gage at Otowi Bridge, just downstream from the Rio Grande crossing on the highway to Los Alamos, and compliance with the Compact is based on the flows that enter Elephant Butte Reservoir, even though Elephant Butte Dam is roughly 100 miles upstream from the Texas line.[18] That is because the water is delivered at Elephant Butte to the Rio Grande Project, which in turn includes two irrigation districts, one in New Mexico (the Elephant Butte Irrigation District) and one in Texas (El Paso County Water Improvement District No. 1).

Among a number of other terms, the Compact provides for an accounting of debits and credits for under-deliveries and over-deliveries; Colorado is limited to a debt of 100,000 acre-feet, and New Mexico to 200,000 acre-feet. Colorado ignored the Compact, and the debt reached 100,000 acre-feet by 1951; shortfalls continued until ultimately the accumulated debt reached 944,400 acre-feet in 1967. New Mexico didn't do any better, and exceeded its debt limit by 1948. Because of these shortfalls, Texas sued its upstream neighbors in 1952.

It was well known among groundwater scientists at least as early as the 1940s and 1950s that pumping from a well in a river-connected aquifer such as the valley

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[18] The Compact originally called for measurement of deliveries to Texas at San Marcial, about 28 miles downstream from Socorro. The change was made in 1948.

fill in the Rio Grande valley leads to a reduction in the flow of the river. O.E. Meinzer of the U.S. Geological Survey, the "father of modern groundwater hydrology," had described the basics of groundwater occurrence and flow in 1923 (Meinzer, 1923, p. 56).[19] And as it happened, Albuquerque had become a center of groundwater science by the late 1930s. C.V. Theis, who as described in the previous section became one of the best-known of groundwater professionals, came to Albuquerque with the U.S. Geological Survey in 1936, shortly after the publication of his vitally important equation relating the pumping from a well to water-level drawdowns in other wells (Theis, 1935). Theis continued his groundwater studies at the Geological Survey, even after retirement, until just before he died in 1987. (I worked in the same office from 1965 to 1969, and we were both members of the Rotary Club of Albuquerque.)

Application of Theis's groundwater principles leads to the conclusion that all the water pumped from a well in a river-connected aquifer, after adjusting for water returned to the river, as treated wastewater for example, ultimately is at the expense of the river itself. The timing can be long or short, depending mostly on the characteristics of the aquifer material and the distance from the river, but the issue must be dealt with. By 1954, a further development of Theis's equation made it possible to calculate the rate of depletion of the flow of a stream, as it changed over time, due to pumping from a well (Glover and Balmer, 1954).

Stephen E. Reynolds (Figure 42) was State Engineer, and thus responsible for water-rights administration in New Mexico, and therefore for compliance with the Rio Grande Compact, from 1955 until his death in 1990. He was a self-described "enginoyer," a rigorously professional engineer with a deep understanding of water law and administration, and was so well respected that he served as an appointee under nine successive New Mexico Governors. The U.S. Geological Survey groundwater scientists worked closely with their State Engineer counterparts.

[19] Meinzer did some of his research in New Mexico. The lake that formerly occupied the Estancia Valley is called Lake Meinzer in his memory.

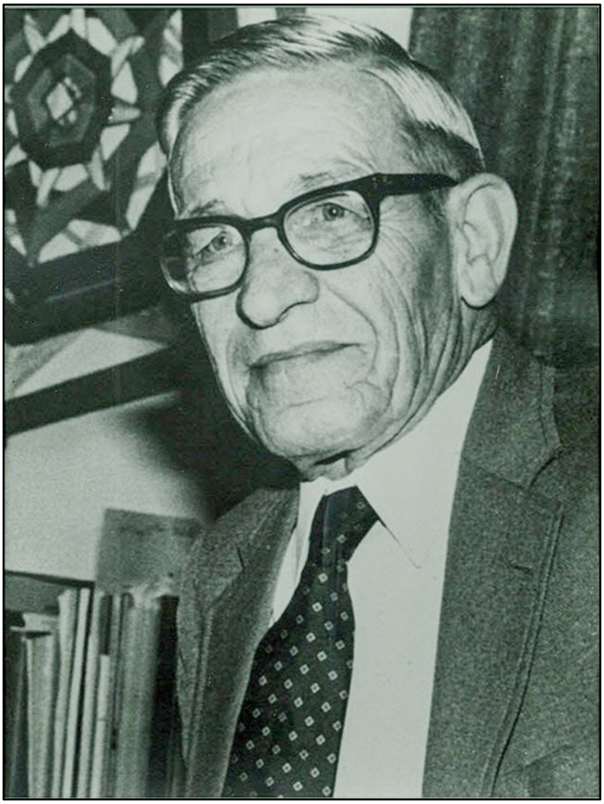

Figure 42. Stephen E. Reynolds, New Mexico State Engineer, 1955-1990. Photo from Office of the New Mexico State Engineer website.

As Albuquerque was described by Emlen Hall, UNM Law professor and former State Engineer attorney (1998, p. 543), "[i]n the 1950s the city was perched on the edge of a growth spurt previously unheard of in New Mexico. Real estate promoters and politicians touted Albuquerque as sitting on top of a bottomless ocean of underground water, free for the taking from deep city wells drilled helter skelter into the mesas east of the city and the river."

But by the time Steve Reynolds became State Engineer in 1955, New Mexico was being sued over its debt to Texas under the Rio Grande Compact, and at the same time the state was suffering the worst drought on record. It was clear that the continued growth of Albuquerque, relying entirely as it did on groundwater, would make compliance with the Compact even more unlikely. On November 29, 1956, Reynolds asserted the State Engineer's jurisdiction (the formal term is "declared") over the Rio Grande Underground Water Basin.

The reaction from Albuquerque's civic leaders and business community was swift and vitriolic. As related by Hall, (1998, p. 543):

> Reynolds himself loved to tell the story of his announcement of his proposed Rio Grande basin plan. Called by the Chamber of Commerce in Albuquerque to account for his water policy in early 1957, the brash, new State Engineer found himself in a huge, oak-wainscoted board meeting room with every New Mexico big-shot banker and mogul seated around a long, narrow conference table. Reynolds had been invited to explain his plan for conjunctive management of the water resources in the middle Rio Grande basin. As the audience realized the implications of what State Engineer Reynolds was telling them, they became, related Reynolds, grinning, more and more hostile. By the end of the meeting, the angry audience, led by then Albuquerque city commissioner Maurice Sanchez, pledged to fight him tooth and nail in the courts and in the legislature.

The agricultural community was no happier than the businessmen were. The Bernalillo and Sandoval County Farm and Livestock Bureau named a committee to attack the State Engineer's order in court and in the State Legislature, and "delivered sharp criticism against the basin declaration stemming from their belief that it eventually [would] dry up and halt farming in the middle valley," and that it was unnecessary at that time as a water conservation measure (Albuquerque Tribune, December 22, 1956).

The City and its business interests did indeed fight with great vigor and determination, but after intense struggles in the courts, and efforts in the State Legislature on behalf of Albuquerque to change the underlying water law, Reynolds won. The fight began in earnest when Albuquerque applied for four new wells under the "Pueblo Rights Doctrine," which in principle would have allowed unlimited growth of a city's water use with no obligation to acquire existing water rights; the permit was denied by the State Engineer. The City appealed all the way to the State Supreme Court, and finally lost in 1962 (Albuquerque Tribune, December 9, 1962).

The days of untrammeled access to water were over, and Albuquerque took its place among all the other water users in the Middle Rio Grande Underground Water Basin—agriculture, industry, even the riverside vegetation—as subject to the limitations on water use imposed by State Engineer regulations and the Rio Grande Compact. Pumping from the existing wells could continue, but any new pumping from new wells would require that the effect on the river be offset by purchase of existing water rights, typically by buying the rights associated with irrigated farms and "drying up" the lands. For legal reasons, the rights would have to date from before 1907, and must have been in more-or-less continuous exercise since then.

Steve Reynolds had tried to sooth Albuquerqueans by explaining that, under his plan for the retirement of water rights to offset pumping, only about 1,500 acres of farmland—a small fraction of the land in irrigation in the valley—would have to be taken out of production before the time that the San Juan-Chama Project would begin to deliver water to the Rio Grande, and that "San Juan water would then offset Albuquerque's effects on the river until 1990 to 2000 (Albuquerque Tribune, December 17, 1956)." The Tribune's editors found Reynolds' explanation to be slight comfort, and opined that "anything as far-reaching as the establishment of an underground water basin ought not to be delegated to one man no matter how competent or how public-spirited he might be (Albuquerque Tribune, December 18, 1956)."

The San Juan-Chama Project would indeed have major implications for Albuquerque's water future, and it began to be pursued vigorously in the late 1950s. Planning for the project, which would make it possible for part of New Mexico's Colorado River Basin allocation to be delivered across the Continental Divide to the Rio Grande Valley and Albuquerque, had begun in the 1930s, but efforts to obtain Congressional authorization and funding were at a high level in the late 1950s. The project would divert water from three tributaries to the San Juan River, itself a tributary of the Colorado, and deliver it into the headwaters of the Rio Chama, a Rio Grande tributary, upstream from their confluence at Espanola.

New Mexico's existing allocation of Colorado River water under the Upper Colorado River Compact would be 838,125 acre-feet,[20] in a full-supply year, but much of the foreseeable new demand was not in our part of the Colorado River Basin, but in the Rio Grande Valley on the east side of the Continental Divide. And New Mexico had been failing to meet its obligation to downstream Rio Grande water-users since the early 1940s, so additional water would be a great help. As the project was later completed, Albuquerque would receive 48,200 acre-feet/yr in a full-supply year; the City could use the water to offset the depletion caused by pumping from its wells, so that it would be able to drill new wells when and where

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[20] The Colorado River Compact of 1922 allocates an aggregate of 7.5 million acre-feet/year to the Upper Basin states, including New Mexico, but does not specify any division among the states. The Upper Colorado River Compact of 1938 allocates 50,000 acre-feet/year to Arizona, and divides the remainder among the Upper Basin states, including Arizona, with New Mexico to receive 11.25 percent.

needed, and it could also use the water directly and conserve the groundwater in the aquifer. San Juan-Chama was authorized in 1962 under Public Law 87-483, and eventually resulted in a major addition to Albuquerque's water supply.

The City drilled some 17 wells after the declaration of the basin and before the end of 1960, and continues to drill new wells, but for each of them the State Engineer has calculated the associated depletion of Rio Grande flows, and has required the dedication or transfer of equivalent existing Rio Grande surface-water rights. The rights to surface water that are implied by the use of wells that existed in 1956 were recognized by the State Engineer.

Epilogue

The span of time for this report ends with 1960, but the reader deserves to be told a little about what has happened since then. For most of the next couple of decades, Albuquerque continued to drill wells and add to the system, generally pumping more water each year from storage in the aquifer. It was generally understood that water levels in wells were going down over time and would continue to, but the vast amount of water in the aquifer made that seem a minor issue. We were serenely confident in the validity of Bob Grant's 1977 remark, mentioned earlier, that the volume of recoverable fresh groundwater in the Albuquerque subregion is around 70 percent of the amount of water in Lake Michigan. And in any case, we also had access to some Colorado River Basin water.

The San Juan-Chama Project, to bring water from tributaries of the Colorado River in southern Colorado, through canals and tunnels across the Continental Divide and into the Rio Grande drainage, largely for Albuquerque's benefit, was authorized by Congress and signed into law in June of 1962. Work began on the Azotea Tunnel near the end of 1964, and the last major construction, Heron Dam, was completed in 1971 (Glaser, undated). Albuquerque continued to rely entirely on its wells, however, and stored (in Abiquiu Reservoir) or leased its 48,200 acre-foot/year allocation of San Juan-Chama Project until much later.

In the early 1980s, W. Kelly Summers, the City's recently hired hydrogeologist, began to look seriously at the rates of water-level decline in the supply wells. Water levels in some of the newer wells west of the river were dropping by as much as 12 feet per year, and declines of 2 or 3 feet per year were common among many others. Summers became concerned that the groundwater was being over-exploited, and also decided that the City needed to know the vertical extent of the highly productive part of the aquifer, and the quality of the water at depths beyond those of the existing wells. He expressed his concerns, and persuaded the City to drill four test wells in the northeast heights to 3,000 feet or deeper; in all cases, the aquifer and the water quality were relatively good, even at those depths. The water-level declines were another matter.

A New Mexico Bureau of Geology study in 1995 (Haneberg, 1995) concluded that "over the long term…there is a considerable potential for widespread land subsidence if drawdown approaches the 80-120-m range." In other words, regardless of the total thickness of the valley-fill aquifer and the volume of water it contained, a water-level decline of 260 to 390 feet would be likely to cause trouble with foundations, buried utilities, and streets. The City had already recognized that some changes were necessary, and about this time commissioned a study of water policy for the long term, led by F. Lee Brown, Professor of Economics at the University of New Mexico (Brown et al., 1996).

The results of considering these various concerns amounted to a dramatic shift in paradigm, beginning about 1990, toward thinking of the groundwater, not as a resource to be exploited, but as a working reserve, and to a policy of "living within our means" by relying for the very long term on the renewable supply provided by the Rio Grande and the San Juan-Chama Project (see, e.g., Albuquerque Tribune, March 15, 1996). This new paradigm also included a very intensive effort toward water conservation. The new approach, which culminated in the 1997 Water Resources Management Strategy (WRMS), was led by A. Norman Gaume, the City's Water Resources Program manager at the time.

To broaden the effect of the new approach, the City of Albuquerque and Bernalillo County, along with the Village of Los Ranchos, formed the Albuquerque-Bernalillo County Water Utility Authority (ABCWUA) in 2003, which began construction of the Drinking Water Project, the works required to bring Rio Grande water into the system, in 2004. The $400 million project diverts Albuquerque's San Juan-Chama Project water, and water available under its native Rio Grande water rights, directly from the river at an adjustable dam just downstream from Alameda Boulevard. The surface water is pumped to a treatment plant a few blocks northwest of the intersection of I-25 and Montaño Road, and then distributed through a system of new water mains to the trunk mains of the existing system.

The conservation program has been based on a "carrot and stick" combination of education, rebates for reducing landscaping and other water losses—and significantly increased water rates. The efforts have been strikingly successful: per capita water use dropped by about half, from 251 gallons per day (GPD) in 1995 to 127 GPD in 2015, and the number continues to decline toward the policy goal of 120 GPD (ABCWUA, no date). Water levels in wells have been rising since about 2009.

The ABCWUA system now owns roughly $5 billion worth of assets including about 100 wells and more than 3,000 miles of water-supply pipeline, has about 635 employees, and manages about 214,000 customer accounts. It also has, in effect, a dual groundwater-surface water supply based on both the local aquifer and water imported from the Colorado River Basin via the San Juan-Chama Project (see https://www.abcwua.org/your-water-authority-overview/).

The whole range of questions related to Albuquerque's very long-term water security were not thought to be fully answered, though, by the 1997 Water Resources Management Strategy or its 2007 update, and continued to be addressed. More recently, ABCWUA convened groups of staff, consultants (including the writer), and public participants, led by John M. Stomp, then Chief Operating Officer, to plan for the next 100 years, taking into account the projected demand, a broad variety of possible supplies, and a range of climate-change scenarios. It is fair to say that about every imaginable potential source and scenario was examined at some level. The result, *Water 2120: Securing Our Water Future* (ABCWUA, no date), represents a comprehensive set of policies that will see the region safely into the next century.

The *Water 2120* groundwater-policy objective is "for groundwater to be managed such that there is no long-term net removal of water from storage once a set management level is reached, while utilizing the working reserve to respond to changing hydrologic conditions." One might say that we are back to the original idea of the early 1880s—to divert our supply from the river—but now with the two great assets of imported Colorado River Basin water, and a vast working reserve to buffer the ups and downs.

References Cited

ABCWUA, (no date), Water 2120—Securing our Water Future: Albuquerque Bernalillo County Water Utility Authority. (https://www.abcwua.org/wp-content/uploads/Your_Drinking_Water-PDFs/Water_2120_Volume_I.pdf).

Anderson, G.B., 1907, History of New Mexico—its Resources and People, v. 2, Pacific States Publishing Co.

Barroll, P., 2001, Documentation of the Administrative Groundwater Model for the Middle Rio Grande Basin: New Mexico State Engineer Technical Report TDH-99-3, 52 p.

Bjorklund, L.J. and Maxwell, B.W., 1961, Availability of ground water in the Albuquerque area, Bernalillo and Sandoval Counties, New Mexico: New Mexico State Engineer Technical Report 21, 117 p.

Bloodgood, D.W., 1930, The ground water of middle Rio Grande valley and its relation to drainage: N.M. State Coll. [NMSU] Ag. Exp. Sta. Bull. 184, 60 p.

Brown, F.L., Nunn, S.C., Shomaker, J.W., and Woodard, G., 1996, The value of water: consultant's report to City of Albuquerque, 143 p. and appen.

Bryan, H., 2006, Albuquerque Remembered: Albuquerque, Univ. of New Mexico Press, 96 p.

Bryan, K., 1909, Geology of the vicinity of Albuquerque: Univ. of New Mexico Bulletin, Geological Series, v. III, no. 1, 24 p.

Connell, S.D., 2008, Geologic map of the Albuquerque-Rio Rancho metropolitan area, Bernalillo and Sandoval County, New Mexico: New Mexico Bureau of Geology and Mineral Resources, Geologic Map GM-78, scale 1:50,000, 2 pls.

Darton, N.H., 1922, Geologic structure of parts of New Mexico: U.S. Geological Survey Bulletin 726-E, 125 p.

Fergusson, E., 1922, Do you remember—the first city water works: The Albuquerque Herald, Dec. 18, 1922.

Flint, R., and Flint, S.C., 2021, Overhaul—a social history of the Albuquerque Locomotive Repair Shops: Albuquerque, Univ. of New Mexico Press, 227 p.

Follansbee, R., 1994, A history of the water resources branch, U.S. Geological Survey, v. I: U.S. Geological Survey, 286 p.

Glaser, L.H., (no date), San Juan-Chama Project: U.S. Bureau of Reclamation internal document, 28 p. (https://www.usbr.gov/projects/index.php?id=521).

Gilbert, G.K., 1877, Report on the geology of the Henry Mountains: U.S. Geological Survey, 160 p.

Glover, R.E., and Balmer, C.G., 1954, River depletion resulting from pumping a well near a river: American Geophysical Union Trans., v. 35, pt. 3, pp. 468-470.

Grauch, V.J.S., and Connell, S.D., 2013, New perspectives on the geometry of the Albuquerque Basin, Rio Grande rift, New Mexico—insights from geophysical models of rift-fill thickness: Geological Society of America Special Paper.

Hall, G.E., 1998, Steve Reynolds—portrait of a State Engineer as a young artist: UNM School of Law, 38 Natural Resources Journal 537.

Haneberg, W.C., 1995, Depth-porosity relationships and virgin specific storage estimates for the upper Santa Fe Group aquifer system, central Albuquerque Basin, New Mexico: N.M. Bureau of Geology and Mineral Resources, N.M. Geology, v. 17, pp. 62-71.

Hayden, F.V., 1869, First, second, and third annual reports of the United States Geological Survey of the Territories for the years 1867, 1868, and 1869 (1873).

Herrick, C.L., and Johnson, D.W., 1900, The geology of the Albuquerque sheet: New Mexico University Bulletin 2, Geology Series no. 23, pt. 1, 67 p.

Howell, C.H., 1935, The Era of Conservancy, *in* Resources and opportunities of the Middle Rio Grande Valley: Univ. of New Mexico Bulletin, Economics Series, v. II, no. 3, 54 p.

Keleher, W.A., 1983, New Mexicans I Knew—Memoirs, 1892-1969: Albuquerque, Univ. of N.M. Press, 293 p.

Kelley, V.C., 1969, Albuquerque—its mountains, valley, water and volcanoes: N.M. Bureau of Mines and Mineral Resources, Scenic Trips to the Geologic Past, no. 9, 106 p.

Kelley, V.C., 1977, Geology of Albuquerque Basin, New Mexico: N.M. Bureau of Mines and Mineral Resources, Memoir 33, 59 p.

Kelly, T.E., 1982, History of water use in the greater Albuquerque area: *in* New Mexico Geological Society, 33rd Field Conference Guidebook, pp. 351-35.

Lee, W.T., 1907, Water resources of the Rio Grande valley in New Mexico and their development: U.S. Geological Survey, Water Supply and Irrigation Paper 188, 59 p.

Littlefield, D.R., 1999, The history of the Rio Grande Compact of 1938: *in* New Mexico Water Resources Institute Report No. 213, (New Mexico State Univ.) Water Conference Proceedings, 1999.

Meinzer, O.E., 1923, Outline of ground-water hydrology: U.S. Geological Survey Water-Supply Paper 494, 71 p.

Price, L.G., Bland, D., Johnson, P.S., and Connell, S.D., 2009, Water, Natural Resources, and the Urban Landscape—the Albuquerque Region: N.M. Bureau of Geology and Mineral Resources, Decision-Makers Field Guide 2009, 106 p.

Reeder, H.O., Bjorklund, L.J. and Dinwiddie, G.A., 1967, Quantitative analysis of water resources in the Albuquerque area, New Mexico: New Mexico State Engineer Technical Report 33, 34 p. (https://www.ose.nm.gov/Library/TechnicalReports/TechReport-033.pdf).

[RGJI], 1938, Regional Planning, Part IV, the Rio Grande Joint Investigation in the Upper Rio Grande Basin in Colorado, New Mexico, and Texas, 1936-1937: Washington, Natural Resources Committee, 566 p. (Vol. I) and maps (Vol. II).

Schwalen, H.C., 1924, The California or stovepipe method of well drilling as practiced in Arizona: Master's Thesis, University of Arizona College of Mines and Engineering, 76 p.

[Senate], 1890, Report of the Special Committee of the United States Senate on irrigation and reclamation of arid lands: United States, U.S. Government Printing Office.

Simmons, M, 1982, Albuquerque—a Narrative History: Albuquerque, Univ. of New Mexico Press.

Sorensen, E.F., 1977, Water use by categories in New Mexico counties and river basins, and irrigated and dryland cropland acreage in 1975: New Mexico State Engineer Office, Technical Report 41.

Theis, C.V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage: American Geophysical Union Trans., v. 16, pp. 519-524.

Theis, C.V., 1938, Ground water in the middle Rio Grande valley, New Mexico, *in* (U.S.) National Resources Committee, The Rio Grande Joint Investigation in the Upper Rio Grande basin: U.S. Government Printing Office, Washington, D.C., v. 1, pt. 2, p. 268-291.

Theis, C.V., and Taylor, G.C., Jr., 1939, Ground-water conditions in the middle Rio Grande· valley, New Mexico: N. Mex. State Engineer 12th and 13th Bienn. Repts., 1934-38, p. 263-270.

Weinzirl, J., 1905, The potable waters of New Mexico, with special reference to the city water supply: University of New Mexico Bulletin, Biological Series, v. 2, no. 11, Bulletin of the Hadley Climatological Laboratory of the University of New Mexico, v. 2, no. 11.

The "new town" grew quickly after the Atlantic & Pacific Railroad reached Albuquerque in April of 1880, and a water system, primarily for fire suppression in those early days, became an urgent need. The new Albuquerque Water Works Co. planned a diversion dam on the Rio Grande, a pumping plant, and a reservoir on the mesa east of town, but, following the example of the railroad, developed a groundwater supply instead. The water came initially from a large, shallow, rock-lined pit, along with a nearby pumping plant, near the corner of Broadway and Tijeras Avenue. The pumping plant, a 4-million-gallon reservoir at Central Avenue and Yale Boulevard on what is now the UNM campus, and about 5-1/2 miles of water mains with fire hydrants, were completed in 1886. Although the huge steam-powered pump could push 3 million gallons per day up to the reservoir, it could lift water only about 7 feet by suction from the pit, and many wells close to and actually within the pit, some deeper than 700 feet, were added over time. All were in the same place to be close to the pump.

The public was never happy with the water company, with its continuing financial and operational troubles; in 1918 the system was purchased by the City of Albuquerque and rapid expansion began. The first wells on the mesa east of Broadway were drilled in 1950, and by then it was understood that the thick alluvial sands and gravels beneath the entire valley would support high-yield wells equipped with down-hole turbine pumps and electric motors. The single-source system became diversified, with well fields and reservoirs placed where the brisk post-World War II developments were occurring. By 1960, there were 83 wells in 14 well fields throughout the city.

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