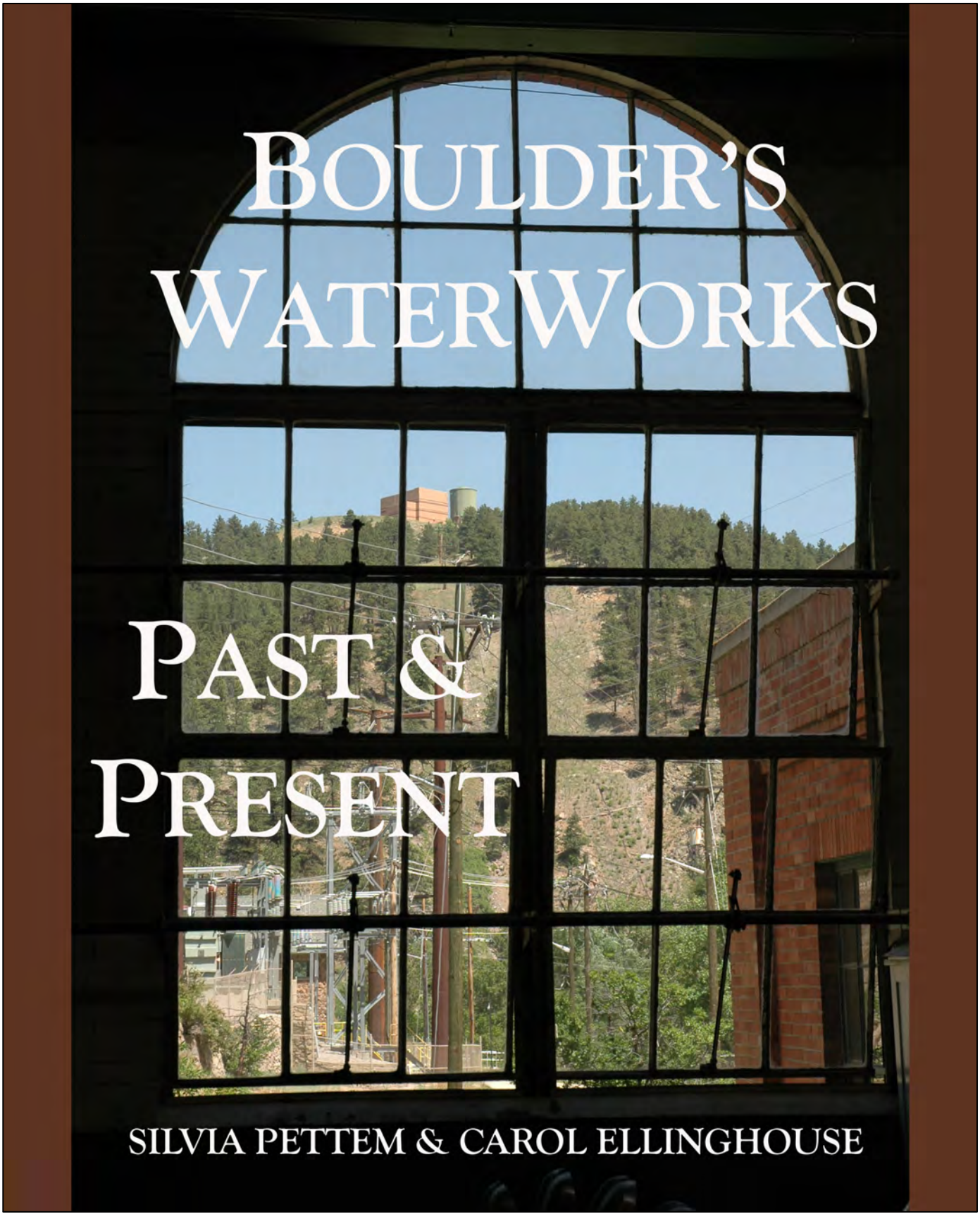
BOULDER'S
WATERWORKS
PAST &
PRESENT
SILVIA PETTEM & CAROL ELLINGHOUSE

This document, by Silvia Pettem and Carol Ellinghouse, is a revision and update of *A History of the Waterworks of Boulder, Colorado*, written by Phyllis Smith in 1986.

The cover image was taken from the Boulder Canyon Hydro Plant, with a view to the Betasso Water Treatment Plant in the background. Pettem photo, 2013

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INTRODUCTION

For many years, this "Welcome to Boulder" sign hung from a pipe over Broadway, near Norwood Avenue. The pipe carried water from Silver Lake Ditch. Carnegie Branch Library for Local History, Boulder Historical Society collection (129-11-44)

The story of Boulder's waterworks is a long and integral part of the City's history. Prospectors used the waters of Boulder Creek to wash their gold-bearing gravels. Farmers, who "mined the miners," dug ditches, grew crops, and raised cattle. Boulder was founded on mining and agriculture, and both needed water.

Water usage became controversial and confrontational. Water rights were determined by who claimed them first, not by who owned the land crossed by rivers, as in the Eastern states. The public, rather than private companies, generally won out in controversies over who should control Boulder's water distribution.

In the late 1800s, pollution of Boulder Creek caused Boulder to seek cleaner water by moving its water intake upstream into the mountains and to carry the water into the City in pipelines. In 1906, the City reached even higher toward the source of Boulder's water on North Boulder Creek with the construction of Lakewood Reservoir near Nederland and ten more miles of pipeline.

The City then began a far-sighted process of acquiring lands to be protected for water supply almost a century before the practice of source water protection became commonplace. The properties were located just below the Continental Divide and included the recently discovered Arapaho Glacier. The threat of contamination continued, however, when the world's largest tungsten mill built next door to the City's newest intake at Lakewood Reservoir. In 1919, the City extended its pipelines even higher with an intake located within the City-owned Silver Lake Watershed.

Meanwhile, in 1910, big advances had come in the private sector with the construction of Barker Dam and Reservoir, along with the opening of the Boulder Hydroelectric Plant in Boulder Cañon (now Canyon). The hydro plant helped electrify Boulder and, beginning in the 1950s, became a key part of Boulder's water supply. But, it would be more than 90 years before the City became owner and operator.

The 1930s brought the Great Depression. For Boulder, the good news was that the unemployed were hired with federal funds to rebuild infrastructure, including the Works Progress Administration's (WPA) biggest local project—Island Lake Dam. The WPA's work ended in 1942, when World War II made the program obsolete.

In 1947, the first Western Slope water from the Colorado-Big Thompson Project flowed through the 13.1-mile Alva B. Adams Tunnel, under the Continental Divide. Boulder, not yet a member of the Northern Colorado Water Conservancy District, eyed its neighbors to the north. Suddenly, in the years following the end of the war, Boulder's population exploded, and everyone demanded more water.

Boulder entered into the Northern Colorado Water Conservancy District in 1953 and built Boulder Reservoir in 1955. The City's continued growth brought many more changes. Water was treated consistently for the first time, in 1964, with the opening of the Betasso Water Treatment Plant. The Boulder Reservoir Water Treatment Plant followed in 1971.

The City looked to the future with additional water supplies from the Windy Gap Project in 1985, the same year that Boulder began producing its own hydroelectric power. Then, in 2001, after constructing six of its own hydroelectric plants, the City ended up as owner of the then-91-year-old Boulder Canyon Hydro Plant in Boulder Canyon. At the time, Boulder purchased all of the Barker system facilities for water supply purposes. With the construction of the Lakewood Hydro, in 2004, Boulder now owns and operates a total of eight hydroelectric plants.

In recent years, the City has been fine-tuning its facilities and maintaining its investments—all for an end product that can be easy for Boulder's residents and visitors to take for granted. The following pages are meant to give readers a better understanding of, and appreciation of, Boulder's water—where it comes from, where it's stored, how it's treated, and how it's used. There were people (and their stories) involved in this process, too, and some of them are included here, as well. The topic is far from dry.

SETTLEMENT & DITCHES

Boulder City Town Company; Early Ditches, 1859

Boulder—first known as the "Boulder City Town Company"—was founded on February 10, 1859 by 54 men who had crossed the Great Plains to seek their fortunes in gold. One of the prospectors, Alfred A. Brookfield, wrote in a letter home to his wife, "We thought that as the weather would not permit us to mine, we would lay out and commence to build what may be an important town."

A few months earlier, the prospectors had split from a larger band of gold-seekers (bound for the Cherry Creek "diggings," now the Denver area) and followed St. Vrain Creek to Boulder Creek and on to Boulder Canyon. After weeks of traversing the seemingly endless prairie, Boulder's first Anglo settlers pitched their tents in the shadows of towering sandstone slabs that would later be called the Flatirons.

The men had neighbors—the Arapahos.[1] At the time, Colorado, and even Colorado Territory, did not exist. The Kansas-Nebraska Act of 1854 had placed most of the Boulder area in Nebraska Territory, with the fortieth parallel (now Baseline Road) the dividing line between Nebraska and Kansas territories. According to federal decree, all of the land belonged to the Indians. But, the prospectors were successful in discovering gold, its lure was strong, and many of the men decided to stay. They elected former Nebraska City mayor Alfred A. Brookfield as "president." The "States," with United States President James Buchanan was far away.

Boulder County's early settlers must have been pleasantly surprised when they noticed the small streams cascading down the Front Range. Although none of the streams were navigable, they brought enough water to the Boulder Valley to support the native plants that fed resident buffalo, antelope, and deer. Members of the Southern Arapaho nation had known for generations that the Boulder Valley was a good place to hunt, as they spent the winter months there, sheltered by the high mountains from intense weather.

Other Anglos had come before the prospectors. Colonel Stephen H. Long, for whom Longs Peak is named, reached the Rocky Mountains in 1829 after crossing what he called "The Great American Desert." Long described the Great Plains as "a rainless, treeless, wasteland" and stated that it was "unfit for human habitation." The next generation of explorers turned their attention to the Far West, particularly when gold was discovered in California in 1848. Boulder's prospectors, like their California predecessors, diverted water from mountain streams when they washed sand and gravel from the heavier particles of gold in rockers, long toms, and sluice boxes.

Eventually, additional prospectors would find silver, tungsten, and fluorspar, as well, while other Boulder County inhabitants turned to farming—the occupation they knew best. Whether they mined or farmed, they needed water.

Boulder County's economy was founded on mining and agriculture, as depicted in this Art Deco bas relief sculpture over the front entrance of the present-day Boulder County Courthouse. Pettem photo

Brothers Sylvanus, Luther, and Henry Wellman arrived in Boulder in August 1859. Instead of prospecting, they predicted that flour would be almost as valuable as gold, and that the miners would provide a ready market for grains and produce. The men selected 640 acres of bottom land along Boulder Creek (in the vicinity of what is now Arapahoe Avenue and the Foothills Parkway), built log cabins, and planted turnips as their first crop.

Although the summer was nearly over, the soil was rich and the rainfall, that year, was plentiful. Then, when the turnips were almost ready to be harvested, they were devoured by grasshoppers. Undeterred, the brothers planted wheat the following the spring. According to Amos Bixby, who wrote the earliest account of the county's history, the Wellmans' first wheat harvest yielded 45 bushels per acre.[2] Sylvanus Wellman later testified as to the brothers' early use of water, and stated that Boulder Creek often overflowed into the grasslands in the bottoms during flood season. He then added that during the summer of 1859, they dug small ditches from Boulder Creek to irrigate approximately 800 acres.

Meanwhile, in the vicinity of Arapahoe Avenue and 17th Street, Marinus G. Smith and William G. Pell took up adjoining properties. In October 1859, they plowed

the ground for a joint vegetable garden and dug the Lower Boulder irrigation ditch—the first in Boulder County. Smith, Pell, Brookfield (who gave up mining for a farm in Valmont), the Wellman brothers, and others lost no time in determining that the construction of irrigation ditches from South Boulder Creek, Main Boulder Creek, Left Hand Creek, and St. Vrain Creek would convey enough water to grow a plentiful supply of crops despite the area's dry climate.

By the early fall, in 1859, barely a year after the first Anglo settlers had arrived in the Boulder Valley, a number of families established the first rights to divert water from Boulder Creek and South Boulder Creek. Some early and/or prominent ditches from Boulder Creek are listed below.[3]

Priority #	*Name of Ditch:*	*Date of: Appropriation:*
1	Lower Boulder Ditch	October 1, 1859
2	Smith & Goss Ditch	November 15, 1859
3	Howell Ditch	December 1, 1859
4	Anderson Ditch	October 1, 1860
5	Godding, et al	March 1, 1861
6	Houck #2 Ditch	April 1, 1861
Early and prominent Boulder ditches also include:		
North Boulder Farmers Ditch		June 1, 1862
Farmers Ditch		October 1, 1862
Boulder & Left Hand Ditch		December 1, 1873
Boulder & White Rock Ditch		November 1, 1873
Town of Boulder Ditch		June 17, 1875
Silver Lake (Maxwell) Ditch		February 28, 1888

First in Time; First in Right

Boulder's early settlers came from the eastern states where water rights are riparian, meaning that water can be freely used by landowners adjacent to the stream because there was enough rain runoff and groundwater flow to always keep rivers running. However, the west was arid and did not receive the ample rainfall seen in eastern states. Western streams often dried up in late summer and barely flowed in the winter. Often the most productive land was not near any stream. So, western water users took their cue from those who had established water rights in the Far West during the California gold rush. Colorado water rights did not automatically go along with ownership of land next to the river, but went to those who put water to use first, no matter where their land was located.

"First in time, first in right" became the common law for most western waterways. This principle was codified as governments formed in the area. Colorado Territory (and its 17 original counties, including Boulder) was created on November 1, 1861.[4] The first-come-first-served rule was then affirmed by the Colorado Territorial Legislature in 1862. By 1864, there were 23 ditch companies that had initiated claims for water rights on Boulder Creek based on actions taken to physically divert water out of the creek, but there would be a long way to go before an enforceable water rights system was developed.[5]

When Colorado became a state in 1876, its Constitution stated, "The right to divert the un-appropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using water for the same purpose."[6]

If the miners had not established some system to fairly distribute the water, early Boulder residents might have resorted to "shovel diplomacy," a term coined by a Colorado water attorney, the late George Vranesh, to describe what one miner would do if he discovered another miner diverting all the water upstream. The first miner simply "walked up the creek and hit the other miner over the head with his shovel."[7]

This 2012 photo, at the headgate of Left Hand Ditch, shows the diversion dam that moves water from the South St. Vrain Creek into the Left Hand Ditch. Courtesy Donlyn Arbuthnot

"Shovel diplomacy," however, did play a part in the benchmark case of Coffin vs. Left Hand Ditch Company, which affirmed the doctrine of prior appropriation—"first in time, first in right." The confrontation involved Boulder farmer Reuben Coffin. He and his brother, George, had owned land next to St. Vrain Creek as early as 1866, but had never declared any claim to use of the water in the bountiful stream next to their lands. Previously, in 1863, the founding members of the Left Hand Ditch Company had built a dam across St. Vrain Creek to divert water into James Creek for irrigation of land further downstream off of Left Hand Creek. This was not a problem in wetter years, but 1879 was a drought year and Coffin found the St. Vrain to be bone-dry while he watched his corn shrivel in the summer heat. Enraged, he and a few other farmers went upstream to the company's dam and tore it apart. The company rebuilt and Rueben Coffin sued.[8]

The case of Coffin vs. Left Hand Ditch Company went all the way to the Colorado Supreme Court. In 1882, the Court determined that Coffin was out of luck and out of line to have trespassed on ditch-company property. The court ruled that the Left Hand Ditch Company's right to divert water was superior to Coffin's claim because water was to be allocated based on date of first use, not proximity of land to the river.[9] The ruling also stated that the ditch company had the right to divert water from one drainage to another, thus paving the way for the trans-mountain movement of water in the future.

A lengthy newspaper article on May 5, 1882, probably by Eugene Wilder (editor at the time) of *The Boulder News and Courier*, sheds light on how the water appropriation issue was handled by the press and perceived by the public.

THE WATER QUESTION
(*Boulder News and Courier*, May 5, 1882)

> The resolution adopted for discussion at Longmont two weeks ago will go far towards establishing a foundation for the water situation. Gradually is it approaching the standpoint of USE as a basis, and the righteousness thereof becoming more prevalent and universally conceded. As men consider the matter, they become convinced that the truth of this view cannot be denied.
>
> Water is a free element given to the people and owned by the people, and there is no law in the United States that will protect a man or corporation in monopolizing that which is so necessary to the wants, rights, or liberties of another. And this great principle, which is the foundation of our institutions, will assert itself in all cases, and bring conviction with it. A corporation may construct

> a ditch and take toll for carrying the water, and the one who uses it is the appropriator––his priority, however, is a matter of date. He owns the water by right of use, and should he choose to receive it through another channel can do so, and who can hinder him?
>
> A man has a farm of 160 acres; in 1874 he may have cultivated 20 acres and used water sufficient for that amount. In 1876 he may have cultivated 40 acres, and in 1880 he cultivates 80 acres. Now, the neighbor, who comes in 1875 and takes water from the same stream, has a priority over the appropriation of the first man for the additional amount he appropriated in 1876 or 1880. We cannot hold others accountable for our shortsightedness or inabilities.
>
> The word “use,” and an honest appropriation of it, will be the equalizing power of this intricate question among our people. It must be so; by no other means can it be settled, and as such must it be finally recognized by the courts. A company has no right to dam up a stream, run the water through a ditch, and compel the people to buy it of them or go without. They own the ditch, but the water, never!
>
> A ditch cannot appropriate water; it is the use of it on the land that does it, and the man who uses it is the appropriator, and consequently the owner, and he can have that water recorded to him for his benefit. And no court can, with justice and human right, deprive him of it. All through the country last season was fraud perpetrated on the people by fraudulent ditch stock. In many of the ditches was water sold, thousands of inches more than the ditch could possibly carry, and many lost their crops.
>
> Now I want to say to the farmers: To you belongs the water by right of use, and not to the ditches.[10]

Municipal Incorporation; Farmers Ditch

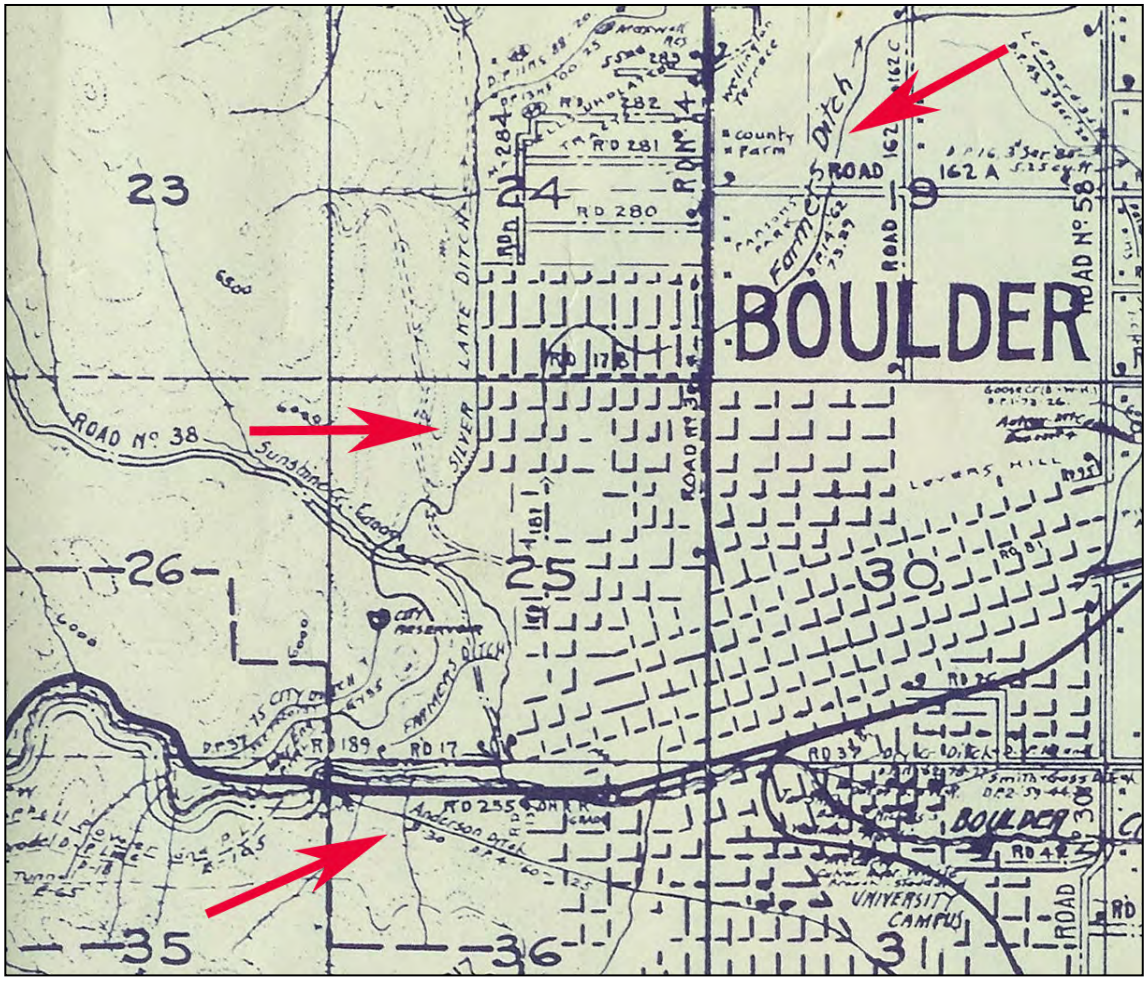
As was the case with many Western communities, Boulder was slow to establish a municipal water supply system separate from the early irrigation ditches that were constructed through the town. The frontier mining supply town did not consider municipal government until 1871 and only then because some residents chafed under what they felt to be dictatorial rulings by the three Boulder County

Commissioners, whose offices had been established in 1861. On November 4, 1871, the name “Boulder City” was dropped, and the “Town of Boulder” was incorporated.[11] By then, Ulysses S. Grant had become President of the United States.

In the 1870s, the establishment of the Town’s waterworks was not immediately perceived as a matter for municipal concern. A few fortunate Boulder residents used water from their recently dug wells or springs on their property, but most of the rest of the 2,500 city residents obtained their domestic water from Boulder Creek or from one of the ditches, while some wealthy homeowners laid pipes (some fashioned from hollow logs) from the ditches to their residences.

The privately owned Boulder Aqueduct Company was organized in May 1872 by three of Boulder’s prominent pioneers— Alfred A. Brookfield, Andrew J. Macky, and James P. Maxwell. Macky would later become the president of the First National Bank of Boulder, and Maxwell, a water engineer, would become mayor of Boulder, as well as a Colorado state senator. In January 1873, the aqueduct company was granted a charter by the Town Trustees.[12] The three businessmen promised to lay wooden water pipes from Farmers Ditch (completed in 1862) along the principal streets, with pipes leading into the houses whose owners requested the service.[13] However, they did not get far with their plans for a private water company because many of Boulder's citizens believed a water system should be public.

Farmers Ditch (visible in the foreground) was built in 1862, and its water was piped into Boulder homes beginning in 1872. This photo of 637 Pine Street was taken in 1973. Carnegie Branch Library for Local History, Boulder Historical Society collection (207-14-7#1)



Arrows point to Farmers Ditch, Silver Lake Ditch, and Anderson Ditch. Drumm's 1926 map of Boulder County, Pettem collection

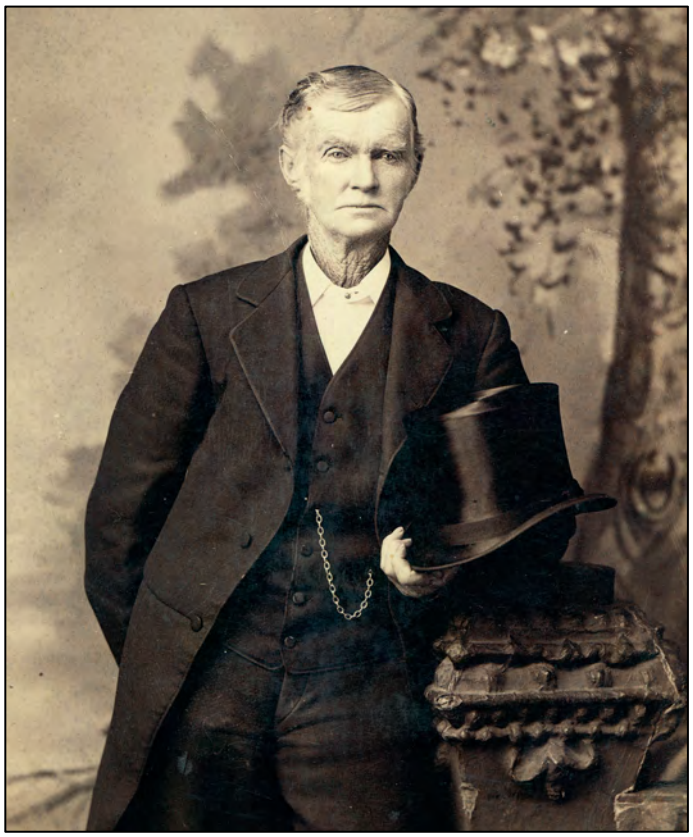
PUBLIC WATERWORKS & PROBLEMS

- 1875, Town of Boulder Ditch
- 1875, Town of Boulder Reservoir #1
- 1877, Boulder's first water supply protective ordinance
- 1879, Town of Boulder Reservoir capacity deemed inadequate
- 1887, Construction began on a new reservoir—City/Sunshine #2
- 1887, James P. Maxwell began construction of Silver Lake Ditch

Boulder's First Public Waterworks; City Reservoir #1

In 1874, a citizen committee was formed to decide whether the waterworks should continue under a private company, or if they should be built by the town. Some voted in favor of the private company, but committee members Frederick A. Squires, Ephraim Pound, and Alfred A. Brookfield decided that, indeed, the waterworks should be publicly funded.[14]

The men proposed an $18,000 bond issue to build a reservoir near the mouth of Boulder Canyon, southwest of Red Rocks. On October 31, 1874, there were 71 citizens who voted for the expenditures and 17 voted against. Hotel owner and former Boulder County Sheriff Ephraim Pound had been elected President of the Town Trustees in 1873 and was appointed Boulder's first water commissioner. He served from 1875 to 1877.



Hotel owner, former Sheriff, and President of the Town Trustees, Ephraim Pound, was also Boulder's first water commissioner, serving from 1875 to 1877. Carnegie Branch Library for Local History, Boulder (420 pound-daniel #2)

Construction began on the Town of Boulder Ditch and the Town of Boulder Reservoir (also known as Red Rocks Reservoir or Sunshine Reservoir No. 1) in 1875. Martin D. Currigan, a contractor specializing in plastering and cement work, was in charge of pipe-laying, and he also built the storage pond which measured 138 feet across and ten feet deep. The intake was at a headgate at the mouth of Boulder Canyon, on the north bank of Boulder Creek. Diverted waters flowed through a wooden flume and ditch that soon-to-be-elected President of the Board of Trustees John A. Ellet dug, in 1875 and 1876, through land acquired by the City from John Brierley.

The land was located south of Red Rocks, about halfway between Farmers and Silver Lake ditches. Shortly thereafter, in 1878, another purchase of approximately ten acres of land was made from John Ryan who owned the land "on which the reservoir is located." Ellet charged $2,000 for his work, but the Town Trustees had run out of money. Instead, they offered Ellet water bonds "with accrued interest thrown in."[15] The ditch measured three feet across and one foot deep, with a five-foot-per-mile grade.

Before the water flowed into the reservoir, it seeped through a sand filter. From the storage pond, the water flowed downhill along Pearl Street through a curved cast-iron-eight-inch pipe to Twelfth Street (now Broadway). Later, another eight-inch pipe was run down to the public square (site of the Boulder County Courthouse), which lay 160 feet below the elevation of the reservoir. (Boulder replaced some of these pipes in 1917, when a portion of Pearl Street was paved for the first time.)

The Town of Boulder Reservoir, built in 1875, was also known as the Red Rocks Reservoir and Sunshine Reservoir #1. The use of the name "Sunshine" is misleading, as the site is accessed through today's Settlers' Park, off of Pearl Street. The Yount flour mill is in the right center of the photo. Carnegie Branch Library for Local History, Boulder Historical Society collection (S-936)

The site of the first reservoir looks like this today. Pettem photo, 2013

Many Boulder residents got their water at the public square. The trip downtown became a social event, as citizens took time to visit, perhaps watch a baseball game, and then trudge home with full pails. With the addition of a few fire plugs, Boulder's hose companies at least had a chance to put out the town's frequent fires rather than stand by and watch wooden buildings burn to the ground. Boulder's fierce seasonal winds made the possibility of a fire a frightening, but common, prospect.

Before long, another bond issue of $12,000 was required to lay pipes to Spruce and Pine streets. Twelve additional fire hydrants were installed, and firefighters had 140 pounds of water pressure for their hoses. But the project received a lot of complaints. According to the Town Minutes, the contractor promised the Town Trustees he would "make tight all joints, connections, and hydrants now leaking or that may be found to be leaking within 20 days."[16]

The complaints continued. When foundry man J. W. Develine ordered his pipe connection, only a trickle of water dropped from his new faucet. Upon investigation, a quantity of swollen corncobs stuffed into the street pipes explained the lack of water. A couple of years later, Boulder fire hydrant pressure had dropped to ten pounds. A cast-iron main was dug up on Twelfth Street, and a five-foot length of wood, four and one-half inches wide, was wedged in such a way that only two-and-one-half inches of pipe were available for water flow.

Meanwhile, the University of Colorado had been founded, in 1876, on a barren mesa. One argument to the Colorado Territorial Legislature that Boulder be chosen as its home was the town's proposed gift of ten shares of Anderson Ditch water to the University. Every tree had to be planted and continually watered. Today this irrigation system is still in use on campus.

In 1877, a "diversion" was built between downtown Boulder and Boulder Creek, so that the water collecting in the streets might flow back to the stream. The following year, $30,000 was spent to patch up the then-five-mile-long water system, but the town's water became more and more clouded with mill tailings from gold and silver workings upstream. Boulder's first water supply protection ordinance was passed the same year. Instead of mentioning minerals, however, it stated, "No person shall put any carcass or filthy animal or vegetable matter into the reservoir, nor shall any person bathe or swim therein or skate upon the ice which may form thereon in cold weather."[17]

With the waterworks in place, a number of businesses used water from the new municipal pipelines, but others continued to rely on the original ditches for their enterprises. One was Andrew Douty's grist mill and waterwheel which used Farmers Ditch water to grind flour for bread. The *Boulder County News* had started using a water-powered typesetting machine in 1874. Meanwhile, pipes were laid to schools and other public buildings.

BOULDER'S EARLY WATERWORKS PRESENTED PROBLEMS
by Silvia Pettem (*Daily Camera,* August 15, 2002)

In 1882, banker Charles Buckingham was taken to police court and fined nine dollars for watering his lawn between the hours of 9a.m. and 4p.m. Like his Pine Street neighbors, he was prohibited by a city ordinance from "using water from the Boulder City waterworks through a hose and sprinkler" during the daytime. Water has always been a precious commodity in Boulder, and the watering restrictions that we have today are nothing new.

Boulder's earliest settlers realized that their semi-arid climate required a dependable source of water, but they didn't find it in the 19th century. At first, the town founders dug irrigation ditches, not only for their farmlands but for their domestic water, as well.

Farmers Ditch was one of the earliest waterways and began at a head-gate on Boulder Creek near the mouth of Boulder Canyon. The ditch then meandered through the Mapleton Hill area before flowing northeast of

Boulder and out to the plains. Within the city, side ditches, called laterals, supplied water to neighborhoods downtown.

The ditch, still in place but intermittently covered, was an improvement over hauling water from the creek, but it was convenient only when the water flowed. In 1869, an early newspaper reported, “There is no water running in the Farmers Ditch which should supply the tidy housewives of Boulder who are grumbling considerably.”

Before long, it became evident that Boulder needed a more permanent water works than Farmers and the other ditches could supply. In 1874, residents had approved a bond issue to finance the building of a small reservoir near the mouth of Boulder Canyon and to fill it from another intake ditch farther upstream. Soon its water flowed underneath Pearl Street through an eight-inch cast-iron water main. Another bond issue financed pipes that were laid to carry water to the cross streets.

“Boulder can already claim to have better water works than any city in the Territory,” stated the *Colorado Banner*, in 1875, a year before Colorado became a state. “The pressure is enough to throw it over any house that ever will be built in Boulder.”[18]

At the time, water rates cost homeowners ten dollars per year for a house with five rooms or less. Each additional room added an extra dollar to the bill. Additional annual rates for lawn sprinkling were 15 cents per linear foot (along the street). Gardens were rated at one cent per square yard. By 1878, Boulder’s water lines had been extended throughout most of the downtown area.

In 1882, when Boulder initiated its first watering restrictions and Buckingham was hit with his fine, the municipal water supply was clouded with mill tailings. Two years later, the newspapers reported that the City’s water was “murkier than ever,” then it was temporarily shut off when dead horses were found in the creek. Town leaders began to talk of an entirely new system.

> The situation was expected to improve in 1891 when the City built the Sunshine #2 Reservoir at the mouth of Sunshine Canyon. According to newspaper reports, its intake pipes were several miles “up in the mountains.”
>
> The water situation, however, went from bad to worse. The Camera stated that city council members, who had described themselves as a “committee of the whole,” renamed themselves a “committee of the hole” because they claimed that instead of water, they saw only “mud and microbes.”

Second Municipal Incorporation, 1878

Boulder’s governmental structure underwent several changes with a second incorporation in 1878. Although the changes didn’t affect the waterworks, Colorado had been granted statehood in 1876, and the state legislature provided for incorporation of cities under state, rather than county, statutes. The President of the Town Trustees became known as the Mayor, and the city limits were extended to include all of the additions that had been platted since 1871.[19]

Even though the town now had a pressurized municipal pipe system, the cobblestone-lined laterals running from the Farmers Ditch continued to play an important water supply role. These small ditches bordered Pearl and neighboring streets and measured two feet wide and eight inches deep. They served to water horses, wandering cattle, and pigs, as well as providing a small amount of water for firefighting or to settle the summer dust on the streets. Small boys were known to have used the waterways to wash their feet. One newspaper reporter stated that, sometimes, water was allowed to run down the streets for no discernible reason, where it formed “nauseating puddles.”[20]

Due to the on-going importance of the laterals, as well as the seniority of the 1862 Farmers Ditch right to divert from Boulder Creek, as compared to the right established in 1875 for the Town of Boulder Ditch, the Town Trustees decided to pursue purchase of shares in the Farmers Ditch Company. On October 23, 1879, the Town Trustees set aside 50 dollars to buy 20 shares of Farmers Ditch stock, but the ditch company shareholders with whom the Town was negotiating—James P. Maxwell, Austin Smith, James H. Carle, Joseph Wolff, and Frederick A. Squires refused to sell any of their shares. On November 3, 1879, the trustees offered $1,000 for ten shares. Again, the ditch shareholders backed off. By January 5, 1880, however, the Town of Boulder had purchased three and one-half shares of Farmers Ditch water, followed by another four and one-half shares for a total cost of $800.[21]

Ditch laterals paralleled 12th Street (now Broadway), near its intersection with Pine Street, when this photo was taken in the 1890s. Carnegie Branch Library for Local History, Boulder Historical Society collection (207-4-42 #1)

Most Boulder residents, however, were still drinking untreated creek water delivered from the Town of Boulder Reservoir into the municipal water system, even though it was becoming more and more clouded with mill tailings. A writer for the *Herald* recommended that the water be taken out at a higher point in the canyon to avoid mining and milling debris. Even so, thirsty shoppers drank from downtown fountains. A few householders also erected, in front of their homes, ornamental fountains—Boulder's new status symbols.

By 1879, the City's first reservoir was declared inadequate for Boulder's growing needs. As a stop-gap measure, the City ordered that the reservoir be enlarged to a depth of 18 feet, a width of 150 feet, and a length of 200 feet. However, the Town Trustees continued to discuss the need for a new reservoir in a better location.

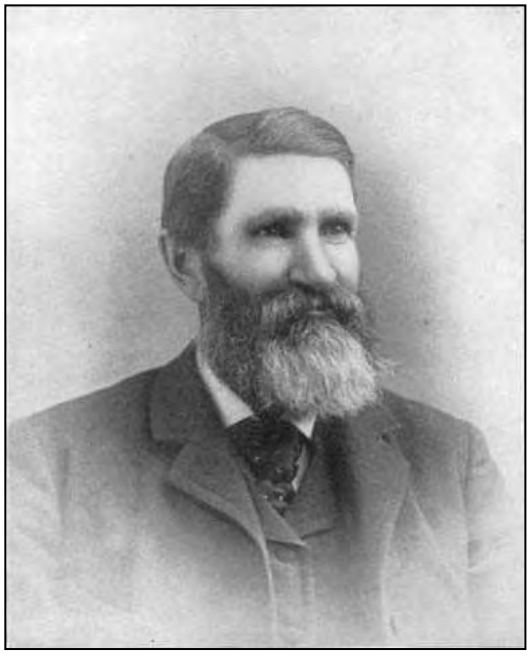
Many ditch companies were becoming interested in building reservoirs as well. Water users were beginning to realize that storing water for future use was essential because the natural flow of Boulder Creek swelled with snowmelt from May to July, but dropped to ankle-deep levels the rest of the year. So many water rights had been claimed on Boulder-area creeks by the late 1860s that there were more demands for water in late summer than was in the creeks. Only the earliest ditches could continue diverting when water levels dropped. There were sometimes disputes over who had the more senior water right because no state or court approved priority list existed. Ditch companies with more junior water rights began building reservoirs in the 1880s to store spring runoff water for late irrigation season use.

New Visions and Plans for the Future

Colorado Governor Frederick W. Pitkin appointed Boulder farmer and stock-raiser Hiram Prince as the state's first Water Commissioner, in 1880. A few years later, while serving in the state legislature, Prince would become known as an advocate—far before his time—of the trans-mountain movement of water.

By 1882, Boulder's population had reached 3,000, and the frontier town was re-incorporated again. This time Boulder became a "city of the second class." Elected officials were Mayor, Treasurer, and four Aldermen (formerly known as Trustees). Together they formed the City Council.[22] Then, on June 2, 1882, local water rights were adjudicated (officially recognized and quantified) *for the first time* by the Boulder County District Court.

During many of the previous months, water users who had diverted from Boulder-area creeks had been giving testimony about when they started using water, how much was used and where it was used. Ninety-eight ditch companies were accorded priority rights to use water in order of priority depending upon the dates when the ditches were first built.[23] The decrees that were issued had limits on how much water each ditch could take based on the size of the ditch. The companies were owned by their shareholders and delivered water for irrigation of shareholder land within the service area of the ditch. The new City of Boulder was granted a decree with an 1875 appropriation date for the old Town of Boulder Ditch that specifically allowed domestic use, which is unusual because the Colorado Legislature did not actually provide for adjudication of any water uses besides irrigation until 1903.



Boulder farmer and stock-raiser, Hiram Prince, was appointed the state's first Water Commissioner in 1880. (Photo from Portrait & Biographical Record of Denver and Vicinity)

A few weeks later, the City Council met to discuss what the local newspaper called “two matters of importance.” One was the construction of the first downtown railroad depot and the other dealt with water. After urging the building of the depot, the *Boulder News and Courier* stated:

EDITORIAL (*Boulder News and Courier*, July 7, 1882)

> The other matter of importance is that of enlarging the water main, as eloquently urged by Major Whiteley at the dedication of Fireman’s Hall the other evening.[24] It is assumed that there will be some objections, on the ground of the great expense, but there was that objection to this town’s constructing water works in the first place. It is an objection which all public enterprises have to face. Let it be faced down by the forward-looking, progressive spirit of the town.[25]

As a result, City Council members, in 1883, proposed a $50,000 bond issue to rebuild the waterworks. A *Boulder County Herald* writer stated, “The system could not be improved in part, but must be made entirely anew. The water question is getting to be a serious one.”[26]

The *Herald* noted that after dead horses had been found in the creek upstream, the water had to be turned off entirely for a short time. As soon as it was on again, residents continued to drink it. A physician recommended that households filter their drinking water and a university professor suggested a formula of alum and soda which, he said, would “settle 95 per cent of the dirt in 20 minutes.”[27] (Formulations of alum and soda are still commonly used in water treatment processes today.)

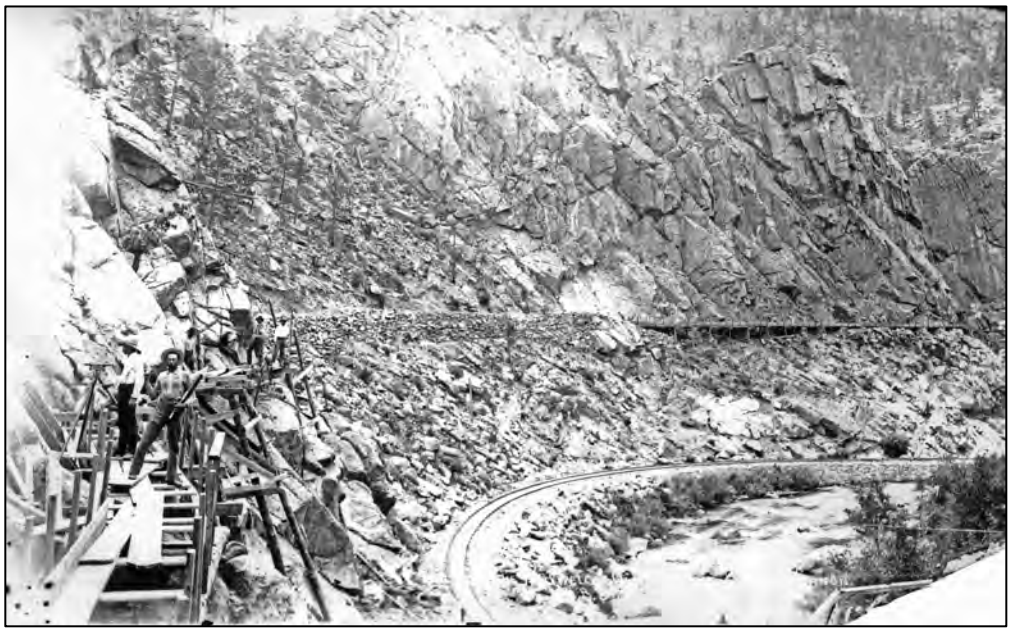
Another problem lay with the aging Town of Boulder Reservoir. In 1886, a group of enraged citizens visited the City Council to demand a new reservoir. Amid great controversy and debate, a $150,000 bond issued passed—459 votes in favor to 39 votes against. Residents hoped this would clear up the water problem for good.

In 1887, excavation began on the new reservoir, located nearer the base of Sunshine Canyon on land newly acquired by the City. The site was 100 feet higher than that of the old reservoir. Dirt from the excavation was carted down to Pearl Street to fill in potholes. Boulder’s residents were optimistic that this would clear up the water quality problems for good. However, the troubled municipal water system was still not considered adequate to support new development and city leaders were reluctant to approve any new extensions of water mains. This left James P. Maxwell and his partner, George Oliver, high and dry without a water supply for their proposed development on Mapleton Hill.

The Maxwell family and the Silver Lake Ditch and Reservoir Company

James P. Maxwell was involved in both private and public water projects. As previously mentioned, in 1872, he was one of the founders of the Boulder Aqueduct Company. Then, in 1875, he surveyed the Town of Boulder Reservoir site and began a long career in public service. From 1876 to 1880, Maxwell served his first term as state senator, overlapping the years 1878 to 1880, when he also was Boulder's mayor.[28]

Meanwhile, Maxwell had purchased 15 acres of North Boulder land known as the "Maxwell Addition." In order to develop his subdivision and make it attractive to prospective buyers, he needed water, but the City refused new connections. Maxwell and his partner George S. Oliver (listed as a feed store clerk in the 1880 federal census) formed a plan to build reservoirs high in the mountains and deliver stored water for the elegant new Mapleton Hill residences through a ditch on higher ground than the existing Farmers Ditch.



Laborers are shown, in 1888, constructing the wooden flume for the Silver Lake Ditch in Boulder Canyon. The line of the narrow gauge railroad (then the Greeley, Salt Lake & Pacific) is visible between the flume and Boulder Creek. Carnegie Branch Library for Local History, Boulder (511-2-1 #1)

In 1887, Maxwell and Oliver began construction of Silver Lake Reservoir near the headwaters of North Boulder Creek northwest of Nederland, just below the Continental Divide. At the outlet of the natural Silver Lake, the men built a dam of earth, rock, and timber which held back some water, but, more importantly, it established their claim to the water.[29] Maxwell also stocked Silver Lake with

fish.[30] In 1888, the men formed the Silver Lake Ditch and Reservoir Company to deliver water throughout Mapleton Hill and to the lands north of Boulder. Their Silver Lake Ditch ran on the far western edge of Boulder and wound through Mapleton Hill. In 1890, the company would begin construction on a second mountain reservoir, Island Lake.

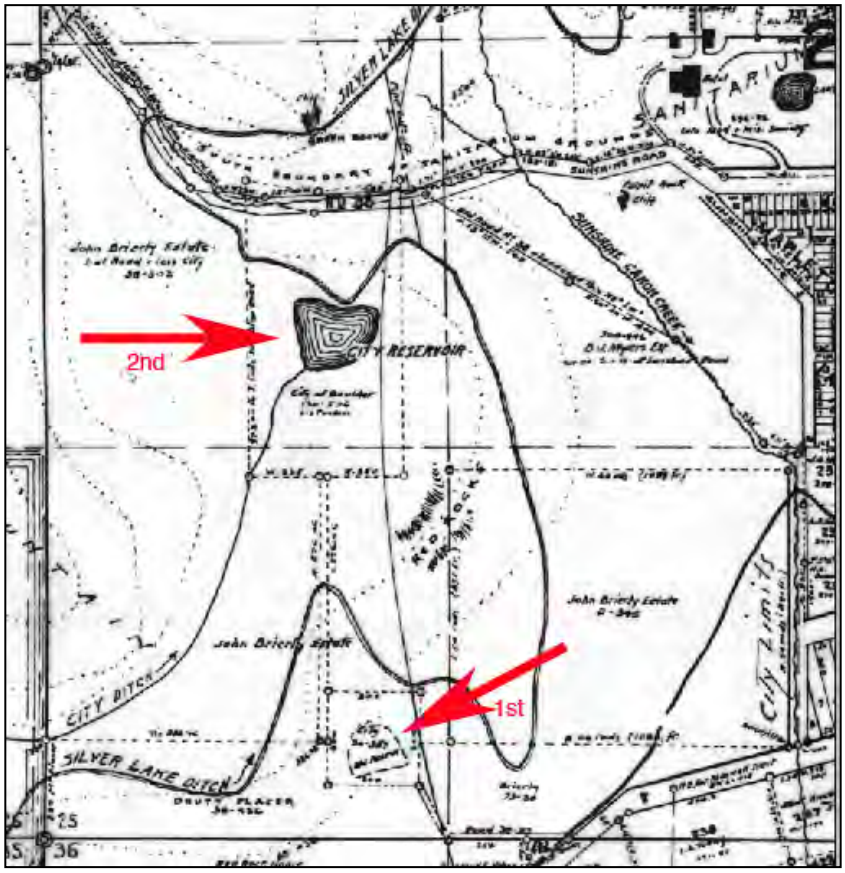
Silver Lake Ditch had five wooden flumes (stretching 1,300 feet) pinned to the walls of Boulder Canyon, as well as a 185-foot-long tunnel dug through a rock formation known as Elephant Buttress.[31] Beginning in the 1890s, laterals from the ditch watered maple saplings that Maxwell had planted along Mapleton Avenue.

The Silver Lake Ditch Company was different from other ditch companies since it was a for-profit company owned solely by Maxwell and Oliver. (Maxwell later bought out his partner and became the sole owner of the company.) The company delivered water under paid contracts to specific parcels of land and did not allow the contract water users to use that water anywhere else. Other companies were mutual ditch companies whose water rights were considered to be owned by the shareholders of the ditch companies and company shares could be freely bought and sold for use on other land served by the ditch.

This distinction would prove important in 1906 when Maxwell entered into a contract selling all of the mountain reservoirs and storage water rights to the City of Boulder. Individual contract water users of the Silver Lake Ditch then became reliant on Boulder to deliver water from city-owned sources to the ditch under the terms of a separate city/company contract. (Maxwell later sold the company to the Degge family who then sold it to contract water users.) During the next decade, the ditch's five wooden flumes were replaced with the steel pipes that now hang on the walls of Boulder Canyon.[32]

James P. Maxwell knew Boulder's waterworks both as a private investor and as a public official. Carnegie Branch Library for Local History, Boulder Historical Society collection (220-5-4)

James P. Maxwell filed for a land patent from the federal government that encompassed Silver Lake and Island Lake, high in the mountains above 10,000 feet. In 1896, he received title from the federal government for 160 acres. Maxwell was actively involved in water issues for the rest of his life. In the early 1890s, he was also state engineer, having authority over all of Colorado's irrigation diversions. He then became an active player in efforts to improve Boulder's municipal water supply sources in the early 1900s.



The locations of both the first Town of Boulder/Sunshine Reservoir and the second City/Sunshine Reservoir are indicated on this section of Drumm's 1915 City of Boulder Map. The first reservoir was completed in 1875; the second in 1891. Silver Lake Ditch was completed in 1888. (Carnegie Branch Library for Local History, Boulder Historical Society collection, Drumm's 1915 City of Boulder map)

NEED FOR NEW RESERVOIRS

- 1891, Opening of the City/Sunshine #2 Reservoir
- 1898, Construction began on Chautauqua Reservoir #1
- 1922, Construction began on Chautauqua Reservoir #2

City/Sunshine Reservoir #2, 1891

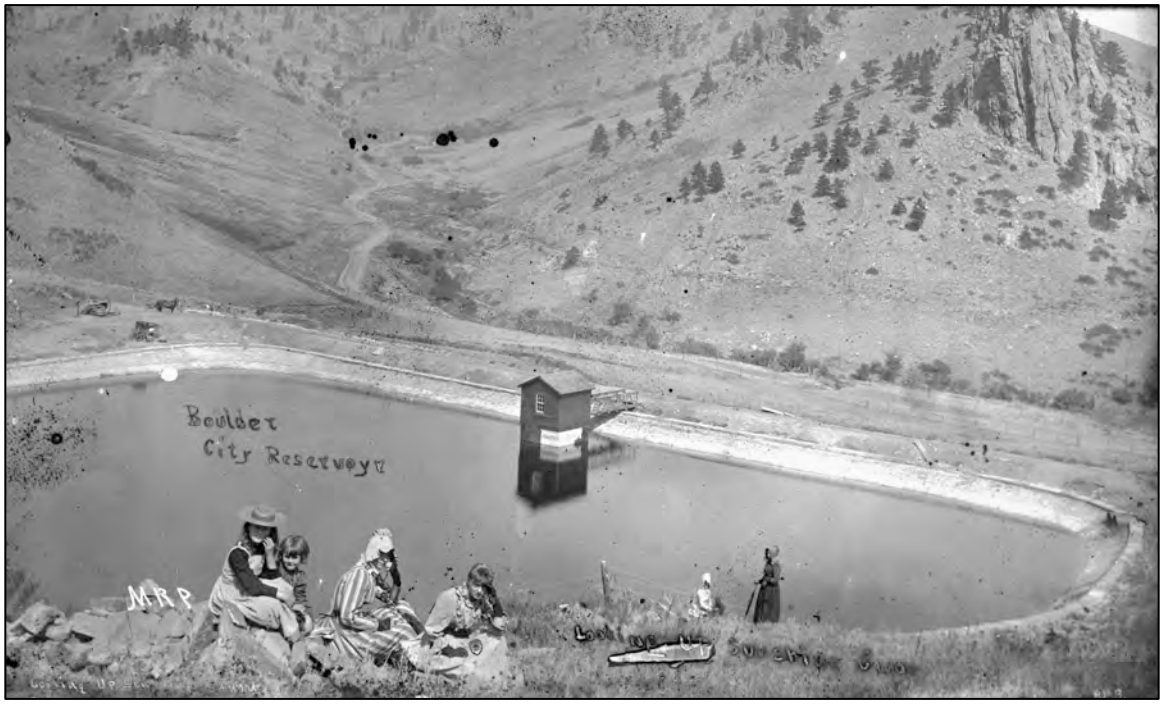
In March 1890, a committee was formed to recommend ways to improve the quality and reliability of the City's water. The committee recommended moving the intake that would feed the City's new reservoir further upstream.[33] The new reservoir to replace the Town of Boulder/Red Rocks/Sunshine Reservoir #1 became known as the City/Sunshine Reservoir #2 and was projected to hold five-million gallons of water. Flagstone was used to pave the reservoir sides. A small stone tower, containing a control valve, was constructed near the center of the reservoir and was connected to land by a wooden pier. A new 20-inch pipe was laid into Boulder in March 1891. One merchant was so thrilled with the prospect of clean water that he offered a sale on “the greatest bargains in Pure Toilet Soap ever known.”[34]

Plans for the new reservoir were somewhat deficient, however, because no one thought, at first, to line the bottom with cement. The *Daily Camera*, during its first year, in 1891, described a trip by City Council members to what its editor called the “much-maligned reservoir.”[35] Finally, in 1893, after extensive discussion in the City Council chambers, the City/Sunshine Reservoir #2 was lined, but the City had to ask its residents for an additional $50,000 in a bond issue, even though it had not yet spent all of the original $150,000 in what a newspaper writer called a “gaudy show of economy.”[36]

Heeding the advice of the editor of a competing newspaper, the *Boulder County Herald*, the intake for the City/Sunshine Reservoir #2 was moved to a natural settling basin above the community of Orodell (originally named Orodelfan), in Boulder Canyon, just beyond the intersection of Four Mile and Boulder creeks.[37] The City hired laborers to build a crude dam of cement sacks and constructed a wooden flume of yellow pine which measured 200 feet long, four feet wide, and three feet deep. A flume was required to measure the flow of water and make sure that diversions didn't exceed the amounts in the City's water rights.

This intake was sometimes called the Blanchard Intake, since the owner of Blanchard’s Lodge (later the Red Lion Inn) homesteaded 160 acres, including the future Betasso Ranch. (This intake would later be called the Lower Intake when the City began diverting even further upstream.) New piping from the intake to the reservoir was laid on higher ground, which required another land purchase. However, water problems continued.

Excavation of the City/Sunshine Reservoir #2 began in the late 1880s. Below, the City/Sunshine #2 Reservoir was a destination for these ladies when this photo was taken shortly after the reservoir's completion in 1891. Both photos, Carnegie Branch Library for Local History, Boulder Historical Society collection (Above, S-937, below S-939)



Continued population growth in Boulder forced the City to re-open the first (Town of Boulder) reservoir for a short time. Again there were complaints of murky water. The Water Superintendent (whose title had changed in 1887 from Water Commissioner to avoid confusion with the new state employees who regulated water users on the rivers) solved the problem, at least temporarily, and called for the use of the City/Sunshine Reservoir #2 water during the day when the customers could see it and the use of the "old reservoir" water at night when they could not.

The "100-Year" Flood and the 1890s

The City/Sunshine Reservoir #2 was never a danger to Boulder residents, but after what was later called the "100 Year" flood, in late May 1894, a rumor circulated throughout the City that the reservoir had burst. The *Daily Camera* gave the following account on June 1, 1894, when flood waters were at their highest:

> THEY TOOK TO THE HILLS (*Daily Camera*, June 1, 1894)
>
> When the report was set in motion by George Whitney rushing frantically down the street crying, "Get to the hills; the reservoir is busted!" it spread like wild fire. Pete Werley rushed home in great haste and met his pale and anxious wife and children. "Get to Lovers Hill [now Sunset Hill]!" exclaimed Peter. "Get there quick!" and then he repeated the order to his anxious neighbors.
>
> Brother Wangelin and his family were already there, and Otto had kindly told his neighbors of their great danger so that when Pete arrived, he counted no less than 75 terror-stricken Boulderites, viewing the waste places from on high.
>
> When, after a few hours, word came that the reservoir had not really and truly burst, they cautiously descended and each and every one of them still lives and will tell the story, let us hope, to future generations with the same modesty as now makes their discourse on this subject.[38]

After all of the bridges had washed out in the 1894 flood, this makeshift conveyance transferred people (and kegs of beer) across Boulder Creek. Carnegie Branch Library for Local History, Boulder Historical Society collection (225-1-8)

With a fair amount of bond issue money then currently at hand, the City, in 1894, concentrated upon improving its water supply lines. A steam-powered pumping station, located at the intersection of Ninth Street and Aurora Avenue, supplied the line to University Hill, since gravity alone could not deliver water with enough force to those areas. Eventually, after the turn of the twentieth century, that portion of the waterworks was re-designed so that the pumping station was no longer needed.

In 1896, a visitor from Iowa was impressed with the City's waterworks, and his, or her, comments ended up in the *Daily Camera*. "The City's water supply comes from an open reservoir 200-to-300 feet higher than the town, which is supplied through pipes reaching several hundred feet still higher, several miles up the mountain," stated the tourist. "It is snow water and is the cleanest, purest, and softest water we have ever seen."[39]

Even so, there still were problems with Boulder's water quality. In 1897, a local laundry sent the City a bill totaling $7.50 for "hauling water while city water was muddy."[40] Contamination continued to seep into Boulder Creek. During the winter of 1895-1896, the City laid its first sewer main.

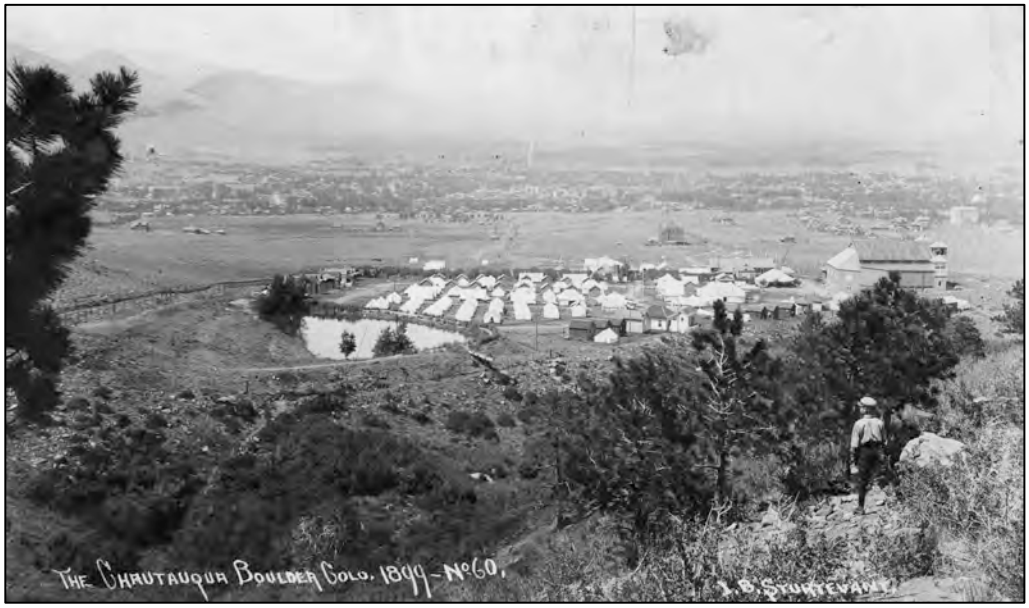
The year of 1898 brought the opening of Chautauqua Park, bringing many new seasonal visitors. And, the City Council saw a need for another city reservoir.

The Chautauqua Reservoirs: 1898 and 1922-1923

A group of Texans built Chautauqua Park on the hillside south of Park Avenue (now Baseline Road). Boulder's Chautauqua was part of a national movement of educational and cultural summer resorts, with speakers and entertainers who traveled the Chautauqua circuit. To accommodate them, the first buildings were the auditorium and dining hall, both still in use today. During the early years, guests stayed in tents which, gradually, were replaced with cottages. But even before most out-of-town visitors had roofs over their heads, excavation had begun on the first Chautauqua Reservoir, located at the very southern, and uphill, end of the settlement. Water for the first Chautauqua Reservoir came from two sources—a ditch that had been dug from Gregory Canyon and a line (with a boost from the Ninth Street pumping station) from the pipes in Boulder Canyon.[41]

In Boulder, laborers replaced pipes, first in south Boulder in 1904 and then in north Boulder in 1905. They installed split pipelines from the Lower Intake at Orodell—a 16-inch line swung north to Sunshine Reservoir and a 12-inch pipe ran to the Chautauqua Reservoir. (Pipes from Orodell to Sunshine Reservoir were replaced again in 1922, 1926, and 1928. Lines to the second Chautauqua Reservoir also received attention in 1934, 1945, 1940, and 1946.)
Another 12-inch pipe went down to the business district.

The first Chautauqua Reservoir, built in 1898, was filled in with soil when Chautauqua Reservoir #2 was constructed in 1921-1922. (After 1948, eight houses were built on the filled-in former reservoir ground.)



When the Chautauqua Reservoir (left of center) was constructed in 1898, Chautauqua was basically a tent city. The auditorium is on the right. Carnegie Branch Library for Local History, Boulder Historical Society collection (212-1-44 #8)

INTO THE 20TH CENTURY

Discovery of Arapaho Glacier

On July 14, 1900, Boulder druggist and future Chamber of Commerce Secretary Eben G. Fine was visiting the owner of a mine in the vicinity of Silver Lake. Fine couldn't find anyone to hike with him, so he set off alone from the lake. He headed for South Arapaho Peak and decided to cross what Boulder residents then called "the big snow bank" (visible from parts of the city).

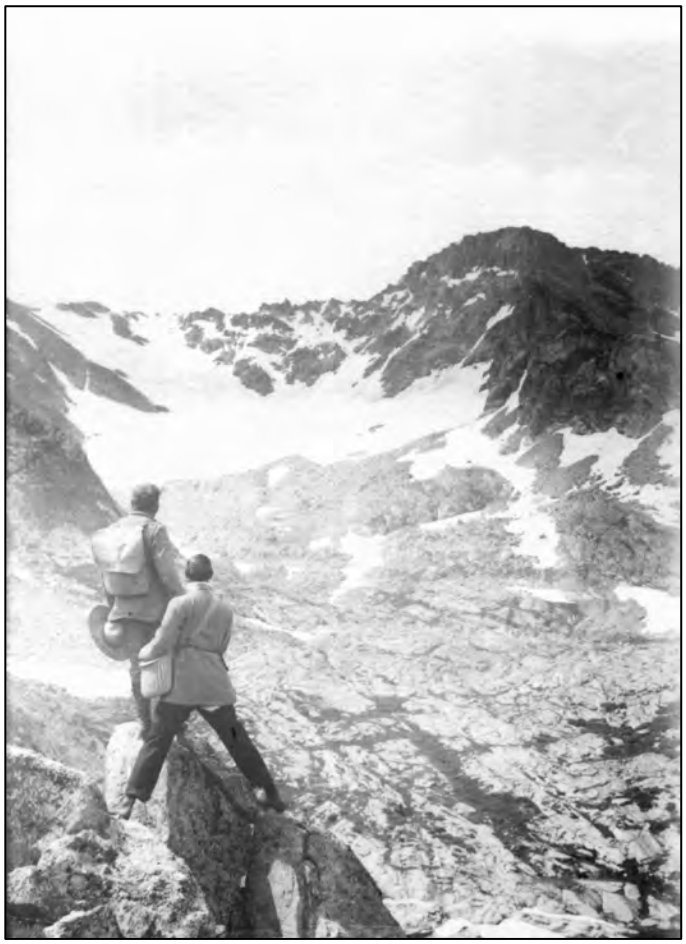
When Fine reached the middle of the snow bank, he realized that he was standing on a living glacier. In his book *Remembered Yesterdays*, Fine noted, "If the glacial character of that snowfield had ever been suspected, certainly no word had ever appeared in print."[42] He added that he was so excited that he nearly fell into one of the crevasses, but he made it home safely and stated, years later, that the discovery of a glacier was a splendid way to bring in the new century.

Darwin M. Andrews (left) and Herbert N. Wheeler (right) were photographed, in 1897, in Barker Meadows (site of the Barker Reservoir) east of Nederland, on their way to the Silver Lake area. Carnegie Branch Library for Local History, Boulder (513-2-12)

However, Herbert N. Wheeler (on a botanical expedition) claimed that, three years earlier, he and Darwin M. Andrews—not Fine—had been the true discoverers of the Arapaho Glacier. In his memoirs, Wheeler wrote of the hike the men took during the last week of August 1897.

EXCERPT FROM THE MEMOIRS OF HERBERT NEWELL WHEELER

> D.M. Andrews and I took his burro and walked up to Camp Albion, an old mining camp in a valley across the ridge to the north of Silver, Island, and Goose lakes. He wanted to get some bulbs of dogtooth violet from the valley floor at the head of the Silver Lake area. After getting the bulbs, he said he had always wanted to see what was at the head of that valley, so we went on beyond the last lake and climbed up the steep slope of rocks and ice. After reaching the top, we walked toward the north and soon came upon cracks in the ice, at first a few inches wide and then several feet wide, rather terrifying. Darwin said this is a glacier. We dropped rocks down into the crevasses but didn't hear them strike bottom.[43]



Early (and unidentified) hikers explored Arapaho Glacier in 1912. Carnegie Branch Library for Local History, Boulder Historical Society collection (141-9-32 #1)

In 1904, glacier hikers even included ladies in long dresses! Carnegie Branch Library for Local History, Boulder Historical Society collection (S-2037)

Watershed Reservoirs and the Lakewood Pipeline

- WATER STORAGE IN THE MOUNTAINS
- LAKEWOOD, LAKEWOOD RESERVOIR & TUNGSTEN MINING/MILLING
- LAKEWOOD PIPELINE, BEGINNINGS
- FEDERAL GRANTS & WATER RIGHTS IN THE WATERSHED
- ALBION LAKE RESERVOIR

Regardless of who had been the first to walk on the glacier, the early 1900s was a time when Boulder began to collect water rights, reservoir storage rights, and watershed lands in earnest. According to the 1900 census, Boulder's population had nearly doubled in the preceding decade, and the Sunshine and Chautauqua reservoirs were viewed as inadequate for a growing city of 6,150 people. A drought in 1902 made the situation more urgent and restricted water use. Water-powered motors in printing plants and other industries were shut down, and heavy water users were told to conserve.

WATER STORAGE IN THE MOUNTAINS

In September 1902, the City Council voted to visit Silver Lake to investigate the possibility of obtaining water storage high in the mountains.[44] Due to the on-going water quality problems near the mouth of Boulder Canyon, it was decided to look into moving the intake for city pipelines up to North Boulder Creek, above its confluence with Boulder Creek. Even then, however, the Silver Lake area wasn't a pristine wilderness. The North Boulder Creek watershed was impacted by runoff from the mining camp of Albion that flowed into Silver Lake. There, 19th-century mines produced lead, silver, and a small amount of gold.

In addition, there were roads and the dams at Silver and Island lakes that had been built by James P. Maxwell. These dams raised the water levels in the easternmost of the natural lakes that had been gouged out thousands of years ago by glaciers. Maxwell's oldest son, Clint Maxwell, had also embarked on a dam construction project in 1901. Clint had placed a small, eight-foot high dam downstream of a natural lake (called Oval Lake) to raise the lake level and create the predecessor to what would become Goose Lake.

In February 1903, James P. Maxwell, who had become City Engineer at the time, proposed to the City Council that he and the City of Boulder form a public-private partnership with regard to his storage right in Silver Lake. The *Daily Camera* published his comments.

"WATER MORE WATER SAYS THE COUNCIL"
Proposition of ex-Senator Maxwell for Construction of a Dam on Silver and Goose Lakes, Near the Snowy Range––If Lawyers and Engineers Approve It, The Proposition Will Be Accepted by the City
(*Daily Camera*, February 5, 1903)

"The Silver Lake Ditch and Reservoir Company will grant to the City of Boulder a perpetual lease or other good and sufficient contract to one-half of its water storage right in Silver Lake Reservoir," he[James P. Maxwell] stated, "on the condition that the City of Boulder shall build and maintain at the present site of the Silver Lake Reservoir a good and substantial structure of such material as may be agreed upon and of sufficient height and body to impound 25 feet in depth of water above the floor of the present discharge flume in the dam now constructed.[45]

The offer was not acted on by the City, possibly because it required the City to pay for the construction of a new and larger dam to replace the leaky timber-crib dam built in 1887. Maxwell did not even have any decreed water storage right, since the courts had not yet issued decrees for any reservoirs in the Boulder Creek basin.[46] If the City followed through, it would not have any ownership in the new dam it built, the land at Silver Lake, any decreed water rights, or in water stored behind the dam. Basically, all Maxwell was offering the City was the privilege of building a sturdy new dam for his company to impound water at its reservoir site in exchange for leasing the right to use water that might eventually be stored in any new reservoir space.

The Maxwells also made a similar proposal for Clint's reservoir at Goose Lake, but, after much debate, both partnership offers were turned down. At this point, the Maxwells reached an agreement with the City to sell some of their Silver Lake area properties that were not needed to provide water supplies for James P. Maxwell's Boulder developments. The City's initial purchase—$15,000 in 1904—was from Clint Maxwell for land surrounding Triple Lakes (three natural lakes with no dams) and Oval/Goose Lake.[47] In January 1906, the City also purchased, from James P. Maxwell, land near the Albion mining camp for $12,000.[48]

James P. Maxwell continued to negotiate with the City about the Silver Lake property, but discussions turned to proposals that would sell full ownership of the land and reservoirs at Silver and Island lakes to the City. The negotiations were complex since Maxwell wanted to sell all of his interests in the Silver Lake Ditch and Reservoir Company, including the ditch, but the City was only interested in buying the reservoirs. Maxwell needed the City to agree to a contract committing to provide enough reservoir water (from what would become the City's reservoirs) to satisfy the contracts that his company had already signed with water users along the Silver Lake Ditch. On January 17, 1906, it appeared that negotiations had reached an end. The following day, a writer for the *Daily Camera* reported:

EDITORIAL (*DAILY CAMERA*, JANUARY 18, 1906)

> Mr. Maxwell says that he is weary with jockeying about Silver Lake and he proposes now to keep the property for himself. The incident was formally closed when City Attorney [Henry O.] Andrew last night told the Council of Mr. Maxwell's withdrawal of the option. Of course, the only thing to do now is to try and see if a dam at Goose Lake will impound enough water for the city's uses. We believe, however, that the very first proposition that should have been undertaken was the securing of the services of some eminent engineer from outside the city or state, to pass on the entire subject matter. The episode which has just closed in

> the discouragement of the people and defeat of the mayor and Council is deeply to be deplored. Some day, Silver Lake or some such body of water or reservoir site will bring a price from Boulder's taxpayers that will require some six figures to express.[49]

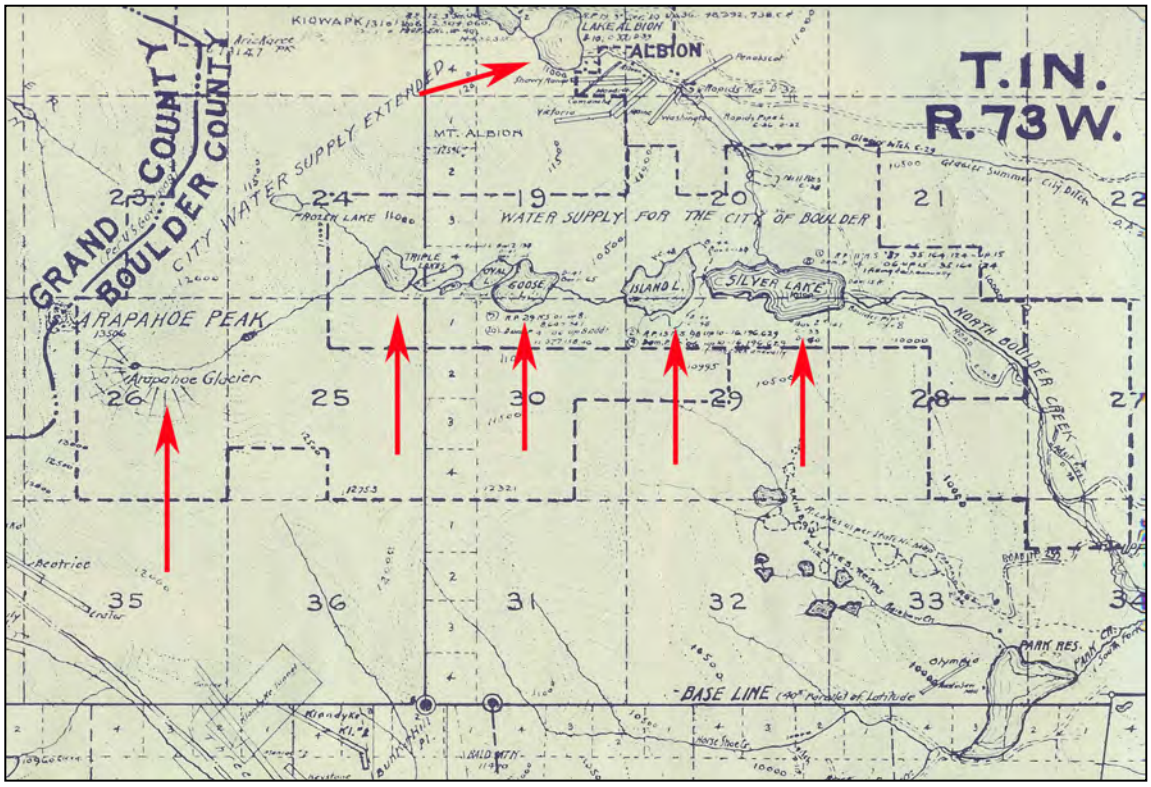
This may have been posturing on Maxwell's part since (by the end of January, 1906) the City and the company had entered into an agreement for the City to purchase Silver Lake and Island Lake for $34,000. The Deed for the transaction included the sale to the City of the land surrounding the reservoirs and "…all water rights, storage rights, water decrees, reservoir decrees, and filings, and filings for further storage of water and all other rights of every kind and nature whatsoever…owned by [Silver Lake Ditch and Reservoir Company]…."[50]

The obligation to satisfy contract holders under the Silver Lake Ditch remained with the company, to be satisfied through the contractual right to use any water from the City's first annual fill of space located above the Silver Lake and Island Lake outlet works and imaginary elevation planes located several feet above the outlets.[51] This left the City with the right to use first-fill water stored in the space above these elevation planes and below the tops of the dams. The City also gained the right to use water from any reservoir space that could be refilled during the course of the year and any first-fill water not used by the company, as well as any water below the outlet in the natural lake area that the City could manage to access.[52]

The contract further stated that the City's obligation to deliver water to the company would decline over time as contract holders abandoned use of their Silver Lake Ditch water or were supplied by other water sources, such as by annexation to the City.[53] (In 1908, Clint Maxwell sold the remaining assets of the Silver Lake Ditch and Reservoir Company to W. W. Degge, developer of a subdivision named Wellington Gardens. These assets were a direct-flow right for the Silver Lake Ditch, the ditch structure itself, and the contract with the City to have storage water released for ditch company use. Degge's property was located on the east side of 12th Street—now Broadway—north of the County Poor Farm that was located northeast of today's intersection of Broadway and Iris Avenue.)[54]

During the time that the "jockeying," as described by James P. Maxwell, was occurring, the City moved forward with plans to enlarge Goose Lake. The City started by extending the road from Silver Lake. In 1905, when the road was completed, John Teagarden began replacing the modest earthen dam at Goose Lake by cleaning rock from the stream outlet. Work continued in 1906 under the supervision of the new City Engineer, Fred A. Fair.[55] A toe trench for the dam was cut into solid bedrock and filled with concrete. Timber cribbing was placed on top with cross ties every ten feet. The cribs were then filled with broken stone. A setback came on March 14, 1910, when the dam was partially completed to a

height of 16 feet. A lightning-caused forest fire burned and destroyed the lower eight feet of the timber cross ties in the dam.[56] Eventually, however, the dam was raised to a height of 30 feet, at a cost of $26,245.65.[57] The improvements increased the size of the reservoir from 65 million gallons to 338 million gallons and fully engulfed Oval Lake. [58]



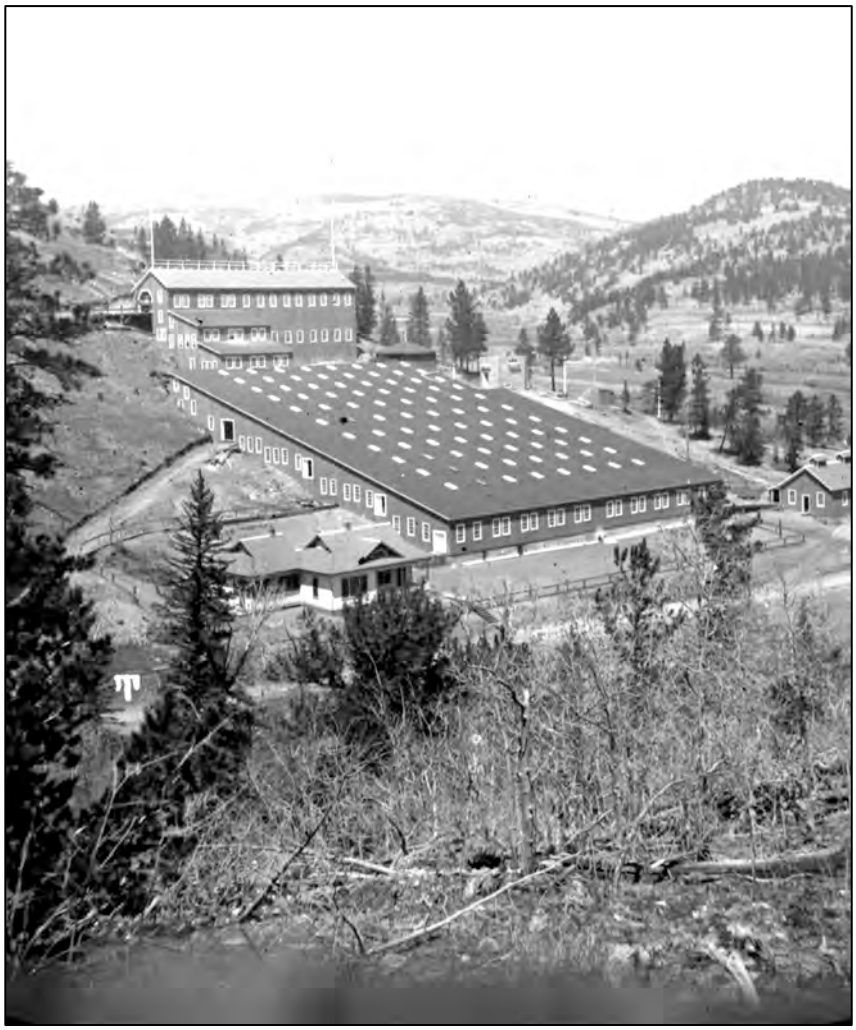
Above is a portion of Drumm's 1926 Map of Boulder County with arrows to show Arapahoe [sic] Glacier, the Triple Lakes, Goose Lake Reservoir, Island Lake Reservoir, Silver Lake Reservoir, and Albion Lake Reservoir. Drumm's 1926 Map of Boulder County, Pettem collection

LAKEWOOD, LAKEWOOD RESERVOIR & TUNSTEN MINING/MILLING

Meanwhile, water quality problems near the City's pipeline intake at the mouth of Boulder Canyon were worsening, and prospectors near Nederland kept stumbling upon a substance they called "black iron." In 1900, the ore was identified as tungsten, in demand as a hardening agent in steel. The earliest-known tungsten deposits were in the vicinity of the Boulder County Ranch (which became the Tom Tucker Ranch, then the Van Vleet Ranch, and is now Caribou Ranch).[59]

By 1904, several large mining and milling corporations had replaced the previous small-time miners. Involved with several of the corporations was Chauncey F.

Lake, so it's not surprising that the mining camp that was located near the entrance from today's Peak to Peak Highway to the Caribou Ranch was named Lakewood. (Lakewood even had its own post office, established October 1, 1912 and discontinued on December 31, 1920.)[60]



Chauncey F. Lake's Primos Mill, in Lakewood, became the world's largest producer of tungsten during World War I. It also was seen as a likely polluter of the Lakewood Pipeline. (*Foundations are still visible from today's Peak to Peak Highway.) Carnegie Branch Library for Local History, Boulder (604-1-49)*

Tungsten was also discovered in Boulder Canyon, and mines and mills opened there, as well. Because of the contamination that filtered down to the intake just above Orodell, the City made the big decision, in 1906, to move Boulder's intake pipeline farther upstream on North Boulder Creek. The first step was to construct the Lakewood Reservoir, used as a forebay for the new pipeline. The reservoir was built on 20 acres of land purchased from Theodore N. Barnsdall of Pittsburg, Pennsylvania, then owner of the Boulder County Ranch.

In addition, the City acquired easements for the Boulder City Pipeline (a portion of which is now called the Lakewood Pipeline) and for diversions from the creeks running across lands owned by Barnsdall. City officials were already considering

the potential need to extend the Boulder City Pipeline even further up North Boulder Creek since the City had also acquired the right to connect a future pipeline from Silver Lake Reservoir into Lakewood Reservoir “should future emergencies require, whether from pollution of the stream or otherwise.”[61]

This was a period when installation of new electric power grids were starting to transform the shape of society. Barnsdall recognized the potential for electric generation using hydropower created by running the City's water diversions through a pressurized pipeline dropping hundreds of feet through the mountain terrain. As a part of the land sale at Lakewood, Barnsdall was given the right to construct a pipeline from North Boulder Creek that would drive a hydroelectric plant before discharging into Lakewood Reservoir. Barnsdall, however, never constructed his pipeline and power plant. It would be eight decades before Barnsdall's vision for hydroelectric power from the City’s water system was realized.

LAKEWOOD PIPELINE, BEGINNINGS

In 1906, the City began laying pipe from Lakewood Reservoir down to Boulder's existing pipeline intake, near the mouth of Boulder Canyon. Crews excavated a pipeline trench through the mountainous terrain using mostly picks and shovels to clear away rock loosened by blasting.[62] Below Lakewood Reservoir, the City laid 32,500 feet of 18-inch pipe, followed by 16,900 feet of 15-inch pipe, before completing the line with the final 3,800 feet of 12-inch pipe. The pipe was made of steel, lap-welded with converse lock joints sealed with lead solder, and was guaranteed to stand a pressure of 500 pounds per square inch.[63]

The Lakewood Pipeline was completed in 1906 at a cost of $155,000— a mammoth outlay for such a small city. The City Council knew, however, that this was just the beginning of larger expenditures for the water system. The acquisition of North Boulder Creek land was falling into place, and City leaders were well pleased with the quality of the water.

WE BEAT THE WORLD
Boulder’s Water Pronounced by a Great Chemical Laboratory to be Nearly Aqua Pura
(*Daily Camera,* January 3, 1907)

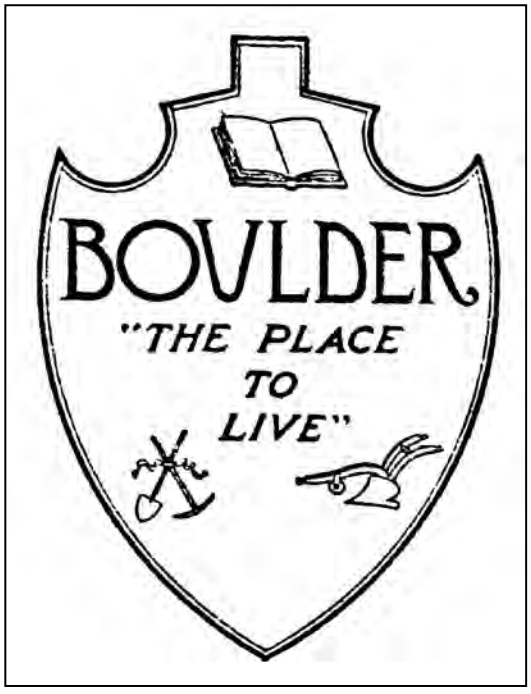
City Superintendent of Water Works W.W. Wells recently addressed a letter to the Dearborn Drug & Chemical Company of Chicago, whose laboratory is one of the greatest in the world, and sent a sample of a gallon of water taken from the mains of the City of Boulder, with a request for analysis. The returns are most

gratifying to the mayor and city council and to Mr. Wells. The water is found to be almost entirely free of any element that can injure the human organism.

If water enters largely into the daily needs of the people, this analysis affords a striking illustration of the boast that boulder is “the place to live.” It is doubtful if any other city of 11,000 or 12,000 souls on earth has water as nearly pure as that given Boulder by its present superb system of pipes and reservoirs. The analysis follows:

Silica	.560 grains
Oxides of iron and aluminum	.116 grains
Carbonate of lime	.700 grains
Carbonate of magnesia	.309 grains
Sodium and potassium sulphates	.311 grains
Sodium and potassium chlorides	.340 grains
Loss, etc.	.116 grains
Grains of solids per gallon	2.452 grains

The above shows that there is one grain of impurity in the 24.576 grains contained in a gallon of water, or a percentage of 99 996/1000 purity.



An image of a pick and shovel for the miners and a plow for the farmers (along with a book for the University of Colorado) were depicted on the City of Boulder’s early twentieth-century logo. No doubt the 99+ percent water added to the city’s slogan, “Boulder: The Place to Live.” Pettem collection

FEDERAL GRANTS & WATER RIGHTS IN THE WATERSHED

Individual purchases from the Maxwells and other area landowners, however, only supplied a portion of the land eventually owned by the City of Boulder in the area that would become known as the Silver Lake Watershed. Most of land was purchased from the federal government for $1.25 per acre based on three grants made by the U.S. Congress in 1907, 1919, and 1927.

The Act that conveyed the first grant to the City, on March 2, 1907, stated:

EXCERPT FROM "AN ACT TO GRANT CERTAIN LANDS TO THE CITY OF BOULDER, COLORADO, 1907"

"…for purposes of water storage and supply of its waterworks… said City shall forever have the right, in its discretion, to control and use any and all parts of the premises herein conveyed, and in the construction of reservoirs, laying such pipes and mains, and in making such improvements as may be necessary to utilize the water contained in any natural or constructed reservoirs upon said premises."[64]

That same year, the City began obtaining court-decreed water rights for the municipal water storage reservoirs within the Silver Lake Watershed area. Prior to March 1907, there had not been any court-issued water decrees for the reservoirs in the Boulder Creek basin. Every earlier decree issued by the court had required that all diverted water was to be put to immediate use, otherwise known as a direct-flow water right. Until the late 1890s, there were sufficient water supplies available to fill existing reservoirs whenever direct-flow rights for irrigation weren't taking the entire flow of the stream. But, by the early 1900s, so many reservoirs had been built that diversions for storage needed to be regulated in order of priority in the same manner as direct-flow diversions.

The 1907 Boulder District Court decree recognized reservoir storage rights for the first time, as well as all water rights that had been developed since the 1882 general adjudication or had missed the previous general adjudication.[65] The City was decreed a 20-cubic-feet-per-second (cfs) direct-flow water right for the Boulder City Pipeline for diversions from North Boulder and Como creeks. The court also issued the first decreed water rights for Silver Lake, with appropriation dates of 1887 and 1906; Island Lake, with appropriation dates of 1890 and 1906; and Goose Lake with appropriation dates of 1901 and 1906, as well as a conditional water right for enlargement.[66]

Other watershed improvements during this era included the strengthening of the log-and-timber dam at Island Lake, in 1908, and the repair of the 16-foot-dam at Silver Lake (assuring its the 263-million-gallon capacity), following a fire in 1910.[67] Boarding and bunk houses were built nearby for work crews.[68]

The *Boulder County Miner* published a special *Magazine Supplement* on June 30, 1910. At that time, Fred R. Dungan was City Engineer, having taken over the responsibilities of acquisition of the watershed reservoirs and the construction of the Lakewood Pipeline from Fred A. Fair, who served from 1906 to 1910. (Fair then transitioned into a consulting engineering role for the City.) The publication's lead story was "Boulder's Water System." Stated the writer:

> Few realized at the time that changing of the point of diversion of Boulder water supply from Middle to North Boulder Creek meant ultimately the expenditure of something like a million dollars in order to retain the rights and secure a supply of pure water, equal to present demands and provide a reasonable margin for the future growth of the city.[69]

The Albion Lake Dam is visible in the background, on the right, in this view of the mining camp of Albion taken shortly after 1913. (Courtesy Alan Cass)

ALBION LAKE RESERVOIR

Albion Lake was the last lake in the watershed area to be raised by the City for use as a reservoir. (The City would later buy the five Green Lakes with the dams already existing on three of them.) Surveying for the 60-foot-rock-fill dam had begun prior to the City's 1907 purchase of land near the Albion mining camp from the Cashier Mining and Milling Company.[70] It was agreed that the Cashier Company could capture any water seeping out of Albion Lake to run through its planned Cascade Pipeline that the company would construct to generate hydropower for mining operations.[71] By 1908, the pipeline drove a hydroelectric plant located below Albion Lake.[72]

Plans for the City's new dam included an outlet channel, a bunk house, and a construction plant, as well as repairs on the road between Albion Lake and Hill Siding (a stop on the narrow-gauge railroad). In addition, a new road was constructed to Silver Lake. The 1910 *Boulder County Miner Magazine Supplement* mentioned the City's concerns about the disposal of surface contamination from the Albion mines. At the time, the output of lead in the previous year had amounted to more than $10,000, with silver and gold production more than $7,000.[73]

Nevertheless, construction began by 1910. Claire Victor Mann, an assistant city engineer, supervised the dam's construction. Mann's crew of 175 men worked day and night, made possible by electric lighting powered by the Cascade Pipeline hydro plant. In addition, steam-powered tramways transported construction materials along cables, thereby avoiding 2,000 feet of steep roads.[74] Mine dump and mill tailings from the Cashier Mining and Milling Company's Snowy Range Tunnel and Albion Mill were used as material for the dam.[75] By 1912, two-thirds of its construction had been completed at a cost of $210,000, but the City ran out of money. Although the dam was originally designed to be 60 feet high, it was only built to a height of 39 feet, and no new work was performed after 1913.[76]

The much-larger Barker Dam—that created Barker Reservoir—would be the dam that made the news.

BOULDER HYDRO SYSTEM, 1910

The twentieth century ushered in sweeping changes for Boulder and Boulder County. Proud of its educational status with the University of Colorado and its cultural advantages with the founding of the Chautauqua Resort, the City of Boulder called itself the “Athens of the West.” While health-seekers sought “treatment” at John Harvey Kellogg’s Boulder-Colorado Sanitarium, Fred White (mine owner at Albion) and other Prohibitionists supported the temperance movement.

Along with social changes came changes in technology. The world's first commercial hydroelectric plant had been built in Ophir, in San Miguel County, Colorado, in 1891, to feed the Gold King mine.[77] Before long, there was an expanding demand for the electrification of cities and towns. In 1904, the newly incorporated Central Colorado Power Company began construction of the Shoshone Plant on the Colorado River (called the Grand River at the time), near Glenwood Springs. The company delivered electricity to Denver from Shoshone via a 153-mile transmission line through Leadville and Georgetown, crossing some of Colorado's most rugged terrain. The line reached 13,532 feet in elevation, and was, at the time, the highest transmission line in the world.[78]

In June 1903, the Denver-Eureka Power Company filed a claim with the U.S. Department of the Interior to allow use of federal land for portions of a hydropower project that would carry water from a new reservoir near Nederland to a power plant on Boulder Creek near Orodell, in Boulder Canyon.[79] In 1902, the company filed claims with the State Engineer for pipeline alignments for the Eureka Ditch.

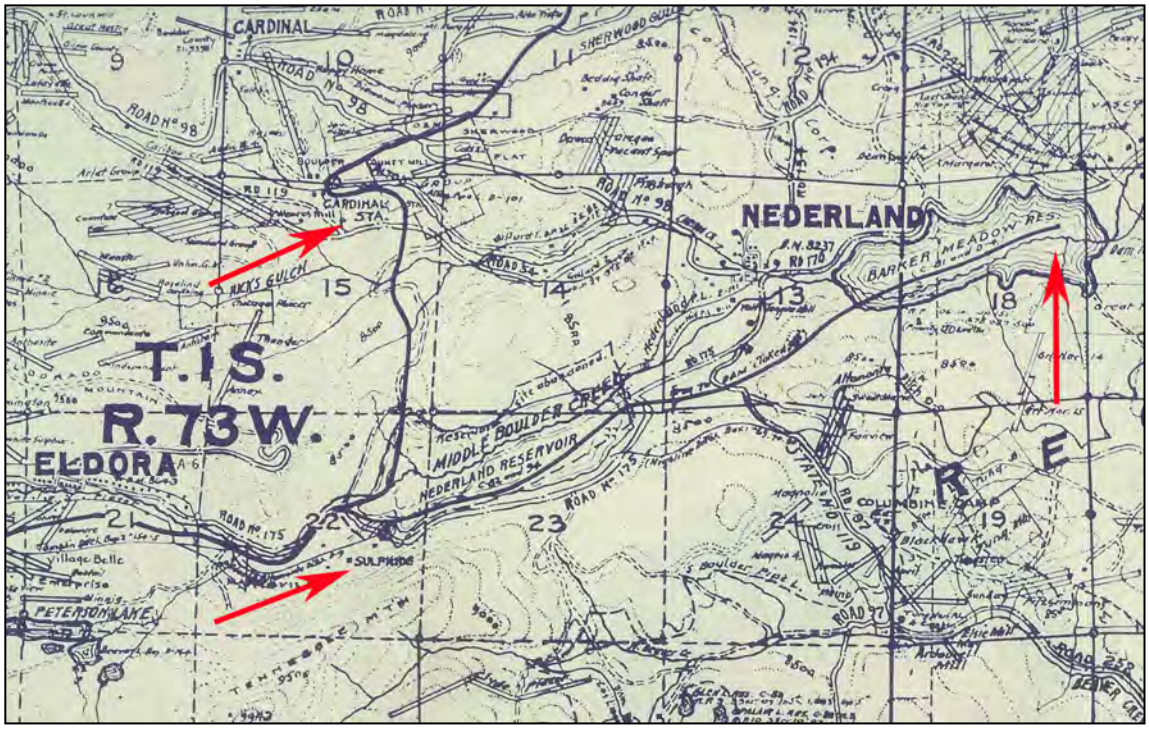
Then, in 1905, the company filed on a pipeline alignment designed to carry water from Nederland to a hydro plant near Orodell.[80] W. Hollingsworth McCleod, a Boulder businessman, purchased land for constructing a reservoir for the Denver-Eureka project at Sulphide (between Eldora and Nederland).[81] The interests of Denver-Eureka and McCleod were bought out by the Eastern Colorado Power Company when it was formed in 1907 for the specific purpose of building a hydroelectric project on Boulder Creek.[82]

Barker Dam

The project was, at that time, proposed to include two reservoirs on Middle Boulder Creek (the Nederland Reservoir and Barker Meadow Reservoir), a non-pressurized pipeline running from Barker Dam to a forebay reservoir at Kossler, a penstock (pressurized pipeline) leading to a powerhouse, and another reservoir out on the plains (Twin Lakes Reservoir) northeast of Boulder to capture water released from the hydroplant for later irrigation use.[83] Eastern Colorado Power eliminated the reservoir site at Sulphide because drilling tests showed that the glacial gravel deposits at the site were so thick and the bedrock layer so deep

that a water-tight reservoir couldn't be built.[84] The plans changed to focus on the remaining dam site in a meadow east of Nederland, owned by widowed schoolteacher, Hannah Barker. She initially refused to sell, but condemnation proceedings in the Boulder District Court in 1907 forced the sale in exchange for $23,800.[85]

As soon as work was begun on Barker Dam, newspaper readers were kept informed. In January 1908, the *Daily Camera* stated that, during the fall, between 600 and 700 men were employed at the various camps. The original plans that provided for the construction of the Sulphide dam first were changed, and work was shifted to Barker Meadows, where winter quarters were built. “A steam shovel is now at work below the dam site,” stated a reporter. “About 50 men are now employed at the Barker dam and this will be increased as fast as weather conditions permit the working of a larger force. It is expected that by the first of May, 300 men will be employed at Barker meadows, when the work will go forward night and day.”[86]



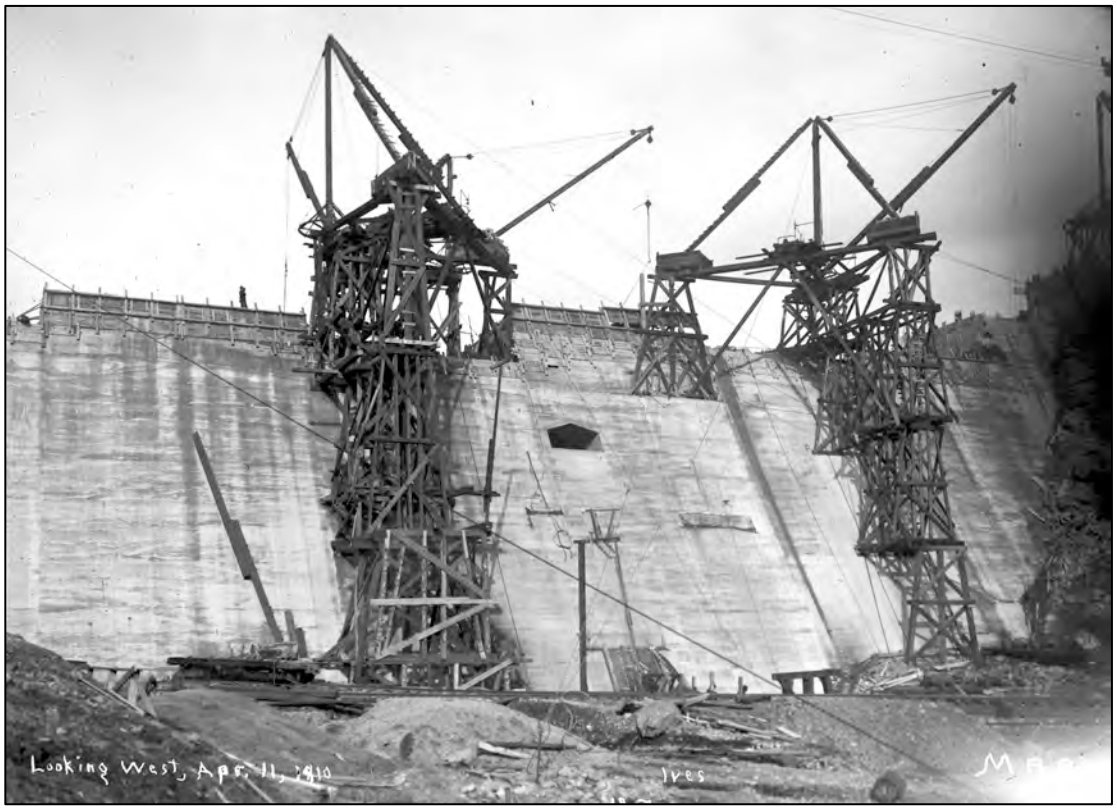
In 1926, when Henry Drumm drew this Boulder County map, the narrow gauge railroad was no longer in operation, but the railroad grades were still in place. The map shows the railroad grade extending south from Cardinal Station. At Sulphide, the main line went west to Eldora, but a spur line went east through the abandoned “Nederland Reservoir” site, then extended the length of the completed Barker Meadow Reservoir. Pettem collection

At the time, a narrow-gauge railroad, then operated by the Denver, Boulder & Western, ran west from Boulder into Boulder Canyon (then spelled Cañon) and to Orodell, where the trains turned northwest and followed Four Mile Creek to the

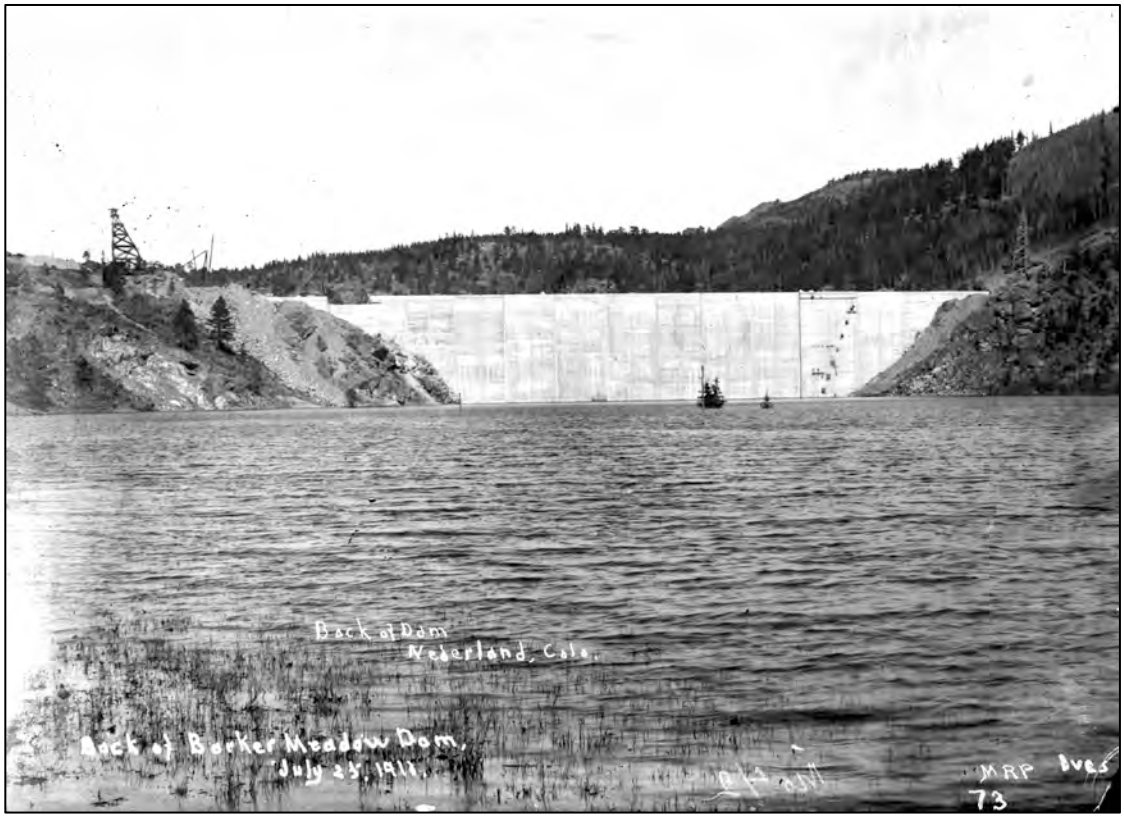
town of Sunset. From there, the train branched north to Ward (completed in 1898) and, also, south to Cardinal, Sulphide, and Eldora (completed in 1904). Neither the hydroelectric plant site nor the Barker Dam site were on the main railroad route, but, even so, the railroad played an important role in their construction.

Cement and other building materials and supplies for Barker Dam were transported via the railroad's southern branch that terminated at Eldora. At Sulphide, the power company hooked several of its 250 rail cars to a company locomotive and transported them down a temporary five-mile spur line, through Nederland, directly to the Barker Dam construction site, where the "McArthur construction camp" employed 356 laborers. While some were American, there also were immigrants from many countries including Germany, England, Sweden, Denmark, Austria, Greece, France, Turkey and Bulgaria.[87]

Barker Dam was completed in 1910. The dam structure, which cost $2.7 million, was built with a storage capacity of 500 million gallons (12,000 acre-feet) and measures 175 feet in height with a width of 720 feet and is made of cyclopean concrete.



The dam was photographed on April 11, 1910, when it was nearing completion. Carnegie Branch Library for Local History, Boulder Historical Society collection (S-288)



This view of Barker Reservoir and Dam from was taken on July 25, 1911. *Carnegie Branch Library for Local History, Boulder Historical Society collection (S-239)*

Boulder Hydro Plant, Pipeline, and Penstock

Progress on construction of other portions of the hydro project proceeded in fits and starts. The *Daily Camera* reported at the beginning of July 1907 that many men were needed for the construction of the powerhouse. Then, at the end of July, hundreds of powerhouse workers were being laid off. The superintendent gave the reason for the delay as "work is ahead of machinery."[88] However, Eastern Colorado Power appeared to be having financial difficulties.[89] Later, the company would be sued by the manufacturer of the turbines for non-payment of $79,038.80.[90] In 1909, the Eastern Colorado Power Company was merged into the Central Colorado Power Company. Central Colorado Power envisioned using power generated at Boulder Canyon Hydro to supplement generation from the Shoshone Hydro.

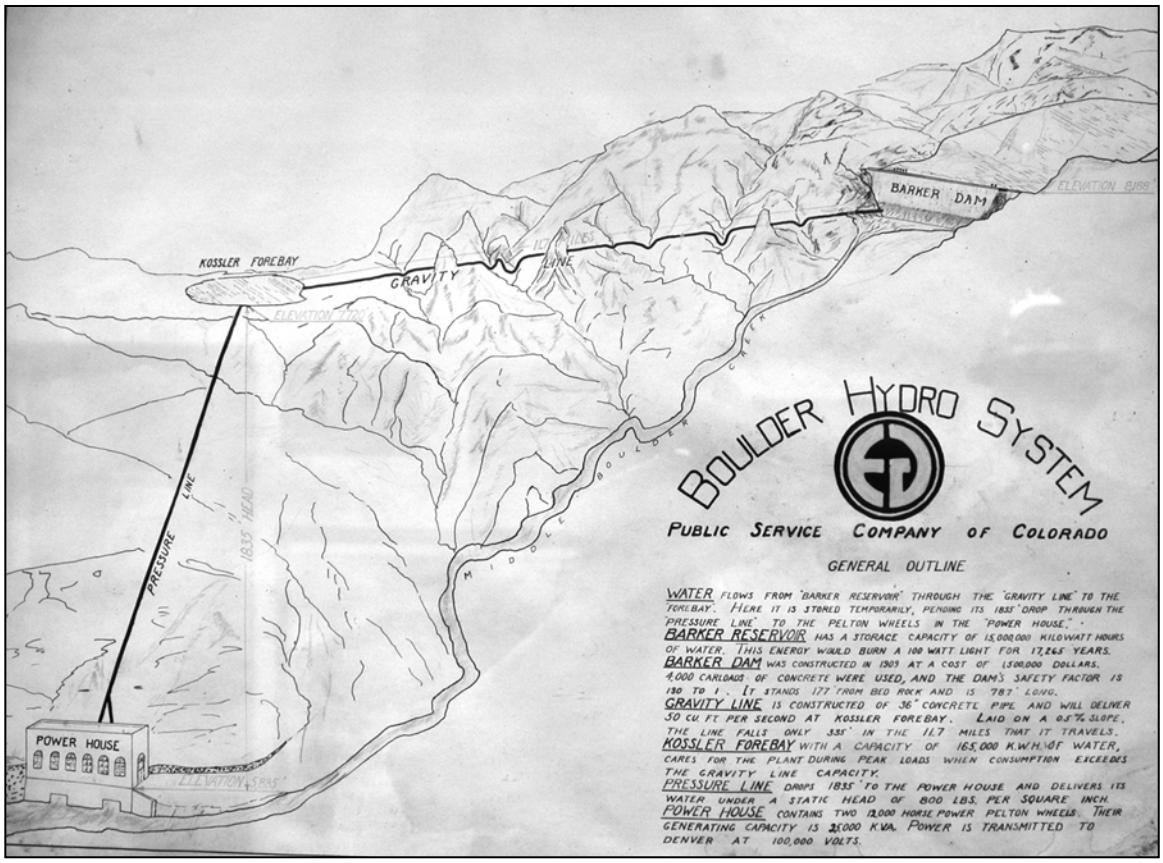
The 107-by-40-foot Boulder Hydro Plant was constructed of brick, stone, and steel. A huge crane permanently installed just below the ceiling was used to place two I.P. Morris Waterwheels connected to two General Electric AC generators. Each generator was capable of producing 5,000 kilowatts (KW) of power, for a total capacity of 10,000 KW.

Building materials and supplies for the construction of the Boulder Hydro Plant also were transported by the narrow-gauge railroad. Steel pipe sections, generators, shafts, turbines and other necessary pieces of equipment were delivered by train to Orodell. The equipment then was unloaded from the rail cars and transferred to wagons. The largest wagons, capable of carrying turbines weighing 36,000 pounds, were pulled by 14-and-16-horse teams.[91] Equipment then was hauled to a construction camp known as Headquarters Camp that was established at the Hydro Plant site. The small village included living quarters, offices, a stable, a blacksmith shop, and a dining hall—all fed with running water through a piped water system diverting from Boulder Creek.

During construction, a tramway was built from Headquarters Camp to carry materials up the steep mountainside to the site of Kossler Reservoir, on the ridgeline of Flagstaff Mountain 1,828 feet above the Hydro Plant. The site was located in a natural depression which required dams no more than 18 feet high. When completed, Kossler Reservoir was connected to the Boulder Canyon Hydro Plant by a 9,647-foot-steel penstock, still in use today. The upper section of the penstock is 50 inches in diameter and tapers to 44 inches.[92] The huge drop between Kossler Reservoir and the plant created the highest head of any hydroelectric plant in the country, at the time.

One difficult construction problem was caused by the tremendous water pressure developed due to the large elevation change in the penstock. The penstock was constructed from steel plates held together with two-inch rivets, but it was not enough to seal the joints against pressures reaching 840 pounds per square inch. A welder skilled in the new process of acetylene welding was brought in to secure the rivets and joints, but the joints cracked when they cooled. After experimentation, the crews discovered that hitting the rivets with a ball peen hammer while still hot from welding prevented the cracking and stopped the leaks. "Ball Peen Welding" was thereby invented.[93]

As work continued on the dam at Barker Reservoir and also at the plant, the Barker Gravity Line—a 36-inch diameter, reinforced-concrete pipeline—was built between Barker Dam and Kossler Reservoir on Flagstaff Mountain. Most of the Barker Gravity Line was constructed out of concrete pipe sections that were two feet in length to accommodate all of the twists and turns the pipeline had to make through the rugged terrain. The pipe sections were cast in place in a meadow on Magnolia Hill, then transported up the mountain for placement.[94] It was estimated that the Gravity Line would cost $550,000 to build.[95] By October 1909, the three dams that formed Kossler Reservoir and the 11.7-mile Gravity Line were completed, and the first water flowed through the pipeline to Kossler on September 1, 1909.[96]



The Boulder Hydro System is explained in this undated, but early, drawing. Courtesy City of Boulder. The transcribed text is enlarged below:

GENERAL OUTLINE

WATER flows from Barker Reservoir through the Gravity Line to the Forebay. Here it is stored temporarily, pending its 1,835' drop through the Pressure Line to the Pelton wheels in the Power House.

BARKER RESERVOIR has a storage capacity of 15,000,000 kilowatt hours of water. This energy would burn a 100 watt light for 17,265 years.

BARKER DAM was constructed in 1909 at a cost of 1,500,000 dollars. 4,000 carloads of concrete were used, and the dam's safety factor is 130 to 1. It stands 177' from bed rock and is 787' long.

GRAVITY LINE is constructed of 36" concrete pipe and will deliver 50 cu. ft. per second at Kossler Forebay. Laid on a 0.5% slope, the line falls only 335' in the 11.7 miles that it travels.

KOSSLER FOREBAY with a capacity of 165,000 K.W.H. of water, cares for the plant during peak loads when consumption exceeds the Gravity Line capacity.

PRESSURE LINE drops 1,835' to the Power House and delivers its water under a static head of 800 lbs. per square inch.

POWER HOUSE contains two 12,000 horsepower Pelton wheels. Their generating capacity is 25,000 K.V.A. Power is transmitted to Denver at 100,000 volts.

On August 4, 1910, a ceremony was held to celebrate the completion of the Boulder Hydro Project. It was intended for Boulder Mayor A. A. Greenman to push a lever to set one of the Hydro Plant's two generators into operation, producing 7,000 kilowatts of power.[97] Power was then to be transmitted to Denver via a steel tower transmission line and connected there with the line from Shoshone, 150 miles west in Glenwood Canyon.

However, unbeknown to all the dignitaries in attendance, the plant was not yet ready for water to hit the turbines and for the turbines to spin the generators. Not wanting to cancel the celebration, the plant operators arranged for power fed from Shoshone to begin turning the generator when the lever was pushed. The ceremony proceeded with no one suspecting the sleight of hand.

Big Wheels Revolve at Mayor's Touch

Mayor Greenman, by Touch of Lever, Sets in Motion
Powerful Machinery at Big Plant in Boulder Cañon
(*Daily Camera*, August 4, 1910)

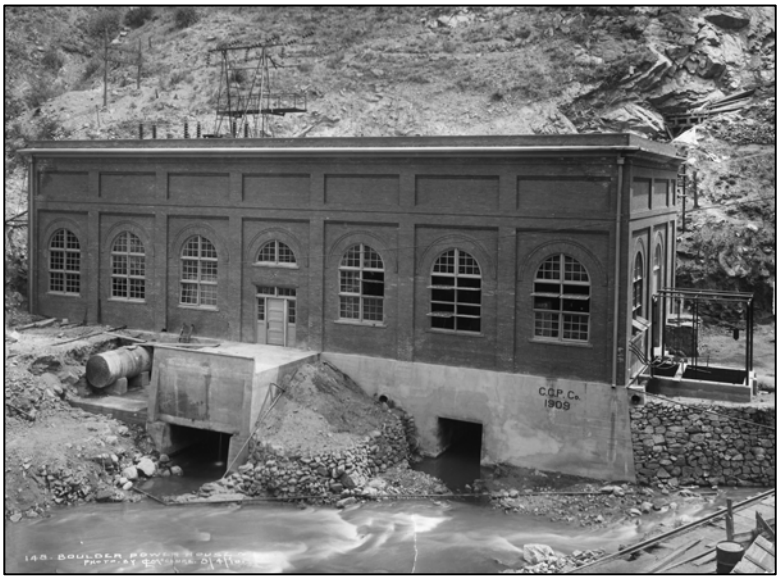
At 2:30 o'clock this afternoon, Mayor Greenman, in the presence of nearly 100 representatives of the Boulder municipality, university, and scientific circles, and the Commercial Association, besides noted engineers from Denver, touched a lever which, in a moment, set in motion the powerful Norris Company wheel of 10,000 horsepower capacity with water having a 1,800-foot head, the wheels moving at 400 revolutions per minute. The transmission shaft in the big wheel is 22 inches in diameter.

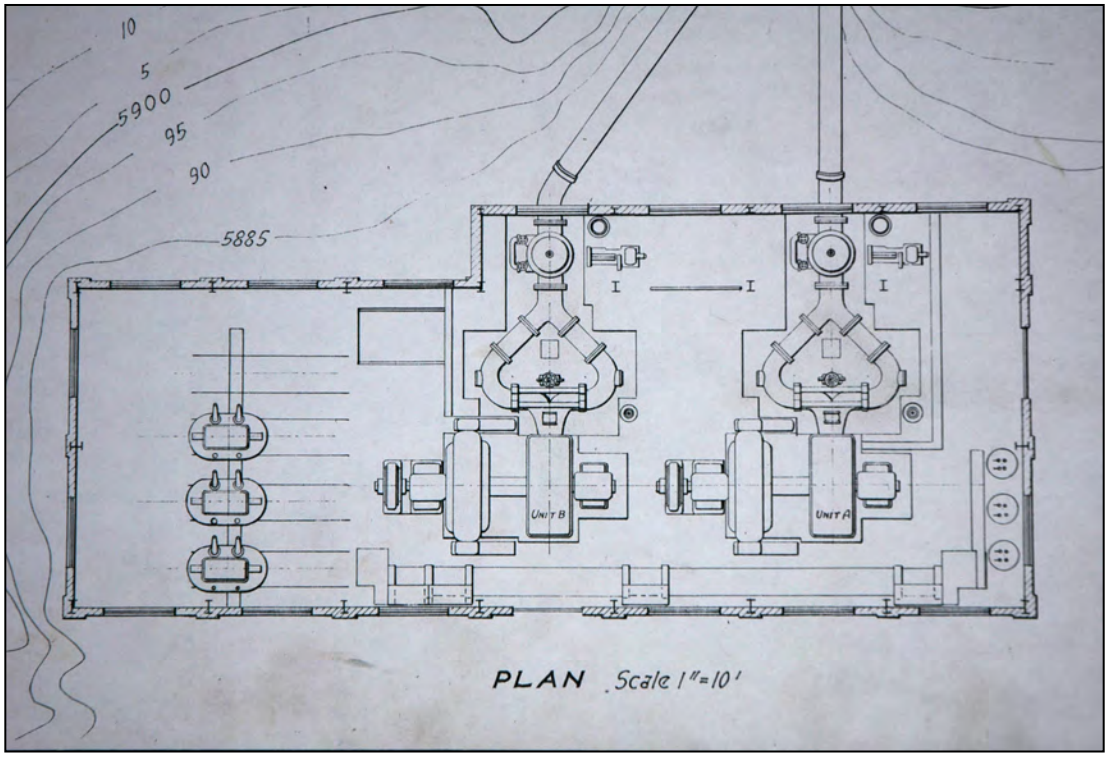
The splendid power house thus formally dedicated has two units, or wheels, of 10,500 horsepower capacity each, but one of which was put in motion today. While Mayor Greenman was congratulating the power company upon the completion of its great enterprise, flashes of lightning from the heavens added to the crackling sensation of a great electric plant and affected the nerves of some of the spectators. The party arrived at the power plant in the midst of a shower which continues at the hour of going to press.

President James H. Baker and Dean Ketchum of the Engineering Department of the University of Colorado, the President and Secretary of the Commercial Association, the Mayor and City Council, Boulder County Commissioners, [and] representatives of local and Denver papers witnessed the formal opening.

The test was highly successful and the machinery and installation are the admiration of the engineers and all others present. Superintendent J.W.E. Taylor, J.D. Dalton and other officials of the company took great pains to explain in detail all of the workings of the great plant.[98]

Luckily, L.C. McClure, a well-known photographer, was on hand on August 4, 1910 for opening day at the Boulder Hydro Plant. Photos courtesy City of Boulder.





This drawing of the original two generators is a detail from the Central Colorado Power Company's original "Power House and Pressure Line" plan. Courtesy City of Boulder

The Colorado Power Company acquired the Central Colorado Power Company in 1913, then merged with the Public Service Company of Colorado in 1924. Except for brief periods for repair and renovation, the plant has operated continuously since 1910.

The narrow gauge railroad was abandoned in 1919 after a flood washed out many miles of track. By then, motorized vehicles had lessened the demand, in the mining communities, for trains to haul out ore and bring in supplies. Forest Crossen, the late author of *The Switzerland Trail of America*, writes that, when Barker Reservoir is low, it is sometimes possible to see the grade of the temporary spur line that extends almost to Barker Dam.[99]

For several decades, there were five houses located at the Boulder Canyon Hydro site where plant operators and their families lived. Everett H. Brines worked as an operator at the plant for 38 years (1920-1958). He and his wife, Daisy Irene, raised six children at the site. In his memoir, Brines recalled that he was paid $90 a month. His compensation also included free rent, water, and utilities.

Brines also recalled lightning strikes at the plant that would "throw a load on our generators and they would start to groan and make a hell of a noise." In 1933,

Brines burned his right hand so badly that it had to be amputated, when he accidentally touched one of the 13,000-kilovolt (KV) circuit breakers. He was given an artificial hand, but he found it cumbersome and didn't use it.[100]

The Boulder Canyon Hydro Plant was substantially rebuilt in the mid-1930s, with the installation of new generators, circuit breakers, and control panels. The new generators doubled the capacity of each unit to 10,000 MW, and the total modernization project cost $287,000. Much of the equipment from this period continued to operate until the next major renovation in 2011.[101]

ADDITIONAL WATERSHED DEVELOPMENTS

After City officials suffered through numerous water quality problems with the City's early water system, one of their major concerns was to assure that the water in Boulder's Silver Lake Watershed remained (nearly) pure. On July 23, 1914, Mayor W.L. Armstrong, City Engineer H.E. Phelps, Consulting Engineer M.C. Hinderlinder, six aldermen, the city health officer, and newspaperman Otto Wangelin piled into one large Stanley Steamer and drove to Silver Lake for an inspection.[102]

Twenty-five species of trout had been identified in the watershed, and the area had become a tremendous attraction to Colorado fishermen. After the field trip, the council discussed the need for a guard for the watershed, or, at least, the possibility of hiring a caretaker for the premises. Shortly afterwards, the City hired its first caretaker, Alfred T. Wheeler to make releases from the reservoirs, but also to keep an eye on recreational users of the area to assure no polluting activities took place.[103]

Silver Lake's first caretaker, Alfred T. Wheeler, posed with some of the trout he had caught in the lake. Carnegie Branch Library for Local History, Boulder (Carnegie 513-2-26 #1).

After talk of further contamination from campers and tourists in the Silver Lake area, a health officer was dispatched to the site in 1916.[104] His report concluded that the City's water supply was not yet threatened, although he did mention that recent outbreaks of typhoid fever had occurred in the Boulder area. However, by 1920, Boulder closed all of its Silver Lake Watershed land to public access, fenced the area, and authorized the watershed caretaker to ticket trespassers.[105]

Engineers then proposed that Boulder water be treated for the first time. By 1917, chlorine and ammonium sulfate were added, seasonally, in Lakewood Reservoir, even though customers complained of the taste. (In 1949, chlorine was added to the water year- round, allegedly so that customers would not notice a change of taste.) Also in 1917, Boulder voters adopted a new city charter. It established a city manager form of government that was divided into five departments: Public Health, Public Welfare, Finance and Records, Public Safety, and Public Service—the department that housed water utilities. The Department of Public Service was headed by a city engineer. Among his many duties, he planned the extension of water systems and maintained 43 miles of water mains.[106]

The City passed an ordinance in 1918 that established new water rates at a level that would remain essentially unchanged until 1953.[107] The water rate structure did not encourage water conservation and, in fact, encouraged water waste. Residential customers were not metered and paid a flat rate for water no matter how much they used. Commercial, industrial and institutional water customers were metered, but paid less money for each additional block of water used as their water use increased.

Meanwhile, winter cold snaps took their toll on the Boulder City Pipeline. Breaks occurred in 1914, 1919, and 1921, requiring the temporary use of a private well near Chautauqua and a spring located near the Boulder-Colorado Sanitarium at 4th Street and Mapleton Avenue. The spring of 1921 was exceptionally snowy as well. In 1921, Silver Lake received 75.8 inches of snow in a 24-hour period on April 14 and 15. This remains the national record for snowfall amount within 24 hours.[108]

Wheeler posed with his snowshoes next to his snow-covered cabin, following the April 1921 snowstorm. Courtesy City of Boulder

Silver Lake Pipeline

In the years prior to and during World War I, the Primos Mill, at Lakewood, became the world's largest producer of tungsten. The mill also continued to be eyed as a likely water polluter. To circumvent the problem, Boulder's city engineers proposed a further extension of the City's Lakewood Pipeline towards Silver Lake. An 18-inch-clay-tile conduit was completed in 1919 and stretched from Lakewood to two miles below Silver Lake, a distance of seven miles.

This new pipeline was called the Boulder City Pipeline Extension, but later became referred to as the Silver Lake Pipeline. The land at its intake was included in the second grant of public lands that the City received from the federal government.[109] Immediately after the pipeline's construction, the City of Boulder received a court decree dating to 1904, as the City needed water rights that showed ownership. The City had also started diverting the 1875 Town of Boulder Ditch water at the new intakes.

These water rights, however, were not enough to allow the City to keep diverting the water flowing past its head gates in late summer when more senior rights were calling for water downstream. Instead, court approval was needed to divert the water at the City's pipeline intakes. So, in 1925, Boulder completed its first water-rights-change-of-use proceeding. This allowed 14 ¾ shares in the Anderson Ditch Company (with an 1860 water right) and 8 shares in the Farmers Ditch Company (with an 1862 water right) to be used in the municipal water system.[110] Following that first change decree, the City continued to buy shares in irrigation ditches located in the Boulder Valley that had senior water rights (e.g. Anderson, Farmers, Harden, Smith & Goss, and McCarty).

Boulder continued to purchase shares from prior agricultural water users—mostly those whose lands had been developed and became served by the City water system. The City periodically returned to court to change newly acquired ditch water rights to municipal use and move the decreed diversion points upstream to the City's water facilities. Change-of-use court decrees for additional ditch company shares acquired by the City were obtained in 1942, 1963 and 1989.[111]

Today, the City's most senior direct-flow-municipal rights—amounting to approximately 45 cfs, if all were in full priority—are derived from ditch company shares. These changed irrigation rights may be used only during the irrigation season to reflect their original pattern of use purposes.[112]

The City continued to make improvements to the dams in the Silver Lake Watershed. In 1925, the dam at Goose Lake was enlarged through the addition of a concrete facing on the lower 13 feet of the upstream dam face and placement of rock fill on the downstream face.[113] The outlet through the dam at Silver Lake was lowered with construction of a siphon structure in 1929. The new

pipe was attached to the existing pipe extending through the dam and allowed the City to gain access to the reservoir pool below the old outlet works.[114]

Purchase of Arapaho Glacier, 1927

Arapaho Glacier was a cool place to go in the 1920s. At the time, the snowfield west of Nederland on the Continental Divide was Boulder County's main tourist attraction. By the end of the decade, however, Boulder residents were more interested in water quality than in tourism, and the hype over glacier trips melted away.

The tourists started to arrive when the Chicago-based Burlington Railroad adopted the Arapaho Glacier trip as one of its featured excursions. "In 36 hours from Chicago," stated a railroad official, "people can see more than the Alps provide in thrills and mountain grandeur."

As soon as the mid-western visitors arrived in Boulder, they piled into seven-passenger touring cars and were chauffeured up Boulder Canyon to a base camp at Rainbow Lakes, west of today's Peak to Peak Highway. Then the flatlanders rode to the glacier on horseback, played on the ice and snow for an hour, and returned to the camp for a cookout.

Eben G. Fine (who claimed to have discovered the Arapaho Glacier in 1900) produced the above tinted postcard during the 1920s, when the glacier was promoted as a tourist attraction. (Pettem collection)

In 1925, the glacier's national publicity continued to draw crowds, so tour leaders planned to build a toll road from Rainbow Lakes to an overlook called Arapaho Saddle, at an elevation higher than the glacier. The scenic lookout was to include a shelter house and refreshment stand. Secretary of the Boulder Chamber of Commerce, Frank Eckel, supported the plan and proclaimed, "Let the [road] builders go through and bid them god-speed." A *Daily Camera* editorial echoed his sentiments and stated, "If the glacier is one of God's masterpieces, are we justified in denying sight of it to any of His children?"

The proposed commercialization alarmed area naturalists. The Colorado Mountain Club and the Rocky Mountain Climbers' Club discussed a possible expansion of the recently created Rocky Mountain National Park southward to include Arapaho Glacier. The club members believed this action would "keep the area free from spoliation by the greed of commercial interests or irresponsible transient tourists."

Finally, over the strenuous objection of the United States Park Service, clean water won out. On March 4, 1927, the United States Congress passed enabling legislation for Boulder's third federal land grant.[115] Nearly two years later, a short *Associated Press* article on the front page of the *Daily Camera*, on February 15, 1929, stated, "The City of Boulder deposited at the federal land office today a check for $4,618.89 in payment for 3,695 acres of federal land west of the City near the Arapahoe [sic] Glacier. Possession of the land was procured by the City to protect the watershed and its water supply, and for the development of the assets of the scenic grandeur of the region."[116]

The deed became official on July 23, 1929, three months prior to the country's devastating stock market crash. The purchase included four peaks along the Continental Divide and, combined with an earlier acquisition of a half section of land in 1919, it guaranteed the integrity of the western portion of the Silver Lake Watershed. The City continued to insist that there be no public access to the area.

Ten years later, a compromise was reached when the Chamber of Commerce led the first of its annual group hikes to the glacier. For one day only, in the middle of the summer, participants could slide around on the ice and snow. The group hikes eventually were discontinued in 1976. Today, individual hikers often hike to Arapaho Ridge for a close-up look, but they are not allowed to venture onto the glacier. They can see the glacier and drink from it, but they can't walk on it anymore.

The Silver Lake Watershed remains closed to public access to prevent wildfire that might impact the water supply, as well as to protect water quality, the fragile alpine environment, and the wildlife habitat. Protection also extends to sensitive University of Colorado research studies, begun in the 1930s, of alpine and climate conditions.

A group of people on one of the former annual Chamber of Commerce hikes are shown on Arapaho Saddle (above Arapaho Glacier) in this undated photo. Courtesy Daily Camera

Infrastructure Development in the 1930s

The 1930s threw the whole country into the Great Depression. In 1933, following Franklin D. Roosevelt's inauguration as United States President, many young men in need of work were hired by the federal government for public works programs. One of the first of Roosevelt's "New Deal" programs was the Civilian Conservation Corps (CCC). In 1933 and 1934, two camps were set up in Boulder—one was west of Chautauqua, and the other was on the site of the Boulder County Justice Center, located at 6th Street and Canyon Boulevard. Laborers from these camps worked on many improvements in Boulder's Mountain Parks, including the construction of the Sunrise Amphitheater and Chapman Drive.

The second public works program, established in 1935, was the Works Progress Administration (WPA). Like the CCC, the program's philosophy was to put the unemployed back to work in jobs that would serve the public good, but instead of housing out-of-town workers in camps, the WPA hired unskilled local laborers. The federal government footed approximately two-thirds of the bill, while the City of Boulder paid the rest. While earning a total of more than two-million dollars, the men graded roads, built parks, and improved schools, but they also were credited with developing the City's water system, years ahead of what would have been possible without federal aid.[117]

The WPA built much of Boulder's water-related infrastructure. The program's largest contribution to the City of Boulder was the construction of the Island Lake Dam during the summers of 1936 and 1937. WPA Federal Art Project, courtesy Library of Congress

Boulder's WPA projects began in 1935 and ended in 1942, when World War II made the program obsolete. "Something very worthwhile was accomplished on every project," stated City Manager H.C. McClintock in a review of the program in 1943. "Much of it cannot be seen. For example, the extensive improvement to the water distribution system is underground, and people soon forget how the streets were before they were improved."[118]

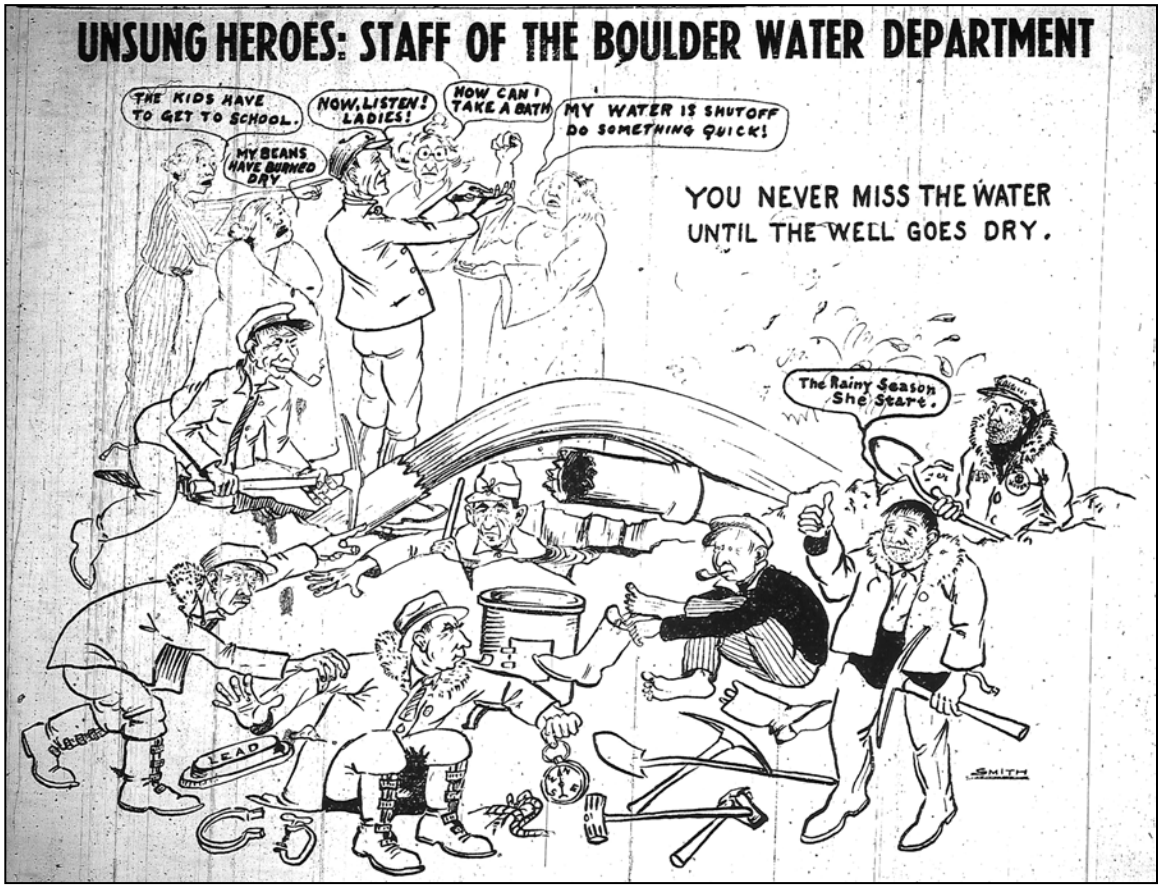
The first project was started in October 1935, when six men mapped the City's water main system and then installed a 12-inch main on 14th Street, between Pearl and Mapleton streets. Their work schedule was based upon the recommendations of a study by the Pitometer Company of Denver and commissioned by the Boulder City Council. (A pitometer is a piece of equipment that measures the relative velocity of fluid.)

Other WPA crews built concrete bridges to replace wooden bridges over Anderson Ditch, and they relocated Farmers Ditch along 4th Avenue (now Dellwood Avenue) between 9th and 11th streets. During most of the seven years that WPA crews worked in Boulder, they installed more than 10,000 lineal feet of mains each year. They also lowered mains and service pipes on many of the city's streets and installed storm and sanitary sewer systems.

In 1935, Boulder acquired the Green Lakes, above Albion, for a total cost of $35,000. (Three of the five natural lakes had been raised with dams in 1906.) That same year, another WPA crew repaired Goose Lake Dam, after first

rebuilding the road from Silver Lake.[119] The road was used again during the summers of 1936 and 1937, when the WPA built the 700-foot-long reinforced concrete dam at Island Lake—the WPA's single biggest contribution to the City of Boulder. In 1938, they repaired the dam at Lakewood Reservoir. Then, the following year, they placed a steel facing on the upstream side of the Green Lake No. 3 dam. From 1941 to 1942, the workers rebuilt Green Lake No. 2 dam as a rock-and-earth-filled dam with a steel upstream facing.[120]

In charge of most, if not all, of these projects was Boulder's Water Superintendent and Swedish immigrant Carl E. Carlson. In 1936, Charlie Smith (a writer and artist with the *Daily Camera*) featured Carlson in a cartoon and also praised the members of the City's water department in an accompanying article.



"Cartoonist Charlie Smith, storekeeper for the City of Boulder, has caught members of the water department in characteristic poses. Attempting to get the women to listen to him is Carl G. Carlson, superintendent, who ordinarily has no trouble in handling the gentler sex. Below Carlson is Jim Pulliam, and in the trench are Ole L. Quam and Lonnie L. Shepherd. At the base of the cartoon to the left is Ernest E. Bierbaum; holding the compass, Clarkson P. 'Jerry' O'Brien; putting on the boot, Michael E. 'Pike' Shanahan, and with the pick Danoto 'Dan' Carmosino."[121]

UNSUNG HEROES: STAFF OF THE BOULDER WATER DEPARTMENT
(*Daily Camera*, February 27, 1936)

Working in the high wind, in sub-zero weather, in wind, snow, sleet, and sunshine may be found members of Boulder's water department. Day and night–– sometimes all night––may be found the unsung heroes–– making repairs, improvements, and emergency replacements.

They may be found in the shadow of Arapahoe [sic] Glacier; along the transmission line from Blue Bird Falls to the City Reservoirs, in the far extremities of the city, and at the outlet of the city sewage. They are charged with the upkeep and cleaning of reservoirs; with perfect maintenance of miles of transmission lines which, in places, has to be anchored to precipitous cliffs with heavy cables.

At places, the transmission line has to be embedded in cement, with steel and stone reinforcements to keep the water from blowing the pipe skyward. There are miles of distribution lines traversing every street in Boulder. The lines have to be kept in perfect condition. Fire hydrants have to be kept in good working condition, and because of the efficiency of the department, a hydrant has never failed the fire department at a critical time.

There are hundreds of water meters to be read, cleaned, repaired, and kept from freezing in the winter time. Air has to be removed from the water through the operation of valves. The air gets into the pipeline and when not released charges the water effectively as bromo seltzer. Overflow from the two reservoirs have to be watched to prevent waste of water.

Turn-on and turn-off orders as people leave or move into houses or buildings keeps members of the staff busy. Roads have to be built, tons of rock have to be blasted away, dams have to be reinforced! Outlets of reservoirs have to be kept free of debris.

Bridge trestles and buildings are constructed by the members of this department. Hundreds of miles of sanitary and storage sewers have to be kept repaired and clear. The city's new sewage plant has to be kept

> in efficient operation. The above are only a few of the many jobs that fall upon the well-staffed water department.[122]

The City continued to buy additional parcels of land in the Silver Lake Watershed area from private owners until it owned approximately 6,500 acres that included 13 reservoirs and natural lakes. Almost all of the water supply from the area came from melting snows, with only a fraction of a percent from the melting of Arapaho Glacier. This high-quality source of water supply was sufficient to meet all of Boulder's water needs until the 1950s.[123]

Northern Colorado Water Conservancy District

Along with the financial hard times of the 1930s came serious drought conditions throughout the West. The trading of water and storage supplies became serious business in Boulder and elsewhere. While the WPA was at work in the mountains helping municipalities repair dams, farmers and ranchers on the plains formed the District Six Water Users Association. It acted as a "watchdog" group to assure that transfers of water rights to the City of Boulder and other municipalities did not harm the association's water rights.

The Great Depression was characterized by a series of dry years and, in 1937, more dry years were predicted for the 1940s. At the time, the United States Bureau of Reclamation joined forces with farmers, ranchers, cities and towns in northern Colorado, located within the Platte River drainage, to form the Northern Colorado Water Conservancy District (NCWCD). Together, they envisioned an immense diversion of Western Slope water to the Eastern Slope.

Theirs was the same dream that Boulder attorney and Water Commissioner Hiram Prince had spoken of in 1889—nearly a half century earlier—in front of the Colorado General Assembly. *"Gentlemen*," Prince had stated. *"Colorado's surplus waters are on the Western Slope of the Continental Divide; the lands available for their use are on the Eastern Slope. I want an appropriation of $25,000 to find a route for bringing these waters across the mountains where they can be used."*[124] Supposedly, the Assembly gave the state engineers some funds to pursue various routes across the mountains, but their conclusions, if any, are unknown. The time had not yet come to act on Prince's vision.

In 1937, the Bureau of Reclamation agreed to pay one half of the proposed expenditure, estimated at $44 million, to be repaid by hydropower revenues from the project. The other half would be paid by the eastern slope water users through the NCWCD. Construction of the complicated facility began the following year. In 1947, the first Western Slope water to be carried through the Colorado-

Big Thompson Project (otherwise known as the CBT Project) flowed through the 13.1-mile Alva B. Adams Tunnel, under the Continental Divide, and out to the Big Thompson River and the plains of the South Platte drainage.

Despite its promise of ample water supplies for the future, Boulder was not an original member of NCWCD, which had its headquarters in Loveland. The Boulder City Council had previously considered acquiring rights to the Blue River on the Western Slope, with the water to be delivered through a pipeline directly over the Divide into the Silver Lake Watershed. After many years of discussion, the project was dropped. Boulder would wait until 1953 to become a partner in the CBT system.

Silver Lake and Lakewood Pipelines Reconstruction

When the lower portion of the Boulder City Pipeline below the Lakewood Reservoir was originally constructed in 1906, its builders had used smaller-diameter pipe that restricted the flow rate. Beginning in 1939, Boulder's water department crews began to replace deteriorated segments of the Lakewood Pipeline (as this section between Lakewood Reservoir and Orodell then became called) with larger-diameter pipe. That same year, the US Forest Service (USFS), for the first time, issued a Special Use Permit for approximately 30 percent of the pipeline that crossed USFS land.[125] This permit was a land use authorization in addition to the right-of-way that the City held for Lakewood Pipeline based on the U.S. Congressional Acts conveying land in the Silver Lake Watershed to the City and the Congressional right-of-way act passed in 1866.[126]

Additional pipeline replacements continued as follows:

- From 1946 through the mid-1950s: All of the old pipe between Lakewood Reservoir and Sugarloaf was replaced with 22-inch steel pipe that was 1/4-inch in thickness.

- During 1947: With the salvaged pipe from the Lakewood Pipeline, crews replaced even older clay tile pipe on the pipeline's upper portion—known as the Silver Lake Pipeline.

- In 1951: The intake of Silver Lake Pipeline was extended from the foot of Upper Boulder Falls several hundred feet upstream to a point inside the fence line of the protected Silver Lake Watershed[127]. (The Silver Lake Pipeline would be rebuilt again in 1997-1998.)

Above, is the watershed gate as it looked in the 1950s. Below, a survey crew posed at Silver Lake, in 1949. Note the "Boulder Eng. Dept." logo on the car. Both photos, Carnegie Branch Library for Local History, Boulder (above, 511-2-13 #3; below, 511-2-19 #4)

NEW WATER SUPPLIES & GROWTH, 1950s-1970s

Boulder in the Post-war Era

Despite signs that Boulder was about to boom, the town of 13,000 residents slept its way through the 1940s, regularly voting down measures to allow serving liquor by the drink and the fluoridation of City water. Letters to the newspaper increased in volume and acidity on both of these issues. Both were poisons, opponents held, and had no place in a college town.

During World War II, the City patriotically put $220,000 of its water revenues into War Bonds. Although Boulder lay far from either coast, armed guards were posted near reservoirs and pipelines as a precaution against possible sabotage. Meanwhile, Boulder's population of permanent residents inched upward from approximately 11,000 in 1925 to 15,000 in 1947. However, the hint of big changes loomed as the student population boomed after the war, jumping from roughly 3,000 in 1925 to nearly 9,000 in 1947.

Each water customer was using an average of 300 gallons of water per day. This was about the same amount used during the 1920s, but was about 50 per cent more than the levels that water use had dropped to during the lean years of the Depression, almost double the amount in 1935.[128] The shortage of materials and workers during the war had prevented the City from making the improvements necessary for the water system to keep up with population growth. In 1947, the City Council reaffirmed its policy to charge outside-the-city users double for metered water and 50 per cent more for those receiving water by flat rate assessment.

The City then commissioned R. J. Tipton of Denver to complete an engineering study of Boulder's water resources and water facility capacities. By October 1949, Tipton had found that the City's water rights would yield enough water to supply a population of 22,000 in average years, but it would be insufficient for a population of 17,000 in a drought. Given that the population was projected to grow by 500 to 2,000 each year, Tipton recommended immediate action. To plan Boulder's water needs for a population of 60,000 in 1970 and 100,000 by 1990, Tipton recommended the construction of additional reservoirs, construction of larger pipelines, the regular chlorination of water, and the further acquisition of water rights.

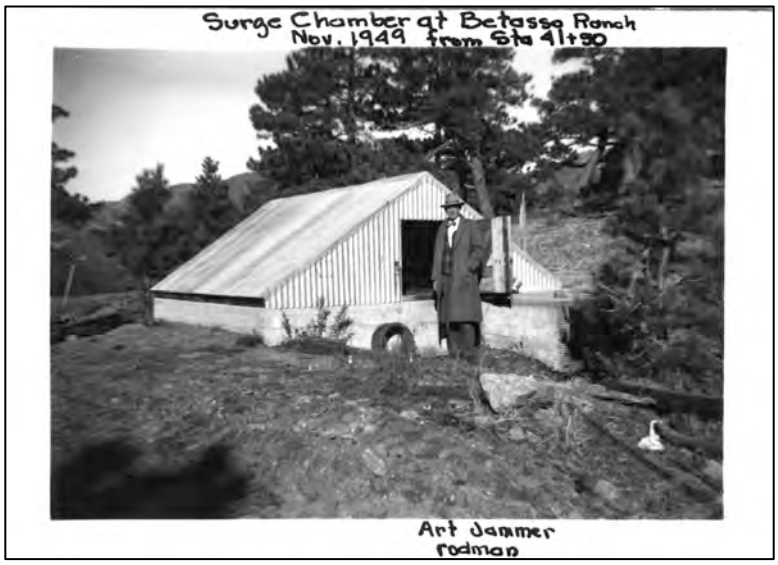
In particular, Tipton recommended the acquisition of additional shares in the Baseline Land and Reservoir Company as a source of water to trade to downstream senior water rights that would otherwise limit diversions under Boulder's more junior water rights. At the time, Boulder owned 50 shares out of the total 555 shares in the Baseline Company. The company's water rights ranged in appropriation dates from 1904 to 1929. The City had been using these

shares to exchange for water delivered to the Silver Lake Ditch rather than having to release water to the ditch from Silver Lake. (The City currently owns 68.265 shares of Baseline Company.)

Tipton was lukewarm on the subject of residential meters and some charged the engineer with bowing to political pressures. The City Council, however, adopted many of Tipton's recommendations. Improvements were begun on the water distribution system, the face of Goose Lake dam was resurfaced, and enlargement projects for pipelines got underway. In addition, $4,000 bought a chlorination plant at Lakewood for year-round use.

In 1949, City water crews replaced the 4,200 feet of the 12-inch segment of Lakewood Pipeline (from Betasso Ranch to the valve house at Orodell) with an 18-inch diameter steel line, eliminating its major flow constriction. In 1954-1955, the old 15-inch segment of the pipeline running from Sugarloaf Hill to Betasso Ranch was replaced with 18-inch diameter pipe.

Due to the scarcity of steel after World War II, the pipe used to rebuild Lakewood Pipeline was only 1/4 inch thick. The use of thin steel pipe meant that the pipe could not withstand the amount of vacuum full pressure that could develop when water flowed up and down mountains and valleys from Lakewood Reservoir into the city. Therefore, air evacuation valves and surge chambers were built at points along the pipeline to let air in and out, in order to avoid collapse of the pipe walls.[129] This pipeline design allowed air to become entrained in the water, actually causing it to fizz. This eventually caused problems with water treatment processes following the construction of the Betasso Water Treatment Facility.[130]



Art Jammer stands by the Betasso surge chamber following its reconstruction in 1949. Carnegie Branch Library for Local History, Boulder (511-2-19 #2)

One of the surge chambers for the pipeline was on the Betasso Ranch, purchased from Walter Blanchard by Steven Betasso, in 1915.[131] Steven was a miner-turned-rancher who had immigrated from Italy in 1883. With his sons

Richard and Ernest, he expanded his property and raised cattle. Steven died in 1939 and is buried in Boulder's Green Mountain Cemetery. Richard and Ernest inherited the property.

The Betasso surge chamber measured 10-by-20-square feet and had a 60,000 gallon capacity. Two diversion chambers were covered by a sheet-metal building. (The original surge chamber, built in 1906, had been rebuilt in 1949. It remained in use until 1964, when it was replaced with a pressure-reducing valve at the time of completion of the Betasso Water Treatment Plant.)[132]

Despite the country's desire for peace and prosperity following the end of World War II, the U.S. government feared that the Soviet Union would acquire atomic weapons. They did, and what we now know as the Cold War was begun. In order to build up our country's own arsenal of atomic weapons, the federal government opened the Rocky Flats plant of the Atomic Energy Commission, just south of Boulder, in 1952. In the intervening years, the covert facility was clouded in controversy and is now shut down, but in its infancy it meant new jobs and unprecedented growth for Boulder.

The news of the site selection caught the community's residents by surprise. According to census records, Boulder's population, in 1950, was only 19,999. The large new plant's expected impact on the small town received national attention. In April 1951, one month after the AEC disclosed the location, a California newspaper predicted Boulder's boom in an article titled "Atomic plant to end town's lazy, quiet life."

Growth in the 1950s

In the early 1950s, the Dow Chemical Company was chosen as the federal government's prime contractor to machine a plutonium component for use in atomic weapons. The first building to go up was a guard house, with a tight-lipped foreman who instructed his watchmen to mount a 24-hour vigil against all visitors.

The Denver-Boulder Turnpike opened in January 1952. That same month, a frustrated *Rocky Mountain News* reporter visited the Rocky Flats site. The next day, he wrote, "The 41-million-dollar Rocky Flats plant of the Atomic Energy Commission will start producing – whatever it will produce – shortly after it is completed – whenever that is. Just what will be produced will probably not be known until a free world can examine atomic progress without fear."

Regular operations at Rocky Flats began in April 1952. By November 1953, the plant employed 1,200 people attracted by the high (for the time) wages of $2.31 per hour. The employees' housing needs quickly stimulated Boulder's real estate

market and also increased the demand for the City's schools, water and sewer lines, and other services.
The secretiveness and security of the weapons facility didn't seem to bother local residents. Many, at the time, believed that nuclear war was imminent, and that Rocky Flats provided their best chance of survival. A University official stated that the plant's work "fitted in well with the cultural aims of the university," while Boulder Mayor J. Perry Bartlett, owner of a clothing store, was quoted as saying, "From an economic viewpoint, Boulder business certainly welcomes the project."

During the boom days of the 1950s, water and its future availability were often discussed by the City Council. Members could not agree how to estimate the number of people that Boulder might attract in the coming years. Most of the estimates, it turned out, were far too low.

A former chief in the Water Department charged that the water utility operated in a wasteful manner, and he demanded that the office be investigated. The City Attorney did, but he reported that he found no evidence of waste. Boulder citizens, however, were known to have wasted water, in both winter and summer. In the summer, they over-watered their lawns and gardens. In the winter, in order to avoid the bills to repair frozen pipes, many residents habitually left their water taps running all the time. Some even attached a string to the faucet so that dripping water would travel down the string with no annoying noise.

In February 1952, City Manager Bert Johnson suggested to the City Council that heavy expenditures in the area of water supplies were necessary "to meet the requirements of the Turnpike era in our municipal history."[133] A $400,000 water bond issue had passed the previous November—1999 votes to 192, and two new reservoirs to be located in the city were on the drawing boards. North Reservoir, renamed Maxwell Reservoir after the notable early financier who owned the land, was built in 1953. South Reservoir was completed and renamed Kohler Reservoir after the family who had previously owned the property.

As the City woke up to the extent to which it would need to expand its water supplies to deal with the exploding population growth, it began considering how to pay for the expansion. Tipton had estimated that more than $15 million would need to be spent to upgrade the City water system to meet the growth demands, with about $1 million needed just to make the system adequate for the existing needs.[134] On June 1, 1952, the City Council passed an ordinance changing the customer water rate structure that differed from water rate structures in place since 1918. For the first time, charges for metered water customers were increased to be more in line with those paid by flat rate customers.

Revenue from metered customers, which included commercial, industrial and institutional water users, was projected to increase by 55 per cent. Although the City began requiring new residential construction to be metered, only 10 per cent of residential customers were metered by 1960. In 1961, the City's consulting

engineering firm, Black and Veatch, recommended that all water users be metered. A universal metering program was completed during the next few years. Black and Veatch estimated that there would be a 40-to-50 per cent reduction in water use for those accounts that had been flat rate and a 25 per cent reduction in city-wide water use.[135]

At this time, Boulder was beginning to view joining the Northern Colorado Water Conservancy District as the only realistic means to acquire new water supplies.[136] Tipton's report had revealed the limits on obtaining the amount of new water needed for growth from the Boulder Creek basin. The possibility of receiving 10,000 acre feet of water from the Colorado Big Thompson (CBT) Project seemed so attractive that some City Council members voted to turn down another $1,647,000 proposal to buy Western Slope water. The Council learned that annexing into the Northern Colorado Water Conservancy District would eventually increase Boulder's water supplies by 50 per cent.

Acquiring CBT water was City Manager Bert Johnson's first priority when he was hired in 1950. But, not everyone agreed with him. The *Daily Camera* was dubious about the proposed arrangement and dragged its feet editorially. By December 1952, however, Council member A. A. Wickstrom, City Manager Johnson, and others were heavy into negotiations with the Northern Colorado Water Conservancy District and the Bureau of Reclamation. Boulder agreed to pay its share of back taxes to the Northern Colorado Water Conservancy District (NCWCD), plus 2 per cent, starting with the year 1937, the year of the District's official formation.

In order to start using western slope water, the City agreed to build a reservoir at the southern end of the CBT Project. Boulder would put up the money—$1.2 million—and NCWCD would refund $450,000 to the City in 40 installments.[137] The enabling ordinance to join the District was approved by the City Council, and citizens voted in the "now or never" election, in 1953, to annex into the District. Membership in the CBT Project, it was stated, would never be offered again. Boulder voters approved the measure and also passed a $2 million water bond issue to fund it.[138]

In 1954, the presence of the federal government increased with the newly opened National Bureau of Standards (now National Institute of Standards and Technology), followed, in the mid-1960s, by the National Center for Atmospheric Research (NCAR). Developers rushed to complete Highland Park, Martin Acres, and Table Mesa, mid-century housing developments south of Baseline Road. Other businesses that brought new workers and residents included Esquire Magazine (later called Neodata), Arapaho Chemicals (later called Syntex), Beech Aircraft's Aerospace Division, Ball Brothers Research Corporation, and International Business Machines (IBM).

Pressure to develop additional water supplies increased even more, beginning in 1954. From that year through 1957, a severe drought further strained the limits of Boulder's Silver Lake Watershed and North Boulder Creek water supply. Senior water rights owned by downstream users routinely forced the City to bypass direct flow diversions, instead using releases from storage reservoirs. In 1954, alone, stream flows fell below 50 per cent of average. The City ran short of water and imposed water use restrictions.

When this photo of the new Highland Park and Martin Acres subdivisions was taken in 1956, Boulder was experiencing a huge new demand for city services. The Boulder-Denver Turnpike (now U.S. 36) opened in 1952 and is on the right. South Broadway is on the left, and Table Mesa Drive is in the foreground. Carnegie Branch Library for Local History, Boulder Historical Society collection (207-23-21 #1).

Realizing that it needed to increase its mountain reservoir storage space to maximize Boulder Creek water yields, the City looked first at what could be done with Silver Lake. In 1940, the original rock-fill-timber-crib structure had been replaced by an earthen embankment that did not increase the size of the reservoir.[139] The City had considered an enlargement to the reservoir in 1941, but plans were set aside. Boulder finally began enlarging the dam and filing for new water storage rights in the mid-1950s. Silver Lake dam was enlarged in 1956, giving 1,181 more acre-feet of reservoir storage, and enlarged it again, in 1966, for another 1,839 acre-feet.[140]

In response to the drought crisis, Water Superintendent E.B. Debler proposed that the City obtain emergency water by leasing supplies from Barker Reservoir, owned by Public Service Company of Colorado (PSCo, now Xcel Energy), and from the City of Denver. The City could use the leased water supplies by releasing them in exchange for increased diversions at Boulder's pipeline intake at Lakewood Reservoir. Boulder would later file for a decreed exchange right on Boulder Creek based on these first water exchanges in 1954.[141]

The City entered into an agreement with the company, in 1955, allowing Boulder to have limited use of the Barker facilities to store the City's own water.[142] A 1959 agreement gave the City the permanent right to store 4,000 acre-feet of water in Barker Reservoir.[143] However, Boulder still did not have an ownership interest in the Barker facilities and had little say in how they were operated and maintained. The City would continue to negotiate with Public Service in the coming decades to secure sufficient control over the facilities to assure its critical function as a part of the municipal water supply system.

Boulder Reservoir, 1955

The early 1950s brought the construction of Boulder Reservoir, required for Boulder to begin using Colorado Big Thompson (CBT) Project water. The City owns the reservoir and surrounding land, but the Northern Colorado Water Conservancy District (NCWCD) owns storage space and controls water deliveries. Meanwhile, the City operates all of the recreational facilities.

Prior to the Boulder Reservoir Water Treatment Plant's completion, in 1971, the City used its CBT Project water only by exchanging it for additional water taken at the City's upper Boulder Creek intakes. Currently, the CBT Project consists of 12 reservoirs, six power plants, three pumping plants, 95 miles of associated canals and waterways, and 35 miles of underground tunnels and siphons, as well as the necessary control and measurement facilities.

Boulder Reservoir was photographed shortly after its opening in 1955. Carnegie Branch Library for Local History, Boulder Historical Society collection (129-12-28 #3)

BOULDER RESERVOIR HAS DRAWN CROWDS FOR MORE THAN 50 YEARS, by Silvia Pettem
(*Daily Camera,* June 11, 2006)

In the fall of 1953, the Camera invited its readers to send in names for the "big new water storage reservoir" then planned for northeast of Boulder. "Panorama, Eisenhower," and "Columbine" were a few of the suggestions. "Foothills" was submitted more frequently than any other name. In the end, however, the Boulder City Council chose "Boulder," the first choice of only three of the 97 people who sent in 142 suggestions.

Although the generic name wasn't popular, the promise of a beachfront recreation area quickly drew large crowds. The 540-acre Boulder Reservoir opened to an enthusiastic public in the summer of 1955. The lake's initial purpose was to provide irrigation water for farm lands. Landowners exchanged some of their ditch rights with the City of Boulder, allotting more water in the mountain watershed for municipal use.

But judging by the reservoir's initial reception, what most people really wanted was a place to boat and swim.

Water from the western slope via the Colorado-Big Thompson project first flowed into the excavated basin in April 1955. Two months later, the Milne Ready Mixed Concrete Company provided 75 tons of sand at cost to construct a beach. City trucks hauled the sand to the reservoir's south shore, just west of a newly constructed boat dock.

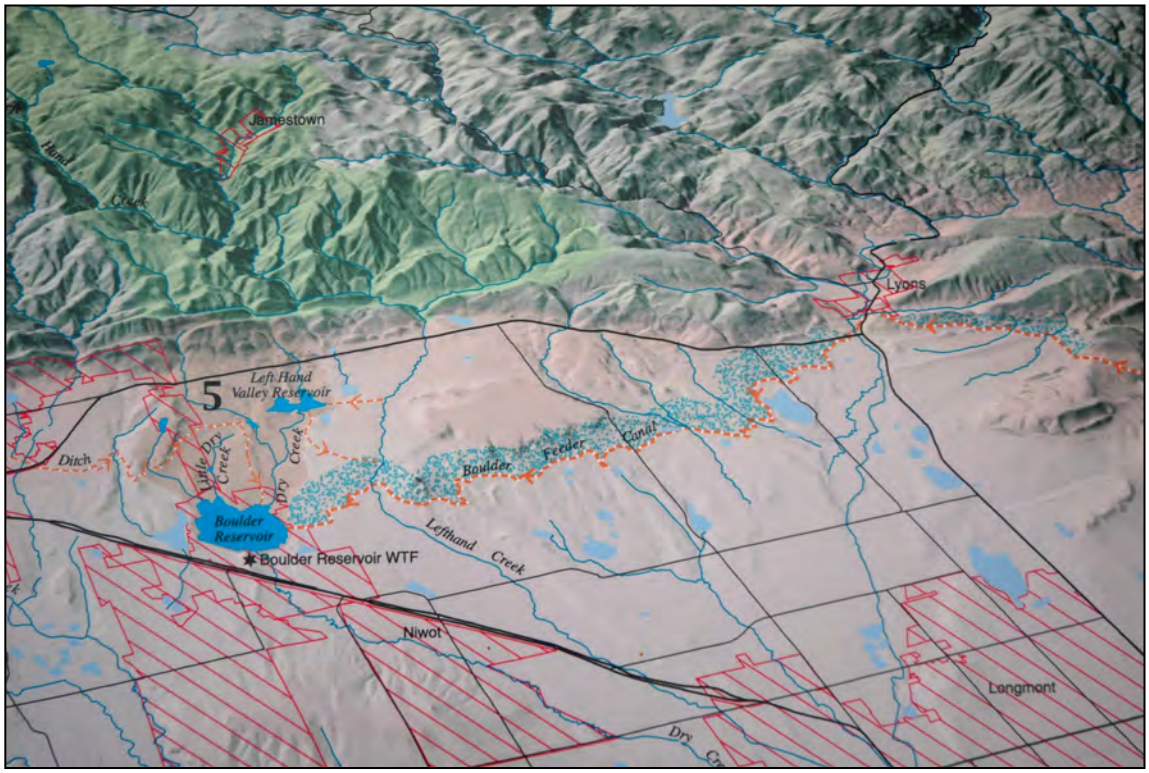
During the recreation area's first Fourth of July weekend, families packed picnics and beach balls into 1,430 cars to enter the parking lot off of North 51st Street. The fee was 25 cents per car. Basking in the sun gave people the opportunity to see and be seen. The Camera called the Reservoir "one of the most popular places in the Boulder region."

At first, if people wanted to change their clothes, they had to do it in their cars. By mid-July 1955, the City of Boulder completed the construction of temporary dressing rooms. Concession space and modern rest rooms were planned for the future. More immediate

concerns were cables and floats to set off the swimming area and the hiring of life guards.

A second beach area was proposed for the north side of the reservoir, but its plans never materialized. Other ideas that never left the drawing board included selected areas for “hot rods,” skeet shooting, rifle and pistol ranges, and a model airplane flying field.

The reservoir today supplies Boulder with some of its water. (The rest comes from Barker Reservoir as well as the Arapaho Glacier/Silver Lake watershed.) In addition to its practical value, Boulder Reservoir is still a good place to swim, boat, and fish, or enjoy the “lazy days” of summer.



Beginning in 1947, CBT Project water from the Western Slope flowed in a tunnel through the Continental Divide to St. Mary’s Lake. After the CBT facilities on the southern end of the system were completed in 1955, some of the water was then carried southward to Carter Lake near Loveland. Then the water flowed in the St. Vrain Canal to Lyons, and then through the Boulder Feeder Canal to Boulder Reservoir. The Boulder Reservoir Water Treatment Plant (on the east side of Boulder Reservoir, as noted on the map) opened in 1971. Excerpt of the City of Boulder’s Watershed map, courtesy City of Boulder.

Silver Lake Ditch and Reservoir Company Agreements

In the 1950s, the simmering tensions between the City and the Silver Lake Ditch water users reached a full boil. Silver Lake Ditch users had been in an uneasy relationship with the City ever since James P. Maxwell, as sole owner of the Company, had sold Silver Lake and Island Lake reservoirs, along with all of their water storage rights, to the City in 1906. Maxwell had included provisions in the 1906 Agreement that the City would continue deliveries of storage water to the contract water users of the Silver Lake Ditch Company. The City took over all maintenance and operation of the reservoirs. And so, the uncomfortable reliance of the Company's water users on the City began.

Under the contracts that the Silver Lake Ditch Company had entered into with individual ditch users prior to 1906, they were to use water only on the land specified in each contract and could not use that water anywhere else. Therefore, Maxwell and the City expected that the City's contractual water delivery obligation to the Silver Lake Ditch would decrease over time, and the City would eventually have full use of the reservoirs. The 1906 Agreement also prohibited Silver Lake Ditch Company from allowing ditch users to transfer water to new properties.

In 1908, James Maxwell's son, Clint Maxwell, sold the Silver Lake Ditch and Reservoir Company, including the contract with the City for storage water deliveries, to W. W. Degge. Under control of the Degge family, the ditch fell into disrepair after it received insufficient revenue under the water user contracts to pay for repairs. In 1946, the ditch users offered to buy the Company in order to bring the ditch back into working condition. The Degge family sold out to a newly formed Silver Lake Ditch Water Users Association in 1948. The ditch users began repairing the ditch and replacing pipelines.

First Supplemental Agreement – 1955

With the onset of severe drought in 1954, the City looked closely at the amount of land irrigated by the Silver Lake Ditch. The Company's 1906 Agreement with the City stated that the City's obligation to deliver Silver Lake Ditch water would decline as contract holders abandoned use of their ditch water or were supplied by other water sources, such as by annexation to the City.[144] The total acreage watered by the ditch had decreased since 1906 from 1,006 acres to approximately 891 acres, in 1947, but the City's storage water delivery obligation had not decreased.[145]

The initial amount of water owed to Silver Lake Ditch by the City was defined in 1906 as equal to the amount lying between two elevations, or "level planes," located above the outlets in Silver Lake and Island Lake reservoirs, as they existed in 1906.[146] This reservoir storage volume had been surveyed and found

to contain space for 951 acre-feet.[147] The amount of storage water released had not been a major issue in most years because the City (since at least the 1930s) had not usually met its obligation to the ditch by dropping water out of Silver Lake or Island Lake. In fact, the City's practice had been to exchange water from other sources, such as Baseline Reservoir, to meet Silver Lake Ditch needs. However, in drought years, there was no opportunity to trade water in this manner.

In 1954, just as City water customers were facing water use restrictions, the City had to release from Silver and Island lakes all of the precious water captured from the fleeting spring snowmelt that year so that Silver Lake Ditch users could continue watering.

The Silver Lake Ditch Company cried foul when the City advised its users that it would be reducing future storage water deliveries based on the reduction in land irrigated by the ditch, and, further, would be reducing deliveries in years when the City's reservoirs didn't fill up to the "level planes" in the 1906 Agreement. When the City had lowered the Silver Lake outlet pipe by 15 feet, in 1928, the lower portion of the reservoir became accessible. Based on this work, the City was given a decreed water right in 1928 for an additional 322.7 acre-feet of storage space. When water was put into the reservoir by the City under the most senior 1887 Silver Lake water right, it filled the reservoir from the bottom up and occupied the space below the "level planes" specified in the 1906 Agreement for storage of water for Silver Lake Ditch Company use.

The next water rights used to fill storage space in Silver Lake were the City's 1906, 1928, and 1941 water rights. Therefore, water that was actually placed in-between the two "level planes" was derived from more junior water rights, which could reduce the amount of water delivered to Silver Lake Ditch in dry years if the junior rights were called out. The Silver Lake Ditch Company contended that, despite City ownership of the reservoirs and water rights, the City had not been legally allowed to make changes to the reservoir facilities without company approval. Even though the City didn't agree that approval was necessary, this was a problem since City plans were well underway for an enlargement of Silver Lake Dam, with construction scheduled to begin in 1955.

The disagreements were addressed in 1955 through a Supplemental Agreement between the City and the Silver Lake Ditch and Reservoir Company.[148] It was agreed that, instead of delivering whatever water lay between the "level planes" defined in 1906, the City would provide Silver Lake Ditch with an amount of storage water equal to what the City could divert that year under the 1887 Silver Lake and the 1890 Island Lake water rights, not to exceed 800 acre-feet. Ditch users gained assurance that the senior water rights would be used to determine the storage water amount released, and the City was relieved that it would not have to deliver more water in drought years than yielded by the 1887 and 1890 water rights.

The company agreed that the City could continue delivering water from any source and didn't have to deliver out of Silver Lake or Island Lake. The 1955 Agreement included a formula for reducing the delivery obligation to less than 800 acre-feet, once the amount of acreage irrigated by the ditch fell below 400 acres. Use of the formula assured that there would always be enough water to cover ditch losses, even if only one ditch user remained. Since the agreement ended the definition of the water to be delivered to the Silver Lake Ditch Company as the specific water that physically existed in reserved storage space within Silver Lake and Island Lake,[149] the Company dropped its objections to the City's previous lowering of the Silver Lake outlet in 1928 and agreed that the City was free to make changes to Silver and Island lakes in the future.

Second Supplemental Agreement – 1965

In 1960, the City requested a list of irrigated properties from the Silver Lake Ditch Company and was given a list showing 526 irrigated acres. This was quite a drop from the 891 irrigated acres reported by the Degges in 1947. The irrigated acreage was still greater than 400 acres, so the drop was not enough to reduce the City's obligation to deliver water under the terms of the 1955 Agreement. However, when the City asked for an updated list in 1962, the ditch company listed properties totaling 696 acres, claiming that the 1960 list was an estimate based on faulty record-keeping.

In 1963, the City concluded that Silver Lake Ditch water was being transferred from properties that were no longer being irrigated to new properties not included in the 1906 agreements and to re-establish irrigation on properties that had previously abandoned use of Silver Lake Ditch water.[150] Both actions were in violation of the terms of the previous Silver Lake Ditch Company/City agreements.

The City attempted to resolve the issue with the Silver Lake Ditch Company, but the Board of Directors refused to meet. So, the City filed a Complaint with the court to stop the Silver Lake Ditch Company from transferring water to new land and to determine the extent of the City's contractual obligations, alleging that the Company served less than 400 legitimate acres.[151] Dissention rolled through the ranks of the ditch users when a flyer was sent out criticizing the actions of the previous board that had approved the 1955 Agreement. The decision to replace the City obligation to use specific storage space for the Company's water with the obligation to provide water based on specific water rights according to an acreage formula was viewed by some as leading to the eventual demise of the ditch .

Owners of newly irrigated land that was not listed under the 1906 ditch-user contracts were warned that their Silver Lake Ditch water supplies were in jeopardy. Everett Long and other ditch users defended the previous board and

advocated keeping a level head. The Silver Lake Ditch Water Users Association met, voted out the Board of Directors, and appointed a new board with a willingness to meet with the City.[152] After negotiations, a new Agreement was signed, in 1965, that identified specific parcels of land that had been irrigated with water from the Silver Lake Ditch prior to 1955.

From that point on, only land associated with a specific Map Number under the 1965 Agreement was allowed to be irrigated with the contract storage water deliveries.[153] The Agreement also provided specific time frames for the periods of non-use of water or non-payment of ditch assessments that would constitute abandonment of the right to use Silver Lake Ditch water.

The 1965 Agreement allowed the City and the Silver Lake Ditch Company to live in tolerance of each other. However, since both entities desire use of the same water, the underlying tension would continue until it would once again boil over 40 years later, or almost 100 years after Maxwell and the City first entered into the agreements that brought about the shotgun marriage.

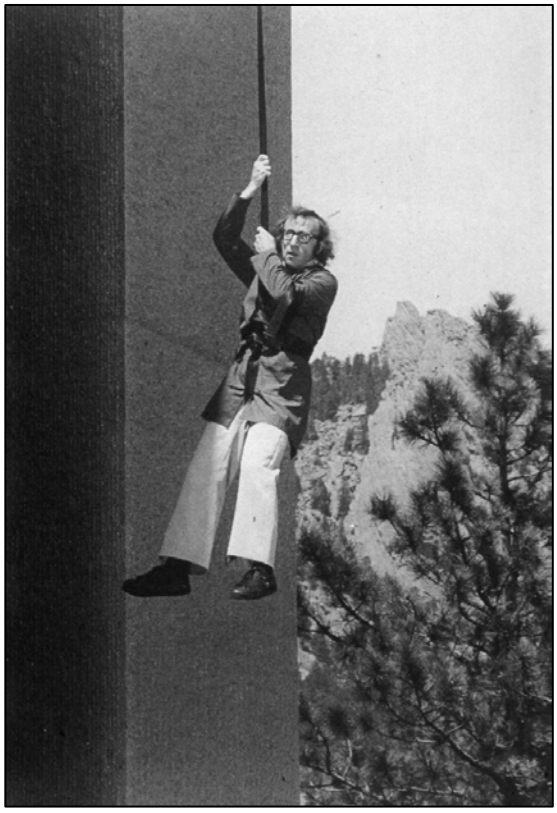
Blue Line, 1959

Since Boulder was growing so quickly during the 1950s, an organization called PLAN-Boulder formed in 1959, with its goal to slow down and direct growth in order to preserve what it saw as the City's special qualities. When the City proposed the burying of water transmission lines in the foothills above Boulder, PLAN- Boulder drew up a proposed Charter amendment, establishing a "Blue Line." No city water or sewer services would be extended west of this imaginary boundary drawn through Boulder's mountain backdrop at approximately 5,750 feet in elevation.

PLAN-Boulder successfully petitioned the City Council to place the amendment on the ballot. Even though a water bond issue was defeated that year, the Blue Line amendment passed overwhelmingly.

However, one and one-half years later, an exception was made to the Blue Line on the January 1961 ballot. Voters were asked to decide whether or not the National Center for Atmospheric Research's proposed building site on a mesa beyond the Blue Line should be accorded water and sewer services. Initially, there was considerable opposition to the exception, but a majority of those voting evidently felt that NCAR's presence on the mesa would not unduly disturb the mountain backdrop. The "exception" passed 5,461 to 1,479.

By 1960, the City's population had exploded to 37,718 and then, by 1970, it nearly doubled to 66,870. The cold war had ushered in an economic boom. When the press predicted "a disruption of Boulder's traditionally placid existence," they weren't far off.[154]



In 1973, actor Woody Allen rappelled down the side of NCAR while filming the movie “Sleeper.” Courtesy of the Daily Camera

Boulder in the 1960s and 1970s

The mid-1960s to early 1970s was a turbulent time for Boulder and the nation as a whole. In 1964, U.S. President Lyndon B. Johnson made a major military commitment in Vietnam, inciting anti-war protesters across the country. Folk singer Bob Dylan released a new song that quickly became a hit—“The Times They Are A-Changing.” And, they were. In the same city that had at one time been "dry" with strict limitations on the sale of alcohol, the police battled an influx of hippies as Boulder became a major crossroads in drug trafficking between Chicago and California. While some characteristics of Boulder appeared to be undergoing radical change, other unique traits of the city were enhanced.

In 1962, Rachel Carson published *Silent Spring*, a book that describes the poisoning of humans and nature caused by widespread use of pesticides. A developing awareness of environmental concerns started sweeping the nation, eventually leading to the observation of the first Earth Day on April 22, 1970.

Although interest in environmental protection increased in Boulder, as well, the desire to preserve the beautiful surroundings of Boulder was nothing new for the City's citizens. In 1897, the City had purchased land to establish a Chautauqua retreat and to protect the surrounding natural areas—later considered the City's

first Open Space purchase. Boulder's citizens had been concerned about the quality of their drinking water since the late 1800s. Beginning in 1905, the City made land purchases to protect the source of Boulder's water supply in the Silver Lake Watershed.

Already concerned with the aesthetic layout of the city in 1907, Boulder's citizens had convinced Frederick Law Olmsted, Jr. to visit and give advice on its development. Olmsted, a pre-eminent landscape architect and son of the designer of New York City's Central Park, was hired by the Boulder City Improvement Association. He published his plan for Boulder's beautification in 1910, calling for the preservation of Boulder Creek and showing all land to the west of the City preserved as open space.[155] Protection of the Boulder Creek corridor would not occur until the 1980s, but Olmsted's vision of open space finally came about in the 1960s.

Following the adoption of the Blue Line in 1959, Boulder citizens wanted additional protection for the mountain backdrop. In 1967, voters approved the first tax for the purpose of open space acquisition in the United States and began purchasing thousands of acres. (The City now has 45,000 acres of open space lands.) Residents of neighboring cities scratched their heads, not realizing that their own cities would have open space programs by the 1990s. Buying up a protective ring of open space, however, wasn't considered enough to preserve the City's character against the onslaught of a burgeoning population. After much public debate, the City adopted a building height restriction ordinance in 1972 and a residential growth management ordinance in 1977.

These changes would eventually slow Boulder's growth rate below the explosive levels experienced from the 1950s through the 1980s. The City's water system planners, however, didn't have the luxury of assuming that the minimum level of growth would occur out of the broad range of possibilities laid out by city planners. Doing so could mean shortages of essential water supplies, particularly since water projects often took 20 years to plan and build. So, efforts to expand water facilities and acquire water supplies continued with an eye on the worst projections of what would be needed 30 years in the future.

BETASSO WATER TREATMENT PLANT, 1964

Until the 1960s, Boulder had been able to avoid providing any significant water treatment processes for the City's water. Most early drinking water treatment programs in the U.S. focused on removing turbidity (dirt and particulates) since they were known to harbor bacteria and pathogens.[156] Although the City, beginning in 1949, had begun year-round chlorination of water at a small station near the Lakewood Reservoir, it was believed that little treatment was needed since Boulder's water was derived from pure snowmelt out of a protected watershed.

Gradually, more became known about the health effects of a variety of potential water contaminants. In 1962, the U.S. Public Health Service adopted standards for municipal drinking water treatment that addressed 28 contaminants.
In 1962, the City of Boulder purchased land for the Betasso Water Treatment Plant to be located in the mountains west of Boulder, near Sugarloaf Mountain.[157] The seller of the land was Ella Rhea Newsome, a longtime property owner who had bought the land from its original homesteader, Lewis Lindemuth, one of Steven Betasso's neighbors.[158]

In 1964, the plant began operation with a capacity of 28 million gallons per day. The construction of the Betasso plant had a dual purpose:

- Filter and disinfect water delivered from the City's historic facilities in the Silver Lake watershed and the Lakewood Reservoir.
- Allow direct use of the new water supplies from Barker Reservoir gained by the City under its new contracts with Public Service Company. (Prior to the construction of the Betasso Plant and new pipelines, the City had only been able to use water from Barker Reservoir indirectly by releasing it to Middle Boulder Creek in exchange for additional diversions into Lakewood Pipeline.)

This sign greets visitors to the Betasso Water Treatment Plant. Pettem photo, 2013

Also in 1964, the portion of the old Boulder City Pipeline that carried water between Lakewood Reservoir and the western edge of Boulder was re-plumbed to connect to the new Betasso Water Treatment Plant. The upper segment that brings raw water to the plant is still called the Lakewood Pipeline. The lower segment of the old Boulder City Pipeline that now carries treated water from Betasso into the City became known as the Boulder Canyon Pipeline. A second treated water pipeline, the Sunshine Pipeline, with a 30-inch diameter, was constructed in 1965.

The interior of the Betasso Water Treatment Plant was photographed shortly after it opened in 1964. Carnegie Branch Library for Local History, Boulder (511-2-14 #4)

A new raw water pipeline was constructed between the Public Service Company's Boulder Canyon Hydro Plant, on Boulder Creek, at Orodell, and the Betasso Water Treatment Plant in order to deliver water from Barker Reservoir for treatment. The City would use capacity in the Public Service Company's Barker Gravity Line and the penstock leading to the hydro plant to carry City water based on contractual agreements with the company.

The series of pipeline segments running from Barker Reservoir to the Betasso Water Treatment Plant is called Boulder City Pipeline #3.[159]

Fluoridation

When the Betasso Water Treatment Plant first opened, fluoride was not added to the water. In fact, the question of whether Boulder's water should be fluoridated was highly debated. The issue had been simmering for years, and, until 1969, voters had twice soundly defeated the additive. Fluoridation of Boulder's water finally went into effect in July 1970.[160]

THIS BOULDER CONTROVERSY HAD SOME TEETH
(by Carol Taylor, *Daily Camera*, November 3, 2012)

The U.S. Center for Disease Control cites fluoridation of drinking water among the 10 great public health achievements of the 20th century. It took three elections to get fluoridation approved in Boulder. At one point there were so many letters to the editor, both for and against, that the *Daily Camera* called for a moratorium.

Groups in favor thought Boulder should join other progressive cities in fluoridating the water supply to prevent tooth decay. Opponents rejected chemical additives to their pure glacier water.

Interest in the topic was piqued after results of studies reported in the *Daily Camera* in 1952 revealed a high rate of tooth decay in Boulder, reportedly the result of a lack of the element fluorine in the City's water supply. The National Institute of Dental Research conducted one study in Boulder and Colorado Springs and found Colorado Springs residents superior to Boulder's in terms of dental health.

The variation was related to the amount of fluorine in each city's water supply. Boulder's natural water supply contained practically no fluorine, which was why the City was chosen for the study. Colorado Springs' water supply had averaged 2.5 parts per million for many years. Upon the recommendation of dentists and public health officials, the Boulder City council passed an ordinance for water fluoridation in April 1954.

Not so fast, opponents said. A referendum petition forced the issue to a vote of the people. Mr. Archibald Lacy (A.L.) Camp headed the campaign against adding fluoride with The Committee for Pure Boulder

Water. Camp wrote in a letter to the editor, “I believe we have the best and purest water in the world; it is the joy and pride of beautiful Boulder.”

Camp and his ilk said adding the chemical fluorine to the public water supply was a form of mass medication with a poisonous substance and a violation of their human rights. If people really wanted this chemical for dental health, they could get it individually from their dentist, the group argued.

Proponents insisted there would be no ill effects from the addition of a small amount of the chemical and that research backed up their position. In October 1954, the measure was defeated by 742 votes. “Boulder Citizens for Good Teeth” petitioned fluoridation onto the ballot again in 1964. Nearly every medical, dental and public health group in the city endorsed adding fluoride to the water supply. The Committee for Pure Water again formed the opposition.

The *Daily Camera* reported that the U.S. Surgeon General sent a wire to Boulder’s acting mayor, Robert W. Knecht, supporting fluoridation. Even so, the measure was defeated for a second time.

In 1969, the measure was petitioned onto the ballot once more. The Fluoride Study Group staged a series of public information meetings at which they emphasized the harmful effects of adding the chemical.

However, just before the election, the World Health Organization adopted a resolution calling on member nations to introduce fluoridation of community water supplies. With a large voter turnout, the measure was approved by 278 votes, 3,257 to 2,979 against.[161]

Boulder now fluoridates its drinking water to 0.9 parts per million, as recommended by the Colorado Department of Public Health and Environment.

Improvements to the Betasso Plant, 1976

The Safe Drinking Water Act was signed into law by President Ford in 1974. It gave the newly created Environmental Protection Agency and state health departments authority to regulate the nation's drinking water supplies. Increasingly more was being learned about the health effects of small doses of

chemicals that had previously been considered harmless. Studies had shown the presence of carcinogenic chemicals in the water supplies of New Orleans and Cincinnati. Some of these "volatile organics" were from the environment, but some were thought to occur as a result of chlorination processes for drinking water that were not carefully controlled in timing and amount.[162] The City of Boulder knew that it would soon have to meet new EPA drinking water standards. Planning began for improvements to the Betasso Water Treatment Plant that would improve treatment processes as well as expand capacity to meet ever-growing water demands.

In 1976, the Betasso Water Treatment Plant underwent a $2.4 million expansion that was planned to more than double capacity up to 50-million gallons of water per day. However, EMA, Inc., a St. Paul, Minnesota, water consulting firm, issued its commissioned report shortly after the expansion and stated that Boulder still did not have sufficient capacity to treat water for its growing population. Given the limits on land available at the Betasso site and on the water supplies available from the City's Boulder Creek basin sources, any future treatment expansions for growth needs would have to occur at the City's other water treatment plant at Boulder Reservoir.

In 1977, the new EPA drinking water regulations mandated under the Safe Drinking Water Act went into effect. They required testing for bacteria, ten inorganic chemicals, six organic pesticides, turbidity and radiological contamination. Any violations of the maximum limits on these contaminates had to be reported to the public. Boulder was well prepared to meet these standards for water produced at the Betasso Water Treatment Plant due to its protected water sources and the new expansion.[163]

Betasso Treatment Process

The basics of the treatment process at the Betasso Treatment Plant are as follows:

COAGULATION is the first step in removing contaminants by forming clumps of particles known as floc that trap pathogens and other contaminants. Coagulants are rapidly mixed (within one-to-three seconds) into the source water. Coagulant chemicals used at Betasso are Alum blended with a polyaluminum chloride polymer called Sumaclear.

FLOCCULATION is the process of allowing the floc particles to grow using slow mixing in order to remove suspended solids. Flocculation occurs in four basins for three-to-six hours, depending on plant flow.

SEDIMENTATION is accomplished in four sedimentation basins. At Betasso, clear water spills off the top of the basins and the residuals settle to the bottom where it is scraped into a solids collection system for disposal.

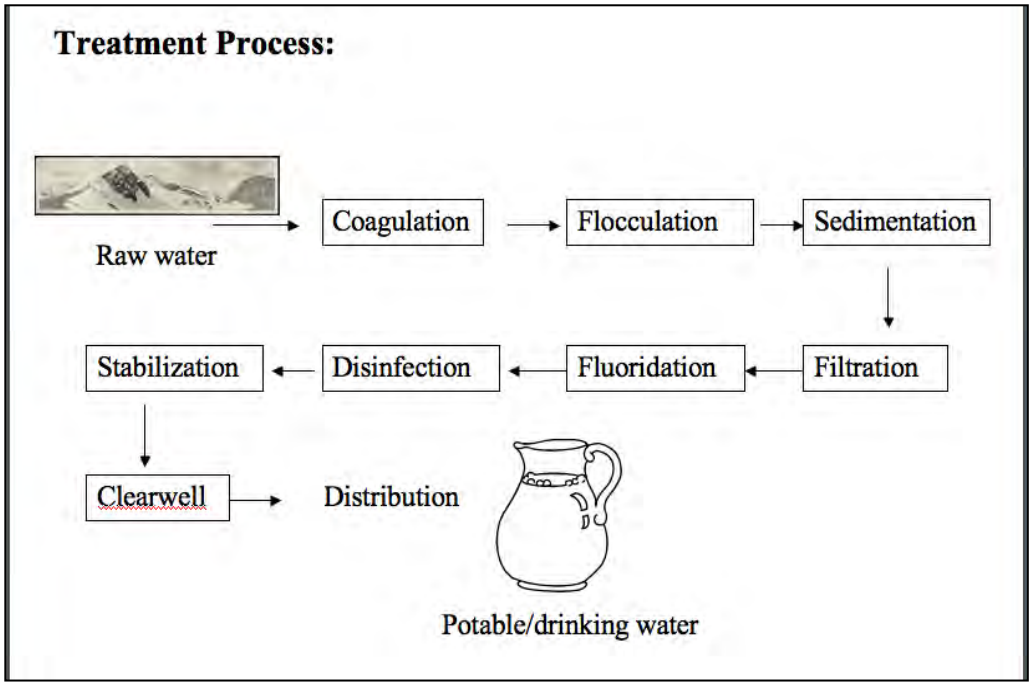
FILTRATION is performed using beds of fine sand and anthracite that are 30-32 inches deep with clay tile under-drains. Water drains through the filter beds for 48-to-60 hours. Flushing water is then forced upwards through the filters for a period of about ten minutes to clean them before they are allowed to settle and are re-used.

FLUORIDATION involves adding liquid fluoride to a level that reduces tooth decay in children.

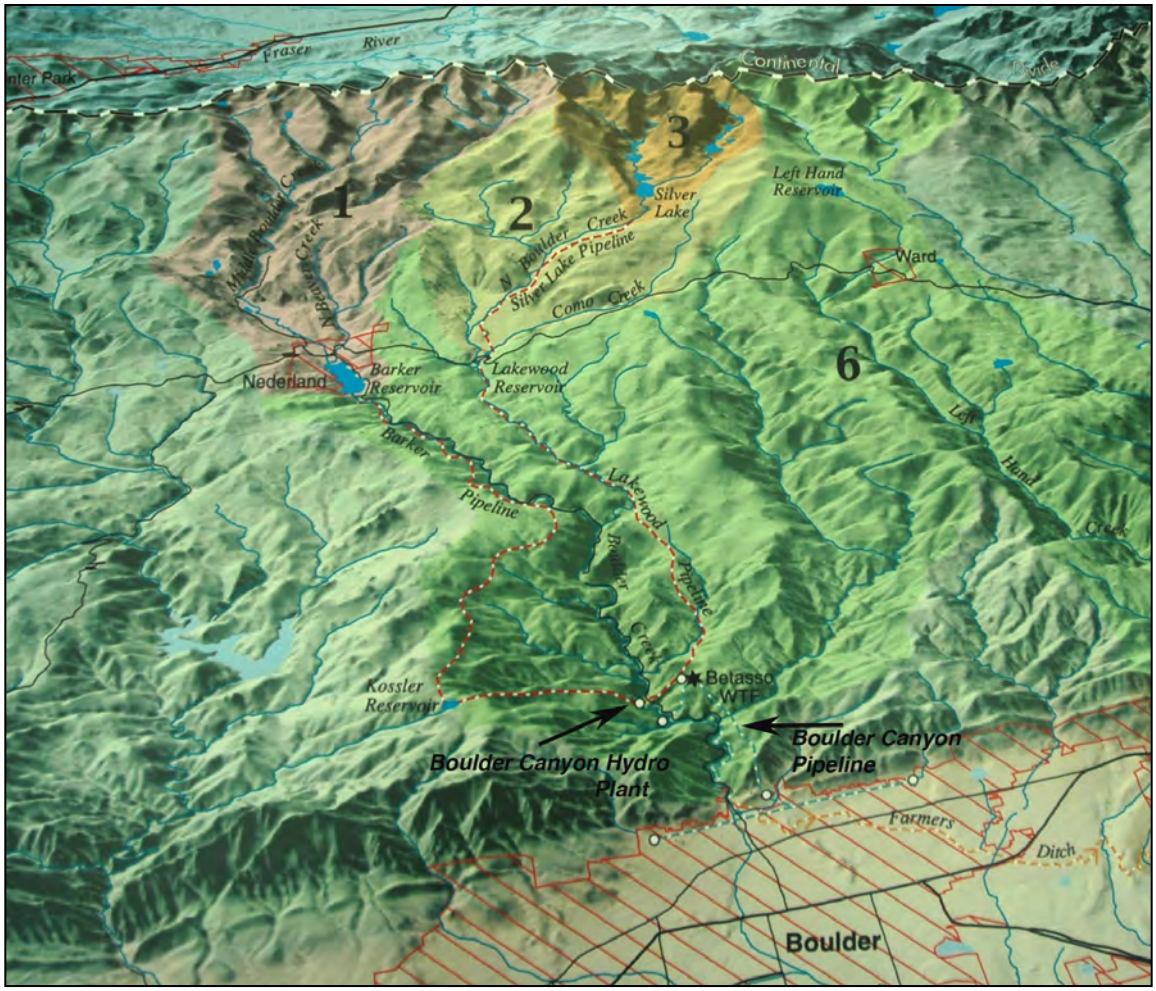
DISINFECTION kills or inactivates pathogens (disease-causing organisms) using chlorine.

STABILIZATION adjusts alkalinity and pH (to 7.8) through lime and carbon-dioxide gas to prevent erosion of pipes in the distribution system and in buildings.

Prior to being piped to distribution reservoirs in the City (Kohler, Chautauqua, and Maxwell), the water is held in temporary storage in a large tank, called a clearwell, at Betasso to allow the disinfecting action to complete.



Boulder's water is treated to protect public health, comply with drinking water regulations and standards, and for aesthetic reasons. The current process at the Betasso Water Treatment Plant is graphically depicted in the above diagram. Water treatment process diagram courtesy City of Boulder.



This portion of the City of Boulder's Watershed map shows #1 (Barker Reservoir watershed, 38 square miles), #2 (Lakewood Reservoir watershed, 21 square miles), #3 (Silver Lake watershed, 10 square miles), and #6 (watersheds occasionally linked to Boulder Reservoir).

Also note the Silver Lake Pipeline between Silver Lake and Lakewood Reservoir, the Lakewood Pipeline between Lakewood Reservoir and the Betasso Water Treatment Plant, and the Barker Pipeline from Barker Reservoir to Kossler Reservoir, then to the Boulder Canyon Hydro Plant, in Boulder Canyon, and on to the Betasso Water Treatment Plant.

Also shown is the Boulder Canyon Pipeline between the Betasso Water Treatment Plant and Boulder. Courtesy City of Boulder

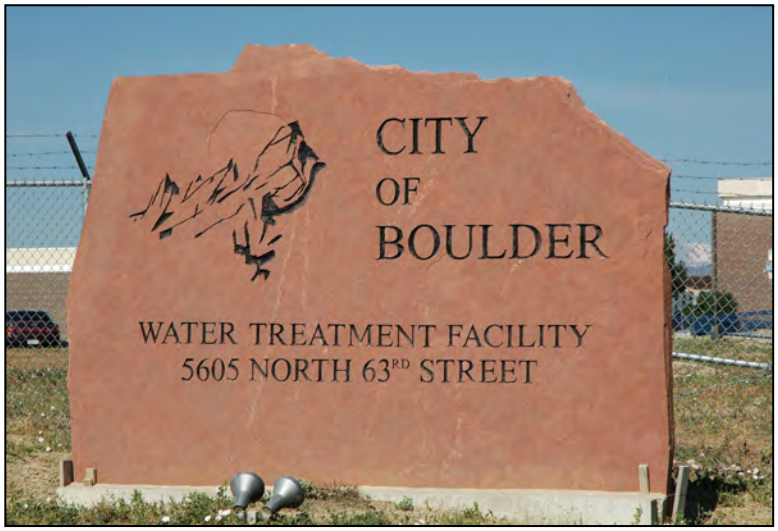
BOULDER RESERVOIR WATER TREATMENT PLANT, 1971

In 1967, after residents passed a water bond issue and allocated $3 million for a second water treatment plant, the City of Boulder began constructing the Boulder Reservoir plant, east of Boulder Reservoir on 63rd Street. Also, during this time, came the opening of the sprawling IBM (International Business Machines) complex, the second lane of the Diagonal Highway, and the Gunbarrel Estates subdivision.

The Boulder Reservoir water treatment plant began operation on September 30, 1971. For the first time, Colorado-Big Thompson water was treated and used directly by Boulder customers instead of water delivered to Boulder Creek in exchange for more diversions into the Barker system or Lakewood Pipeline.

The treatment plant had a sustainable capacity of eight million gallons of water per day when it first opened. The plant design provided for treatment of up to 12 million gallons of water per day for short durations under conditions referred to as “overload.” Initially, only three million gallons per day could be delivered into Boulder due to limitations on pumping capacity for the treated water coming out of the plant.

When first constructed, the treatment processes in the Boulder Reservoir plant were similar to that in the Betasso plant.



The Boulder Reservoir Water Treatment Plant opened in 1971. Pettem photo, 2013

On October 1, 1971, the *Daily Camera* published a photograph of the Boulder Reservoir Water Treatment Plant. Underneath was a caption that stated:

> Boulder’s new $3.25 million water treatment plant, north of the Longmont Diagonal Highway at 63rd, began serving the City Thursday under this panoramic view of

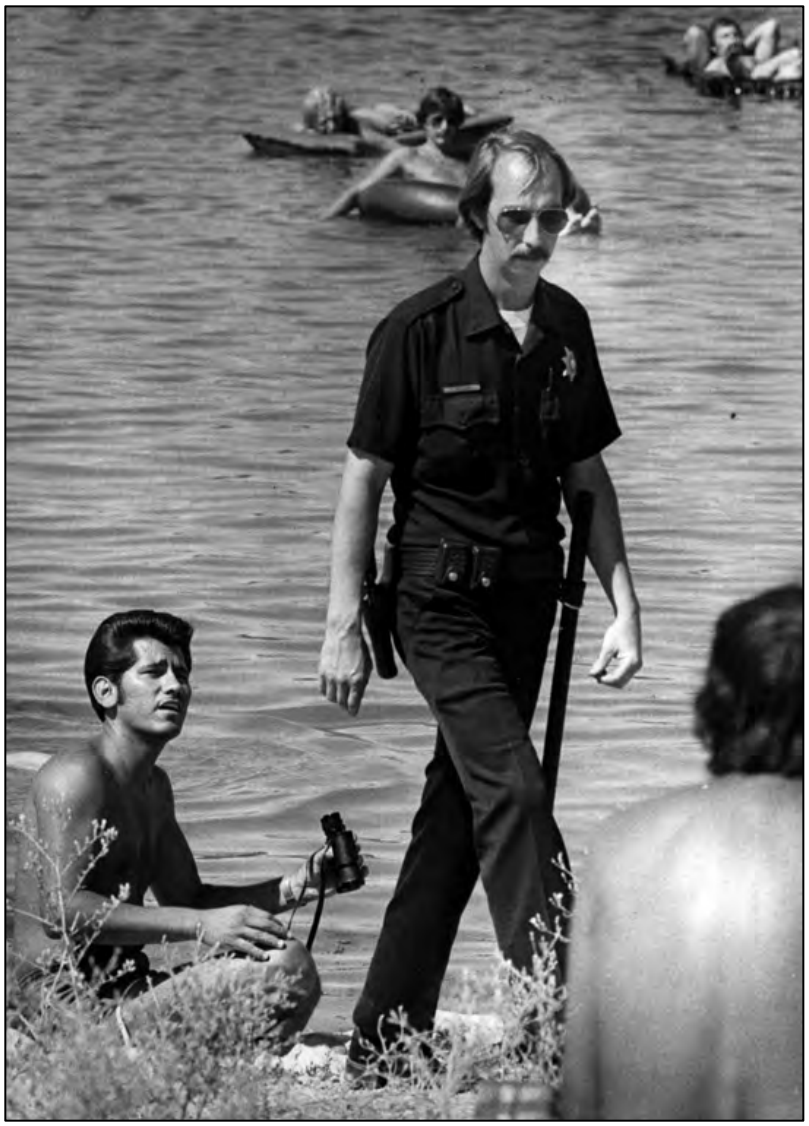
> sky and clouds. Aided by a northeast-city pumping station, the plant can provide up to three million gallons a day for in-city and Gunbarrel area users. With the aid of a planned second pumping station, the facility's full eight-million-gallon-a-day capacity, linked with that of the Betasso Hill plant, could serve a population up to 90,000.[164]

The Boulder Reservoir Water Treatment Plant is located east of Boulder on 63rd Street. Pettem photo, 2013

During the first years of its existence, the Boulder Reservoir Water Treatment Plant was run just during the summer months. Water to feed the plant could only be taken directly out of the Boulder Feeder Canal and not out of Boulder Reservoir. The Canal operates only in the months of April through October when there is no potential for ice to block the water flow. In 1982, a pump station was added to draw water from Boulder Reservoir to feed the plant, in addition to the Boulder Feeder Canal intake, allowing the plant to operate year-round. This pump station includes three pumps capable of delivering eight million gallons per day, and one pump with a four-million-gallons-per-day capacity. Three of these pumps were installed in 1982, and the fourth was installed in 2010.

Throughout the 1970s, employees of the Boulder Reservoir plant couldn't avoid driving past college-aged-skinny-dippers who outraged the neighbors by walking along 63rd Street to sunbathe and swim in the nude in nearby Coot Lake. The lake, also owned by the City of Boulder, had been created when bulldozers scraped the ground for earth to build the dam for Boulder Reservoir.

The activities of the "cooties," as the skinny-dippers were called, even made the July 1980 issue of *Newsweek Magazine,* putting Boulder in the national spotlight. The problem was resolved in the early 1980s, when the City passed an ordinance that prohibited public nudity.[165] Today, Coot Lake remains a city park, but only dogs are allowed to swim.



Boulder County Sheriff's Deputy Tom Ecker was among the City and County law-enforcement officers on patrol at Coot Lake, in 1979. The man at the lower left had just been asked to pour out his beer. Photo courtesy Daily Camera

WATER AND POWER FOR THE FUTURE, 1980s

Boulder's Population (from census records)	
1950	19,999
1960	37,718
1970	66,870
1980	76,228

Boulder's population nearly doubled from 1950 to 1960, and then, during the next decade, it nearly doubled again. In 1961, Boulder had also begun entering into water service agreements for areas outside the city limits. By 1980, it was obligated to serve water to about 13,000 people outside the City.[166]

Other cities along the Front Range grew rapidly, as well. They all would need more water, and many were concerned about the effects of continuing to move local water supplies out of agricultural use in order to quench the demands of the urbanites.

Windy Gap Project

Planning for future municipal water supplies of the northern Colorado Front Range moved into the execution stage in the summer of 1967, when Longmont Mayor Ralph Price filed for water rights for a water diversion project in the Colorado River Basin. Price was acting as trustee for a coalition of six cities—Boulder, Estes Park, Fort Collins, Greeley, Longmont, and Loveland.

The cities jointly considered a project that would construct a small 445-acre-foot reservoir at a local natural geologic cut called Windy Gap, located just below the confluence of the Colorado and Fraser rivers near the town of Granby.[167] Initially known as the Six Cities Project, the name was changed to the Windy Gap Project.

After studying the booming growth rates and water supply and demand projections, representatives of the six Front Range cities concluded that a new water supply project was necessary, specifically to meet the needs of their cities. In order to make this happen, the cities petitioned for a Municipal Subdistrict to be formed as part of the Northern Colorado Water Conservancy District. This formation required court approval after petitions were obtained that included signatures of at least 5 percent of the landowners within each of the six cities, as well as 25 percent of the owners of irrigated land within the proposed boundaries. The Subdistrict—formed for the purpose of building and operating the Windy Gap Project—was approved in 1970.[168]

Bonds were sold to finance the Windy Gap Project, and construction of a pumping plant and a diversion dam on the Frasier River began in 1981.[169] The Project was completed, tested, and became operational in the spring of 1985. Since then, water has been pumped (primarily during the snowmelt-runoff

season between April and July) from Windy Gap Reservoir into a six-mile pipeline up to Lake Granby. There, the water is stored for later delivery through the Colorado-Big Thompson system to northern Front Range cities and industries.

There are 480 ownership units in the Windy Gap Project. Due to sales of units in the Windy Gap Project to new project participants, there are now ten project allottees. Boulder initially owned 80 units of the Project, but, in 1991, sold 43 units to the City of Broomfield. A decade later, this income would finance the purchase of the Barker Water System, which includes Barker Reservoir, the gravity pipeline, Kossler Reservoir, the penstock, and the Boulder Canyon Hydro plant.

Increasing Use of Barker Reservoir

The City's first agreement with the Public Service Company, signed in 1955, only allowed Boulder to have limited use of Barker Reservoir. In 1959, a new agreement gave the City access for storage of 4,000 acre-feet of water in Barker Reservoir. Under successive agreements, the storage space allotted to the City was increased until 1978 when it reached 8,000 acre-feet out of the 11,686 acre-feet of space in Barker Reservoir. The City's rights to use the Barker facilities were still just a lease from Public Service, which continued to use Barker storage space for water to generate electricity at the Boulder Canyon Hydro Plant.

Throughout the years, Public Service had made some improvements to Barker Dam. In 1946 and 1947, the company modified the outlet works on Barker Dam and placed concrete panels on the upstream face to reduce seepage. In 1971, an enlarged spillway was designed to pass flood flows up to 4,544 cfs. Cosmetic improvements were made to the downstream face of the dam in 1971. However, the Federal Energy Regulatory Commission believed more extensive repairs were needed.

In 1982, the Commission placed a storage restriction on Barker Reservoir due to concerns about the ability of Barker Dam to withstand an over-topping event from flooding. The needed repair for the dam involved securing it with post-tensioned anchors to increase the factor of safety.[170] The Public Service Company’s reluctance to pay for such an expensive repair presented the City with an opportunity. The City and Public Service entered into a new agreement, in 1984, that called for Boulder to pay for the stabilization repair at a cost of $3,315,000. In return, the City received a perpetual interest in the Barker facilities that gave Boulder the permanent use of 8,000 acre-feet of Barker Reservoir storage space and two-thirds of the flow capacity in the Barker pipeline facilities.[171]

Silver Lake Watershed Dams

Meanwhile, there were problems with the Goose Lake and Green Lake No. 2 dams in the Silver Lake Watershed. In 1983, the timber cribbing inside the Goose Lake Dam caught fire, after a contractor applied shotcrete (concrete through a hose) to the dam's upstream face. The damage was repaired the following year with wire fabric, anchored and welded in place.[172] In 1989, while repairs were made to the outlet works and the spillway and a new outlet house was constructed, the downstream face of the dam was covered with roller-compacted concrete to increase the ability to safely pass floodwater over the dam.[173]

In 1989, roller-compacted concrete was installed on the downstream face of Goose Lake. Photo courtesy City of Boulder

The dam at the old Green Lake No. 2 Dam was no longer able to safely contain water due to deterioration of its steel face and the instability of the base. Inspectors recommended that the problem be addressed prior to the next snowmelt season, so the City temporarily removed a portion of the dam embankment.

Wittemyer Ponds

In 1986, the City's Public Works Department purchased a 159-acre property known as Wittemyer Ponds, from John Wittemyer, a descendant of a longtime Boulder County family. The property, which cost $380,000 and is located along Boulder Creek south of Highway 52 near the Boulder/Weld County Line, includes both mineral and water rights.[174] Prior to its acquisition by the City, 68 acres had been mined for gravel. The gravel pits have since filled with groundwater, creating a series of five ponds.[175] The City purchased the property with the intention of lining the gravel pits and using them to store reusable water for later exchange into the City system, or to lease to downstream water users.

Boulder's New Hydropower Development

Public interest in the hydroelectric potential of Boulder's water system had been growing in the 1980s, so the City finally began to pursue the possibility. An idea that had first been proposed at the time of the Lakewood Pipeline construction in 1906 was now, three-quarters of a century later, ready to be developed.

In 1980, a study was completed for the City titled *Waste Water Pressure and Potential Energy Generation: A Feasibility Study of the Hydroelectric Potential in Part of the Domestic Water System of Boulder, Colorado.* The document examined five potential power generation sites within the City's water system: Silver Lake Pipeline, Betasso Pipeline, Sunshine Pipeline, Orodell, and the 6th and Canyon site. This initial study revealed the extent to which hydroelectric development potential existed on Boulder's water system. By 1983, Boulder was granted a preliminary permit by the Federal Energy Regulatory Commission to conduct feasibility studies of the hydroelectric development potential of the City's watershed, supply, transmission, treatment and distribution systems.[176]

Boulder's water system is ideally suited for hydropower development. Pressure develops in a pipeline through the force of gravity when there is a drop in elevation from one point on the pipeline to another. The City's watersheds extend to the top of the Continental Divide—more than 5,000 feet higher than downtown Boulder. Raw water pipelines drop hundreds of feet in elevation from the stream intakes to the Betasso Water Treatment Plant. The treated water pipelines from Betasso also drop hundreds of feet into Boulder. There also are pressure zones within the distribution system in the City as the elevation drops by 600 feet from the west to the east side of Boulder.

This pressure needs to be reduced before entering into the water treatment plant or customers' homes. The City uses pressure-reducing valves to dissipate this energy, but this wastes a potential power source. By installing turbines and generators on pipelines running parallel to the pressure-reducing valves, the

pressure can be used to generate electricity, while still maintaining the valves as backup for the pressure-reduction function when needed.

Along with the public, the Boulder City Council enthusiastically supported generating electricity using the non-polluting "green" power within Boulder's water system. No new dams had to be built, and no new water diversions were needed for power production since the hydropower generation used the same water already being delivered to Boulder's water customers. In the 1980s, Boulder embarked on a journey that has resulted in the construction of seven hydroelectric stations and may result in still more in the future. (The City would later purchase the Boulder Canyon Hydro Plant as its eighth station.)

As previously noted, the Boulder Canyon Hydro Plant (owned by the Public Service Company of Colorado) had been producing electricity since 1910. Many decades later, in 1983, the City negotiated its first power sales agreement with Public Service for a tiny hydro plant located between Pressure Zones 2 and 3 within the City's water distribution system at Maxwell Reservoir. The Maxwell Hydro/Pump Station went into operation in 1985. The Maxwell station can generate electricity whenever water is flowing downhill from the high pressure zone into the lower zone. However, when water needs to be pumped up into the high pressure zone, the turbine is run backwards and used as a pump.

The City soon entered into separate agreements with Public Service to sell power from three more small hydro plants, and construction soon followed. Two of these plants, Orodell and Sunshine, are located on treated water transmission lines running from the Betasso Water Treatment Plant into Boulder. The third plant, Kohler, is a pump/turbine plant like Maxwell station and is located between pressure zones in the distribution system.

In 1984, the City and Public Service entered into another agreement for three proposed hydroelectric projects on the City's raw water transmission pipelines—Betasso, Lakewood, and Silver Lake.[177] Only one of these plants, Betasso, would be built in the 1980s. The other two would have to wait until the rebuilding of the Lakewood and Silver Lake pipelines.

Two years later, the City hired new project manager June Heinrich Busse to oversee the permitting and construction of the hydro plants, the reconstruction of the two pipelines, and other projects on the raw water system. Also in 1986, the City began efforts to get permit approval from the U.S. Forest Service for reconstruction of the Lakewood Pipeline in the location where it had been since 1906, prior to the reservation of the Arapahoe Forest.[178] Little did June know that it would take almost 20 years and the entirety of her career with the City to finally accomplish the reconstruction at a cost of more than $28 million.[179]

In its first year of hydro operation, the City generated about 400,000 kilowatt-hours of electricity—sufficient to supply the annual needs of approximately 70

Boulder households and yielding $16,700 in revenue for the City's water utility. The City of Boulder now owns eight hydroelectric plants capable of generating more than 50,000,000 kilowatt-hours every year (enough for about 9,000 households) and providing more than $2 million in revenue each year to the water utility fund. By 2012, the City's hydro plants had generated a total of more than 645,000,000 kilowatt-hours and brought in more than $31 million in revenue. As of this writing, 5 per cent of Colorado's electricity comes from nearly 70 hydroelectric facilities, most of them being very small.[180]

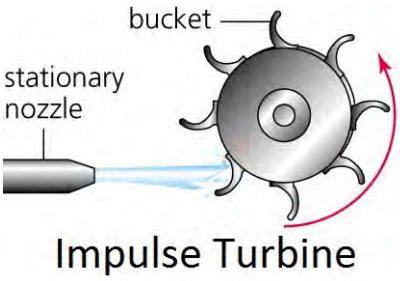
During the 1980s, construction of the Maxwell plant was followed by four others, as follows:[181]

Plant	In Service	Treated/Raw	Penstock
Maxwell	April 1985	Treated	12" approximately 2 miles long
Kohler	October 1986	Treated	12" approximately 2 miles long
Orodell	September 1987	Treated	18" – 1 mile long
Sunshine	September 1987	Treated	30" – 4.5 miles long
Betasso	December 1987	Raw	20" – 3 miles long

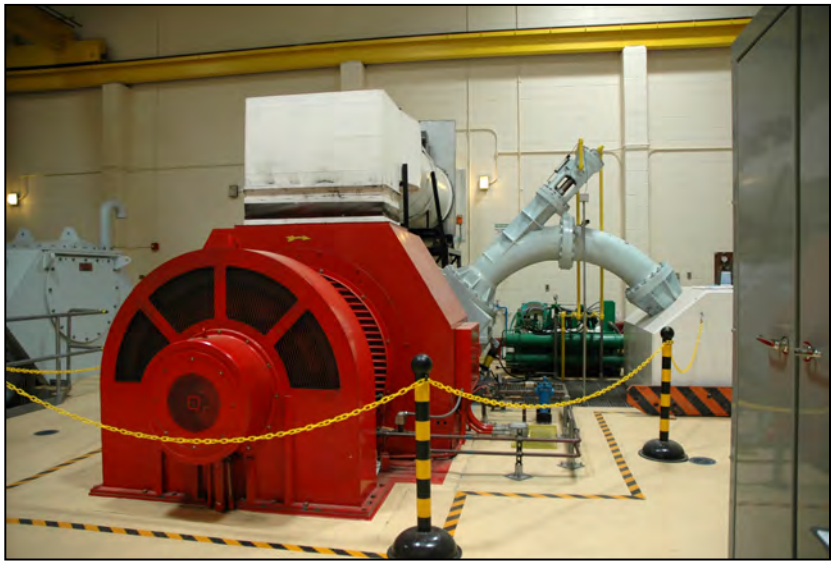
The Maxwell, Kohler, Orodell, and Sunshine hydro plants use Francis turbine wheels (similar to centrifugal pumps), but the remaining plants, including the Betasso Hydro Plant, have Pelton wheels. The Pelton wheel is a water impulse turbine that is driven by a pressurized stream of moving water. Unlike traditional overshot wheels rotated by free-falling water and used by Boulder County's early farmers in their gristmills, Pelton wheels spin when high-pressure water, from nozzles, is forced against a series of buckets. The rotating turbines/wheel turns generators that create electricity.

The Pelton wheel was invented in 1878, in California, by millwright Lester Allan Pelton after the Ohio native had observed gold miners concentrating streams of water under very high head, through a nozzle and against banks of dirt and gravel, in a process called hydraulic mining. He patented his water wheel in 1889.

This Pelton impulse turbine (on display in the Betasso Hydro Plant) is similar to the one in use at that facility, located in a separate building on the grounds of the Betasso Water Treatment Plant. Pettem photo, 2013



Below, the Pelton Wheel is located in the unit in back, in this photo in the Betasso Hydro Plant. In the foreground (painted red) is a 700 rpm 3.1 Mw Chinese synchronous generator. Pettem photo, 2013



Continued Interest in Environmental Protection

In addition to renewed interest, in the 1980s, in the environmental benefits of hydroelectric power, the decade also brought continued public concern with protecting the natural beauty of Boulder's surroundings.

Protecting Enchanted Mesa

The City had its Blue Line in place but, in May 1983, it had a new problem. In order to better regulate water flow from the Chautauqua Reservoir to the Kohler and Devil's Thumb reservoirs, City officials called for a new pipeline to be laid underground through part of Enchanted Mesa, parallel to the existing pipeline. Water Utilities Director Roger Hartman explained to the public that if the transmission line went by way of Enchanted Mesa, the bill would cost $585,000. However, if the City were forced to go under the existing streets, costs would rise to $999,000. Hartman told the Council that he might have to charge a two-cent-per-1,000-gallon surcharge in order to pay for the more expensive route.

City Council members realized that few citizens would stand for pipes running through Enchanted Mesa, even underground. Council member George Boland spoke of previous "scars" nearby. To avoid going through the greenbelt, the two-cent surcharge was adopted. Council member Greg Lefferdink dubbed it an "environmental surcharge." After peace had returned to civic matters, at least for a time, Hartman found out that the pipeline estimates were high, and he did not have to charge extra after all.

Protecting Boulder Creek Streamflow and the 1988 Raw Water Master Plan

When Frederick Law Olmsted Jr. published his beautification plan for Boulder, in 1910, he envisioned a park running the length of Boulder Creek through the City. With the creation of the Greenways Plan in 1984, this vision was finally on its way to being realized. Unfortunately, as pathways and parks were built along the banks of Boulder Creek, the lack of any significant flowing water in the creek during most months of the year became apparent. Irrigation diversion structures, such as the huge Boulder and White Rocks Ditch head gate, located in Central Park at Broadway, pulled most of the water out of the creek during the mid-and-late summer months. The City's diversions far upstream pulled off much of the water in the winter months.

In 1973, Senate Bill 97 had given the Colorado Water Conservation Board (CWCB) the legal right to acquire water to be used for stream flows to preserve the natural environment and to own water rights that are specifically decreed for instream flow use. Water that is left in a stream under a decreed instream flow right can't be taken by other downstream water users. The CWCB made one of its first filings for an instream flow water on Boulder Creek and was granted a 1973 year-round right for 15 cfs for flow in the creek. Unfortunately, a 1973 water right on a creek with rights dating back to 1859 is a very junior right.

All that this water right could do was prevent the Boulder Creek instream flow situation from getting worse under new water rights filings. Fortunately, however, the CWCB was also given the right to acquire senior water rights for instream

flow through donations or purchase. The CWCB began discussions with the City on what more could be done to provide streamflow on Boulder Creek. Some temporary water trades were done with irrigation ditch companies until more permanent solutions could be found.

At this time, the City had an increasing number of questions about the adequacy of its water rights portfolio. How far toward meeting impending water demands had all of the efforts at increasing Boulder's water supply gone? How much more water was needed to secure Boulder's future? The City hired Lee Rozaklis through WBLA (later Hydrosphere, then AMEC) as a consultant to do a Raw Water Master Plan and received some surprising answers. All the while that the City had been striving to meet water demands based on the worst case population projections, Boulder had been taking growth control measures and buying open space to make sure that the worse case didn't happen.

Somewhere along the way, the amount of water acquired by the City had surpassed the projection of water demands for the now-limited, but fully built-out, population of the City's projected water service area. The finding that Boulder owned enough water rights and contracts to meet all of its future needs except in the worst drought conditions led to a new question. In years when Boulder had enough water supply, how could the surplus water be used? Lee Rozaklis would become an essential part of answering questions such as this over the next several decades by modeling the City’s water system and advising on water policy.

In 1988, Boulder’s Raw Water Master Plan identified a goal for the City of achieving instream flows in main Boulder Creek and its tributaries.[182] As a result, City Council adopted policies supporting an instream flow program that would still allow the City to meet water system reliability goals.[183] In 1990, Boulder donated senior water rights that had previously been used in the City's water system to the CWCB to use for instream flows during the months when irrigation ditches were drying up Boulder Creek.

As a condition of the donation, the City reserved the right to use the water for municipal purposes in drought years and during high streamflow periods when they were not needed for instream flow. The agreement was amended in 1992 to add donation of storage water for use on North Boulder Creek below the City's water intakes to address the low flow conditions in winter.[184] A decree for a change in use of the water rights to allow instream flow was signed by the Water Court on December 20, 1993.[185] The City's Water Utility has operated the instream flow program as an agent of the CWCB since that time. David Harrison and Veronica (Ronni) Sperling were the water attorneys hired by the City to usher the instream flow program through Water Court. Ronni would continue to advise the City on all its water rights issues for the next two decades.

DEVELOPMENTS IN THE 1990s

From the 1950s through the 1980s, much of the City's attention and resources had been directed toward expanding the distribution water system in Boulder to keep up with exponential growth in population and building water treatment capacity to meet new drinking water regulations. As water bills increased to fund the expanded facilities, the City's water customers began to have very negative reactions to any new request for water rate increases. Maintenance of existing raw water infrastructure suffered as a result.

During the 1990s, the City turned its focus to rebuilding much of the aged source water and treated water delivery systems. This work included an expanded program to replace distribution piping within the city, seal leaking water storage tanks, improve safe access to facilities, and replace equipment such as pumps, values and hydrants. Also, with better hydraulic modeling capabilities, numerous weaknesses in the delivery system were discovered and improved with the addition of large-diameter-treated-water transmission pipes, monitoring and control features, and armoring of vulnerable pipes at stream crossings. Many people contributed to this work including Terry Rogers, Annie Noble, Randy Earley, Barbara Kenyon, John Mellblom and Brett Hill.

In 1994, City staff was reorganized to create the Water Resources work group. For the first time, the City had personnel dedicated solely to management of the City's raw water pipelines and reservoirs, raw water diversions and storage, water rights, and interactions with irrigation ditch companies. Carol Ellinghouse moved out of the Utilities Project Management group to become the Water Resources Coordinator and worked with Project Manager June Busse to begin the reconstruction of the raw water system.

Raw water system rehabilitation

Boulder's raw water system was in dire need of repair. Lakewood Pipeline frequently broke, often when it peeked through the road surface and was hit by county snowplows. At some places in the pipeline, there were "temporary" air release valves made from plumbing fittings that could have been picked up at a local hardware store and which discharged water so frequently that deer had learned to drink from the pipe. Silver Lake Pipeline regularly sprang leaks at broken joints and, in some places, was rusted completely through. The patchwork repairs to Goose Lake Dam in the 1980s produced a very strange-looking structure that did not stop the seepage, contributing to crumbling and failing on the upstream shotcrete face.

One spring morning in 1994, Craig Skeie, the City's Source Water Facilities Manager, walked out onto the deck of his house at Lakewood Reservoir with coffee cup in hand, to find that the reservoir had, overnight, turned into a mudflat. The spillway structure had failed dramatically, causing the reservoir to empty into

North Boulder Creek. The City-owned house at Lakewood Reservoir also had problems that needed attention, since it was found to have a cobbled-together electrical system that was a fire danger, along with two-by-four rafters perilously holding up the roof. In 1995, extraordinarily-high streamflows during spring runoff caused the disintegrating diversion structures for both Lakewood and Silver Lake Pipelines to collapse.

The City rebuilt the Lakewood Reservoir spillway in 1994, then rebuilt a large section of the Lakewood Reservoir Dam in 1996. Boulder reconstructed the Silver Lake and Lakewood diversion structures on North Boulder Creek and added measurement devices for instream flow releases. Also rebuilt was the Como Creek diversion. A new screened inlet for the Lakewood Pipeline was installed in Lakewood Reservoir in 1998, and a new valve house at the reservoir, complete with a new pressure-reduction (Mokveld) valve, was completed in 1999. The City's house for the Facilities Manager at Lakewood was rehabilitated and remodeled, as the septic system at the house had failed. In addition, the walls and floors of the caretaker's house at Silver Lake were replaced, along with the septic system for that house and for the bunkhouse.

By the 1990s, Boulder had acquired the majority of shares in the Farmers' Ditch Company. Most of Boulder's shares had been changed in use through Water Court proceedings to allow diversion at the City's upper pipeline intakes on Boulder Creek instead of at the Farmers' Ditch head gate. However, a group of the City's Farmers' Ditch shares that were included in a change decree issued in 1989 were required to be delivered through the Farmers' Ditch to Boulder Reservoir for Boulder's use.

In order to allow this use, the City constructed a larger outlet from the ditch into Boulder Reservoir in 1993. In addition to the City having an on-going interest in the condition of Farmers' Ditch, there still are hundreds of small shareholders in the Company that rely on the ditch to deliver irrigation water for use on property stretching from Mapleton Hill to above Boulder Reservoir. Boulder worked with the Farmers' Ditch Company in 1995 and 1996 to complete the first thorough head-to-tail cleaning of the ditch since the 1960s.

Goose Lake Dam underwent an extensive rehabilitation in 1999. A geo-membrane was attached to the upstream face and covered by an earth-fill and rock-fill slope, significantly altering the appearance of the upstream face. Seepage was reduced considerably.[186]

Reconstruction of Silver Lake Pipeline & Construction of Silver Lake Hydro

The Silver Lake Pipeline was rebuilt in 1997-1998.[187] The City removed the old pipeline, which was built with pipe salvaged from the original Lakewood Pipeline construction in 1906, and replaced it with a welded steel, cement mortar-lined

pipeline. The new pipeline is fully-gravity-pressurized with a 27-inch diameter and has a nominal capacity of 20 million-gallons-per-day. The pipeline extends approximately 3.6 miles from the Silver Lake Diversion on North Boulder Creek (located approximately two miles below Silver Lake) to Lakewood Reservoir. The pipeline carries both water released from Silver Lake and direct flow diversions from North Boulder Creek.

By building a fully-pressurized Silver Lake Pipeline, the City was able to create enough pressure to drive Boulder's sixth hydroelectric plant. Silver Lake Hydro Plant is located at Lakewood Reservoir and was completed in 1999.[188]

Plant	In Service	Treated/Raw	Penstock
Silver Lake	July 1999	Raw	27" – 3.6 miles long

During negotiations on easements for the Silver Lake Pipeline with the neighboring property owner James Guercio, he objected to the industrial look proposed in the initial drawings of the hydro plant building. The discussions led to the final design of a building compatible with the architecture of buildings on the adjacent ranch. Silver Lake Hydro became affectionately referred to as the "hydro in a barn."

The Silver Lake Hydro Plant is located next to Lakewood Reservoir. Pettem photo, 2013

As work neared completion on the Silver Lake hydroelectric facility in 1999, preliminary testing was started on the turbine equipment. But, during this testing, an equipment failure caused a pressure surge to travel through the Silver Lake Pipeline. The resulting water hammer pounded and dented air-release valves on the pipeline. It was quickly shut down, but streams of water poured out of the damaged valves until the pipeline finally drained out hours later. The valves were repaired, and Silver Lake Hydro became fully operational in 2000. However, the gremlins haunting the plant had not left. After going into service, the hydro plant's electrical control equipment sustained damage from a lightning strike. The hydro was again operational by the end of the year.

The City had employed hydro technicians as a part of the water treatment work group since the 1980s. In 2001, management of the hydro plants and hydro technicians was moved to the Water Resources work group, and the City's first Hydroelectric Manager, Jake Gesner, was hired shortly thereafter.

Implementing the Raw Water Master Plan

The 1988 Raw Water Master Plan had shown that the City held enough water rights and water delivery contracts to meet its build-out needs during most years. However, it was expected that there would be drought years when Boulder's water supply would not meet unlimited water demands.[189] As a result of the plan, the City Council decided that, in a semi-arid climate like Boulder's, it was not worth the expense to buy all the water rights necessary to meet all water demands in the face of any and all droughts. Very dry years happen, on average, about every ten years in Boulder's area. The City set goals that would try to assure that Boulder's citizens only faced water use reductions once every 20 years on average and that the reductions were usually minimal.

This was a departure from the way water planning had historically been done in Colorado (and is still done by many cities). Boulder was not planning to run the water supply system full out during dry years until all water was almost gone, and all water use had to be radically restricted (known as the firm yield approach). Instead, the City was actually planning to have controlled reductions in water use during drought years, with the level of reduction imposed on its customers based on objective criteria such as reservoir levels (known as reliability criteria). The City of Pueblo had tried this approach on a limited basis, but it was not a method that was very widely known or tried. Boulder's novel approach to drought planning would not be tried by other cities until its worth was proven much later during the severe drought of 2002.

In 1989, the City Council adopted water supply reliability criteria that struck a balance between the costs and environmental impacts of water development and the consequences of temporary water supply reductions during the inevitable drought years.[190] These reliability criteria are expressed in terms of the number of years that different levels of water shortages should occur. The criteria support the City's goal to assure sufficient water to meet all municipal demands in 19 out

of 20 years on average over time (a 5 per cent chance of water use reductions each year).

Damage severe enough to cause loss of landscape should not occur more often than once every 100 years (a 1 per cent chance each year).The City works to assure provision of all water necessary to meet essential health and safety needs, such as water for drinking and fire-fighting, at a level where it is not to be interrupted any more than once in a one-thousand year period (a 0.1 per cent chance each year). Therefore, such a drastic shortage of municipal water should not happen in the lifetimes of Boulder's residents.

Another of the recommendations in the 1988 Raw Water Master Plan was that the City should reconfigure its water rights portfolio. The plan recommended that Windy Gap water be sold. The City was advised that the sale proceeds be used for replacement water supplies and assets in the Boulder Creek basin that would be capable of other uses in addition to municipal, leading to enhanced yield of existing water facilities. The City pursued this goal through its 1991 sale to the City of Broomfield of 43 of its original 80 units in the Windy Gap Project.[191]

Broomfield's main reservoir, Great Western, had become contaminated with plutonium from Rocky Flats. The controversy this caused contributed to the decision to end manufacture of triggers for nuclear warheads at Rocky Flats. Regular protests by peace activists had been held outside the closed gates of the plant since the 1970s, but it wasn't until the Berlin Wall fell in 1989, marking the end of the Cold War, that the possibility of shutting down Rocky Flats became likely. The final nail in the Rocky Flats coffin was set upon discovery of wide-spread contamination with radioactive materials and industrial chemicals outside the fenced boundaries of the extensive acreage surrounding the plant.

The U.S. Department of Energy (DOE) agreed to buy a replacement water supply for Broomfield. A deal was reached in 1991 that required DOE to provide not only money for Broomfield to purchase of the Windy Gap units, but to also pay Boulder enough money to cover the operation and maintenance expenses for the 43 units on Broomfield's behalf for the next 25 years. Out of the total $21.5 million received from the Windy Gap sale, $3.7 million was set aside to cover Broomfield's operation and maintenance expenses. Approximately $1.4 million was spent prior to 1999 on purchase of irrigation company shares and other replacement water supplies. In addition, approximately $12.4 million was used to purchase the Boulder Canyon Hydro Project, including Barker Reservoir, from Public Service Company of Colorado.

Part of the sale proceeds also were applied toward the purchase of Caribou Ranch, adjacent to the City's Lakewood Reservoir property. Through agreements made in 1996 and in 2001, the City and Boulder County jointly purchased the 2,181 acres and associated water rights from owner James Guercio.[192] One of the City's purposes for the purchase of the land and its conservation easements

was to gain ownership of a 120-foot wide corridor along the Silver Lake Pipeline. In addition, the City wanted to protect the quantity and quality of the portion of Boulder's water supply coming from Caribou Ranch into Lakewood Reservoir. Provisions mandating the City's right to be involved in any Boulder County management activities that might affect water quality were included in the agreement that also included a land trade made to clear up property boundaries adjacent to Lakewood Reservoir. Boulder County obtained title to the remainder of the purchased acreage with the City holding a conservation easement over that acreage.

Treated Water Master Plan Updates

In 1990, Boulder hired Brown & Caldwell Consulting Engineers to complete the first phase of a new Treated Water Master Plan to assess the City's treated water system infrastructure. One of the recommendations of the Plan was to expand the water conservation program to take aim at reducing peak water demands. The study also recommended the establishment of reliability criteria for the City's treated water delivery system that paralleled the reliability criteria recently adopted by the City Council for the City's source water supplies. New treated water system reliability criteria were approved by the City Council in November 1990. A second phase of the Plan evaluated the hydraulic condition of the City's water distribution system and future needs through the year 2010.[193]

Principal Engineer Bob Harberg worked with the Boulder Energy Conservation Center to establish a new water conservation program. The purpose of the program was to reduce the City's peak water demand during the summer months so that the need to expand treatment capacity at Boulder Reservoir Water Treatment Plant could be delayed by many years.[194]

In 1999, the City started a Water Conservation Futures Study to determine the direction of the water conservation program. The Study suggested several different levels of conservation efforts and predicted the future water demands under each scenario in order to determine when an expansion might be needed at the Boulder Reservoir Water Treatment Plant. As the Study progressed, it became clear that it would be necessary to complete a hydraulic study of the distribution system along with the treatment capacity study.[195]

As a result of this need, in 2000, the City hired Integra Engineering to update the Treated Water Master Plan. The update provided an assessment of the treated water system, as well as improvements required for continued reliable water delivery of adequate quantity and water quality through 2020.[196] In 2000, the City Council adopted the Comprehensive Conservation Scenario as identified in the Treated Water Master Plan and Water Conservation Futures Study.[197] Following completion of the new master plan, the City began the development of a geographic information system (electronic mapping or GIS) and of new hydraulic computer models of the treated water transmission and distribution systems.

Water Treatment Plant improvements

In 1991, the U.S. Environmental Protection Agency (EPA) issued the Lead and Copper Rule requiring all large water systems to provide corrosion control to prevent excess amounts of lead and copper from entering drinking water due to pipe corrosion. To meet these requirements, the City added chemical stabilization processes at both water treatment plants. The goal of the processes was to maintain the pH and alkalinity of the water within specific limits so that metal ions will not be picked up by the water as it passes through pipes. Since the raw water quality is different at each plant, different chemicals are used to attain water stability. The raw water treated at Betasso Water Treatment Plant is low in alkalinity. To raise the alkalinity to the target range, it was decided to add lime and carbon dioxide. At the Boulder Reservoir Water Treatment Plant, chemical adjustment for alkalinity was not needed. Sodium hydroxide was selected as the best chemical to use for pH adjustment. In 1993, Black & Veatch was selected to design improvements at the Betasso and Boulder Reservoir Water Treatment Plants. The City's project manager, Annie Noble, oversaw the construction.

Improvements to administrative facilities at Betasso Water Treatment Plant in 1993 included an addition of 5,000 square feet of new offices at the west end of the plant and a maintenance addition of 1,500 square feet at the east end. Existing space was remodeled to include a new kitchen, lunchroom, operations and control room, laboratory, pilot-testing facility, and maintenance shop .

Chemical feed and corrosion control updates were made to Betasso Water Treatment Plant as well. In 1994, the City completed a new building to house both a chlorine scrubber and feed facilities, as well as providing storage for chlorine, alum, carbon, and fluoride. The improvements allowed the use of lime and carbon dioxide for corrosion control. In addition a new generator was installed for emergency power.[198]

Corrosion control treatment was also installed at the Boulder Reservoir Water Treatment Plant in 1998. Construction of improvements included updating the chemical feed and storage equipment and adding two filters and a high service pump. These improvements did not increase the capacity of the Boulder Reservoir plant but provided increased redundancy and operational flexibility. The project also enlarged the existing laboratory and remodeled the existing chemical building into an administrative building to house Water Treatment Operations and Maintenance, as well as the Water Conservation and the Drinking Water Program.[199]

Although Betasso Water Treatment Plant was designed for a capacity of 50 million gallons per day, operational experience soon showed that the actual capacity is between 35 and 40 million gallons per day. Piping and most treatment processes can handle 50 million gallons per day, but the flocculation and filtration processes must be run at a lower flow rate in order to meet the newest drinking water standards for turbidity

Treated Water System Improvements

In 1992, the City undertook a unique project in cooperation with Pine Brook Hills Water District. The Pine Brook Hills subdivision, in the foothills northwest of Boulder, needed additional treated water storage, as did Boulder. The two entities designed a water tank inside a tank to meet both their needs with one facility. The construction of the Booten (North Terminal) Storage Tank was completed under the direction of Terry Rogers as the project manager. The facility was officially named Booton Reservoir in honor of the cooperative effort the City received from the property owner, John Booten.[200] It was put into successful operation the same year, with the filling of the Pine Brook tank (inside tank) and the outer tank for Boulder.

Another City facility in dire need of attention is the Boulder Canyon Pipeline. A portion of the pipeline still consists of 16-inch-diameter sand-cast pipe laid in 1894 when the City's water system intake was first moved upstream to the Blanchard intake near Orodell.[201] Improvements made to the pipeline in the early 2000s included removing the Fourmile Pressure-reducing-valve (PRV) station and repairing a section of the 16-inch pipeline. Several leaks were identified on the newer 24-inch segment of Boulder Canyon Pipeline, laid in 1952 between the Orodell Hydro/PRV station and the old Fourmile PRV station, and some pipe segments were replaced.

Lawsuits over the Anderson Ditch

In the mid-1990s, tensions between the Base Line Land and Reservoir Company and the Anderson Ditch Company that had simmered for decades spilled over into full-fledged lawsuits. Newspaper writers leapt on the story, but frequently had difficulty with factual reporting due to the complexity of the issues. Both companies were private ditch companies with numerous shareholders, but the majority of shares in the Base Line Company were owned by the City of Lafayette, and the majority of shares in the Anderson Ditch Company were owned by the City of Boulder (with the University of Colorado as the second-largest shareholder). Even though the disagreements involved numerous shareholders and were about Anderson Ditch capacity and not water rights, it quickly became mistakenly portrayed as a water-rights war between the cities of Lafayette and Boulder.

The ditch companies' arguments had started long before, when the majority of shares in both companies were owned by agricultural water users. The two companies had entered into an agreement in 1911 allowing the Base Line Company to use Anderson Ditch to carry water to Baseline Reservoir in the non-irrigation season. Ever since, there had been numerous fights and re-negotiations of the 1911 Agreement. Most of the disagreements were about who held the responsibility to pay for maintaining Anderson Ditch at a capacity that was in excess of Anderson's needs, but needed by Base Line. Base Line Company had on several occasions run more water than Anderson Ditch Company had set as the safe limit and flooded Columbia Cemetery and the basements of properties throughout University Hill.

The dispute escalated when the City of Lafayette set its sights on using the Anderson Ditch to carry water for its municipal water system rather than bearing the expense of building a new pipeline from Boulder Creek. Lafayette joined in Base Line Company's efforts to force Anderson Ditch Company to pay for almost doubling the capacity of the ditch. Lafayette sought to void Boulder's agreement with the Anderson Ditch Company that allowed Boulder's use of all unused ditch capacity to carry storm-water runoff from University Hill and adjoining areas.

Lafayette and the Base Line Company sued the Anderson Ditch Company and the City of Boulder in two separate lawsuits filed in 1996 and 1997. In 1999, a court ruling was issued in one lawsuit denying Lafayette the use of Anderson Ditch to carry municipal water. Boulder's right to use Anderson Ditch to carry storm-water was upheld. The court also found that Anderson did not need to pay to maintain the Anderson Ditch at a capacity greater than Anderson's needs and had the right to limit the amount of water carried by Base Line Company to prevent flooding.

After the court ruling, and before the next trial, a settlement agreement was reached between the cities and the ditch companies. Lafayette and Boulder entered into an Intergovernmental Agreement in 2001 to implement it. Lafayette paid for and constructed a new pipeline to carry its municipal water from a diversion point on Boulder Creek east of 75th Street to Goose Haven Ponds. Boulder paid for and extended its wastewater effluent pipeline to a new discharge point several hundred feet east of 75th Street and downstream of Lafayette's new intake. In return, Lafayette gave up all efforts to use Anderson Ditch capacity to carry Lafayette's water, now and in the future. Boulder and Lafayette completed construction of the new pipeline facilities in 2003.

TWENTY-FIRST-CENTURY PROGRESS

As the new century dawned, the City was continuing to grapple with the problems caused by water supply facilities that had deteriorated since they had first been placed in service during the twentieth century. Boulder was also looking at infrastructure acquisitions and improvements to support its future water supply needs. The City had a good idea of what the boundaries of its water service area would be when it was fully built-out, which was expected to be in the mid-twenty-first century. However, the projections of population size and how many employees would work in the service area kept changing as land use plans were continually revised.

One more unknown thrown into the mix was the potential for climate change to affect the amount of water flowing from the City's water supply basins high in the mountains. The City started planning infrastructure improvements and acquisitions with an eye toward incorporating as much flexibility into its operations as possible. The City took advantage of new technology as it became available.

A computerized asset management system for inventorying and tracking the ages and conditions of water system components was developed. This led to better planning of repair and replacement needs, as well as improved project scheduling and forecasting of capital improvement budgets adequate for sustaining the water system in the future.

In addition, Boulder expanded its use of computer-based tools such as databases, spreadsheets and geographic information systems. These tools helped to prioritize efforts under the on-going waterline and facility replacement program by tracking waterline breaks to identify areas most needing attention. Water meter reading became more efficient when new remote read-out meters were installed throughout Boulder that could be read when the City's meter-reading staff drove by in their trucks.

The City also planned major work programs for each of the three source water systems delivering water into the City to assure both the capacity and flexibility that would be demanded by the mid-twenty-first century. These efforts would lead to the acquisition of the Barker Reservoir system, the reconstruction of Lakewood Pipeline, and the expansion of capacity for delivering water from the Boulder Reservoir Water Treatment Plant into the City. Along the way, Boulder would acquire two more hydro plants, upgrade water system security in the wake of the 9/11/01 terrorist attacks and deal with the worst drought year in recorded history.

Boulder Canyon Hydro––City's Seventh Hydroelectric Plant

Although the Boulder Canyon Hydro Plant had been in operation since 1910, it only came under the City of Boulder's control in 2001.

Plant	In Service	Treated/Raw	Penstock
Boulder	April 2001	Raw	48" – 2 miles long

The exterior of the Boulder Canyon Hydro Plant has changed very little since 1910. Pettem photo, 2013

Throughout the late 1980s and 1990s, the City had expressed an interest in acquiring the entire Barker system (including the Gravity Line, penstock, dams, and reservoirs—with or without the hydro plant), but the Public Service Company of Colorado refused to sell. However, in the late 1990s, the company merged into a larger utility that eventually became Xcel Energy. The new company agreed to dispose of assets that, for them, were underperforming.

Maintenance of the Boulder Canyon Hydro facilities had not been a high priority for Public Service, and the Gravity Line had deteriorated to the point that it was unreliable for municipal water supply purposes. In early 2000, one of the generators burned out and became inoperable, leaving only one turbine-generator unit functioning in the plant.

Meanwhile, the City wanted to gain more control over the maintenance of the facilities and to end water surges, from the hydro plant, into Boulder Creek. Boulder also wanted to increase the amount of reservoir storage space available for the municipal water supply. (Previously, up to one-third of the water stored in Barker Reservoir was used solely to generate hydropower at the Boulder Canyon Hydro.)

In 2001, for $12.4 million, the City purchased the entire Boulder Canyon Hydro Project—including Barker Reservoir—with a portion of the revenue generated from the sale of 43 Windy Gap units to the City of Broomfield. The City acquired the Barker facilities, associated water rights, easements, and rights-of-way, as well as land surrounding Barker Reservoir, Kossler Reservoir, the Boulder Canyon Penstock, and the Boulder Canyon Hydro plant site.

The Barker Gravity Pipeline is on easements, either deeded or prescriptive, and is on land managed by the U.S. Forest Service. Today, the City uses the hydroelectric water rights it acquired for hydropower generation and has obtained additional water rights for storage of municipal water in Barker Reservoir.

One of the two original generators was photographed in 1924. The generators, installed in 1910, were replaced in 1936 (see following page). Carnegie Branch Library for Local History, Boulder Historical Society collection (141-2-9)

Above, two 400 rpm GE 10 Mw synchronous generators were installed in 1936 to replace the original units (see preceding page). This generator ("Unit A") is no longer functional, but it remains in the Boulder Canyon Hydro Plant for historic preservation. (The other unit was replaced in 2012.) Below, the overhead crane dates from 1910. Pettem photos, 2013

Repair of the Barker Gravity Line

Following the purchase of the Boulder Canyon Hydro Project, the City quickly embarked on a program to repair the Barker Gravity Line. At the time of the purchase, about 10 per cent of the water entering the inlet to the pipeline leaked before reaching Kossler Reservoir. A survey of the pipeline was done in 2001 to identify access roads and assess the pipeline's condition. This led to an on-going maintenance program for replacement and repair of pipeline sections beginning in 2003.

The pipeline runs through dense forest and rugged mountain terrain. Access for maintenance and repair is difficult and requires All Terrain Vehicles. Most of the work involved stabilizing the pipe bench that keeps the pipeline perched on the side of mountainous slopes as it winds its way along the ridgeline high above Boulder Creek. Maintenance also involved replacing some of the steel pipe sections in the seven siphons across valleys. Access to the project required a combination of existing historical access roads constructed in 1910, as well as helicopters for transporting steel pipe. Another assessment, done in 2008, found that the most serious defects had been addressed. However, the concrete in the pipeline was more than 100 years old and showed its age.[202]

Left, this 1910-era photograph shows the Barker Gravity Line under construction.

Above, in 2012, steel pipe was used in the repair of one section of the pipeline. Both photos, courtesy City of Boulder

A helicopter transported steel pipe during the repair of the Barker Gravity Line. Photo courtesy City of Boulder

In February 2006, cascades of water poured down the mountainside above Boulder Creek. Overnight, an ice blockage had formed in Siphon 4 of the Barker Gravity Line when the flow of water was stopped for a maintenance shutdown which caused significant erosion damage below the pipeline. Cleanup and restoration took place in 2006 and 2007. The section of pipe just upstream of Siphon 4 was replaced, along with the replacement of a timber-plank, mechanically stabilized earth (MSE)-fill retaining wall below the pipeline bench.[203]

The City is considering various liners and types of pipe for repair or replacement of the aged concrete pipe. In order to do so, Boulder must first obtain a Special Use Permit from the U.S. Forest Service. This became necessary when the City filed to convert its existing Federal Energy Regulatory Commission (FERC) license for Boulder Canyon Hydro Project into a licensing exemption, which would limit FERC jurisdiction to just the hydro plant. (Exemptions are already held for all of Boulder's other hydro projects.)

Although FERC will soon no longer have jurisdiction over the Gravity Line, coordinating approval processes for two federal agencies is complicated. The City had applied for a Special Use Permit for the Gravity Line from the Forest Service in 2008 and expected that it would be issued before FERC was scheduled to issue its order granting the City an exemption from licensing for the Boulder Canyon Hydro. Instead, the Forest Service had not completed its work, and the FERC Order was issued contingent on the Forest Service issuing a Special Use Permit.

The delay is frustrating for the City, but it is nothing compared to the delays experienced with the approval process for the Lakewood Pipeline reconstruction, which took from 1986 until 2001 to complete.

Lakewood Pipeline reconstruction

Burial of the Lakewood Pipeline had been a major accomplishment for the City of Boulder in 1906, when crews first excavated a nearly 10-mile trench through mountainous terrain from Lakewood Reservoir to the intake near the mouth of Boulder Canyon. As noted earlier, routine maintenance had required the replacement of the pipeline, a section at a time, from 1939 to 1955. By the 1980s, however, the age and design of the pipeline were making water delivery unreliable and interfering with treatment at Betasso Water Treatment Plant.

The deterioration of the pipeline also presented several additional problems:

- The thin steel replacement pipe could not be fully pressurized without breaking. At numerous transition zones from high places to low spots, water and air churned inside the pipeline, causing tiny bubbles to be trapped in the water or "entrained." The entrained air began fizzing when the water was released from the pipeline at Betasso Water Treatment Plant.

- The air bubbles prevented particles from settling out during the sedimentation process and created channels for water to pass freely through the filters. The resulting high turbidity levels raised the potential for disease organisms and other contaminants to pass through into the drinking water. Since disinfection is not as effective in water with high turbidity, the City was not able to meet newly issued drinking water standards without fixing the entrained air problem. The entrained air also caused additional expense for frequent replacements of filter material that stuck to air bubbles during filter back-washing. Pressurizing the pipeline would eliminate the entrained air.

- Freezing had cracked the pipeline's interior lining. Since water in the pipeline traveled at a flow rate more than twice the recommended maximum rate, it had stripped the damaged lining from the pipe wall. Lining fragments reduced pipeline capacity when they piled up in low points. Without the lining, the interior surface of the pipe had corroded and became rougher, which further contributed to the capacity reduction. Pipeline capacity had dropped to less than 75 per cent of its original capacity.

- Parts of the pipeline ran under Cold Springs Road and other back roads. Since the pipe was at a shallow depth, snowplows and road graders often caused the pipeline to rupture.

The Lakewood Pipeline carries as much as 40 per cent of Boulder’s total water supply each year. However, at times, including much of fall and winter, all of Boulder’s water flows through this pipeline. During times of peak water use in the summer, all three of Boulder's water sources, including Lakewood Pipeline, need to be operating to meet demand.[204] Another replacement of the pipeline was crucial in order to meet the City’s water supply needs.

Work on the pipeline’s recent reconstruction was exceptionally delayed due to approval processes by the U.S. Forest Service and other agencies. Discussions with the Forest Service began in 1986 when the City requested a Special Use Permit for reconstruction of Lakewood Pipeline in its original location. Issue piled upon issue until what had seemed like it would be a simple process became an ordeal involving numerous studies, lawyers, a public vote, assistance from a congressman and a senator, and a literal Act of Congress. The City finally was issued a perpetual easement by the Forest Service in 2001, but the process had been long and complicated.

The City has a perpetual right-of-way across federal land for the Lakewood Pipeline under the Federal Right-of-Way Act of 1866 and the Congressional Acts of 1907, 1919, and 1927 that granted the City most of Silver Lake Watershed. Although the City believed it was not required to get a Forest Service permit for Lakewood Pipeline because of the 1866 Act right-of-way, there had been no previous problem with getting Special Use Permits. When the City filed an application for a permit to replace the lower four miles of Lakewood Pipeline in 1986, the Forest Service issued a decision approving the work. However, the decision was withdrawn in 1989.[205]

In December 1991, the Forest Service informed the City that it would have to relinquish its permanent 1866 Act right-of-way for Lakewood Pipeline in order to obtain a Special Use Permit good for 20 years. The Forest Service also intended to condition the permit with "bypass flows" that would confiscate about one-third of the City's water from the Silver Lake Watershed. In the face of these unacceptable conditions, the City withdrew from the Forest Service permitting process in 1993, intending to proceed on the basis of its 1866 Act right-of-way alone. In 1994, the City went ahead with the construction of the lower 1.1 mile of the Lakewood Pipeline, which did not cross Federal land.

Both the City and Forest Service wanted to avoid litigation over the 1866 Act right-of-way and sought the help of Congressman David Skaggs. In 1994, Congressman Skaggs personally conducted a mediation with small groups of staff from the Forest Service and the City. The parties agreed to specific language for an easement for the pipeline that was neutral concerning the right-of-way. The Forest Service agreed that the City's instream flow program with the Colorado Water Conservation Board was adequate and no bypass flows were required. The City re-entered the Forest Service process. Work resumed on the permit, but the Forest Service continually added new studies. The years dragged on with no end to the permitting process in sight.

Next, the U.S. Fish and Wildlife Service jumped into the mix. In 1997, the Fish and Wildlife Service issued a Biological Opinion under the Endangered Species Act that found Boulder's water diversions at the Continental Divide jeopardized species along the Platte River in Nebraska. Senator Hank Brown met with the Fish and Wildlife Service staff. Congressman Skaggs assisted with mediation again in 1998. A new Biological Opinion was issued in May 1998. The City made

a one-time payment of $100,000 to the Fish and Wildlife Foundation for the benefit of Nebraska species as the Reasonable and Prudent Alternative under the Endangered Species Act for the Lakewood Pipeline reconstruction.

In May 1998, the US Congress passed specific language in an appropriations bill stating that Boulder's acceptance of a new easement agreement with the Forest Service or reconstruction of the Lakewood Pipeline in a new location did not negate the City's 1866 Act right-of-way.

The Forest Service issued a decision on the Lakewood Pipeline easement in April 1999. The Forest Service approved a route that minimized effects on the environment and area residents by shifting a portion of Lakewood Pipeline to North Peewink Mountain, but avoiding most of Sugarloaf Road by staying near the historic pipeline route.

Finally it was time for Boulder County to weigh in. During the delay in obtaining Forest Service approval, Boulder County had greatly expanded its construction project approval process. The City submitted an application to the County for a permit for Lakewood Pipeline in 1999. Several public hearings were held in front of County boards and the County Commissioners in late 1999 and early 2000.

Many of the residents along the existing pipeline route testified that the alignment should be moved away from their property, so that the majority of the route lay in Sugarloaf Road. City staff, led by Ned Williams and Bob Harberg, valiantly made a case for the benefits of using the existing alignment, which stayed out of Sugarloaf Road and had served well since 1906. The City pointed out the difficulties of construction in a narrow heavily trafficked mountain road. Unfortunately, the residents who lived along Sugarloaf Road and those who drove the road did not appear at the hearings to provide the Commissioners with their point of view.

The Boulder County Commissioners issued a decision on Lakewood Pipeline in early 2000. But the Commissioners selected a pipeline alignment different than the one approved by the Forest Service. Over the City's objections, the Commissioners chose to move much of the Lakewood Pipeline out of its historic alignment and into Sugarloaf Road. Discussions were reopened to modify the previous Forest Service decision to conform with the Commissioners’ action. The Forest Service performed new studies and issued a revised decision approving the Lakewood Pipeline reconstruction in 2001.

The Commissioners also required the City to install three fire hydrants on the Lakewood Pipeline for use by fire districts near the pipeline route, above Boulder’s Blue Line. Voters approved the hydrants at a November 2000 election. The upper mile of Lakewood Pipeline in Cold Springs Road along the original alignment was completed with little fanfare in 2000.

After the City was required to relocate the Lakewood Pipeline into Sugarloaf Road, its reconstruction disrupted the lives of Sugarloaf Mountain residents. The road was (and still is) their only direct access to Boulder. Photo courtesy City of Boulder

Although there had been little comment from Sugarloaf residents during the County Commissioner hearings, that soon changed when they learned that one lane of their mountain road would have to be closed from 9 a.m. to 4 p.m., and both lanes would need to be closed, for safety reasons, for up to 20 minutes during rock blasting activities.

Beginning in the summer of 2002, the reconstruction project disrupted the lives of 600 Sugarloaf residents. Since Sugarloaf Road is their only route down the mountain to Boulder, daytime drivers, for months, had to drive west to the Peak to Peak Highway, then detour through Nederland. Clint Talbott's December 19, 2002 *Daily Camera* column, "Take this pipe and shove it," reflected the frustrations of many of the residents. The City modified the County-approved Traffic Control Plan several times to try to improve conditions for residents (and held the contractor to strict compliance with the 20-minute limit on complete closures), but it was no comfort to the residents that the Commissioners' decision had made the City, staff, consultants, contractors and Council miserable, as well.

Making matters worse, the contractor had used pipe manufactured with sub-standard welds and cracked interior lining for installation of four-and-one-half miles of the newly buried pipe in Sugarloaf Road. The City was reluctant to accept the faulty pipe, but residents' anger had reached the boiling point when faced with the possibility that part of the pipeline might have to be dug up and replaced once again.[206]

By March 2004, however, the pipeline had withstood several high-pressure tests—good news for the City and residents alike.[207] The City filed a lawsuit

against the contractor and the pipe manufacturer for enough money to install additional pipe breakage alarms, do more frequent pipe inspections, reline the pipeline more often and possibly replace the pipeline decades earlier than its expected 100-year life. In 2006, the second attempt at mediation resulted in a settlement agreement, which the Council approved four days later. The agreement provided the City with approximately $15 million from the contractor and pipe manufacturer to set aside for the future needs of Lakewood Pipeline.

Ned Williams, Bob Harberg, Sue Ellen Harrison, June Busse, and Carol Ellinghouse, along with many other City staff members, had devoted years of their careers to seeing Lakewood Pipeline rebuilt. They now believed that the saga of the Lakewood Pipeline easement was ended with the completion of the reconstruction in 2004. But, it was not. In 2004, the Forest Service informed the City it wanted to reopen the 2001 easement agreement because of the substandard pipe. The new Forest Service proposed easement agreement contained insurance and liability provisions like the ones that the City had rejected in 2001, as well as new vague easement suspension language.

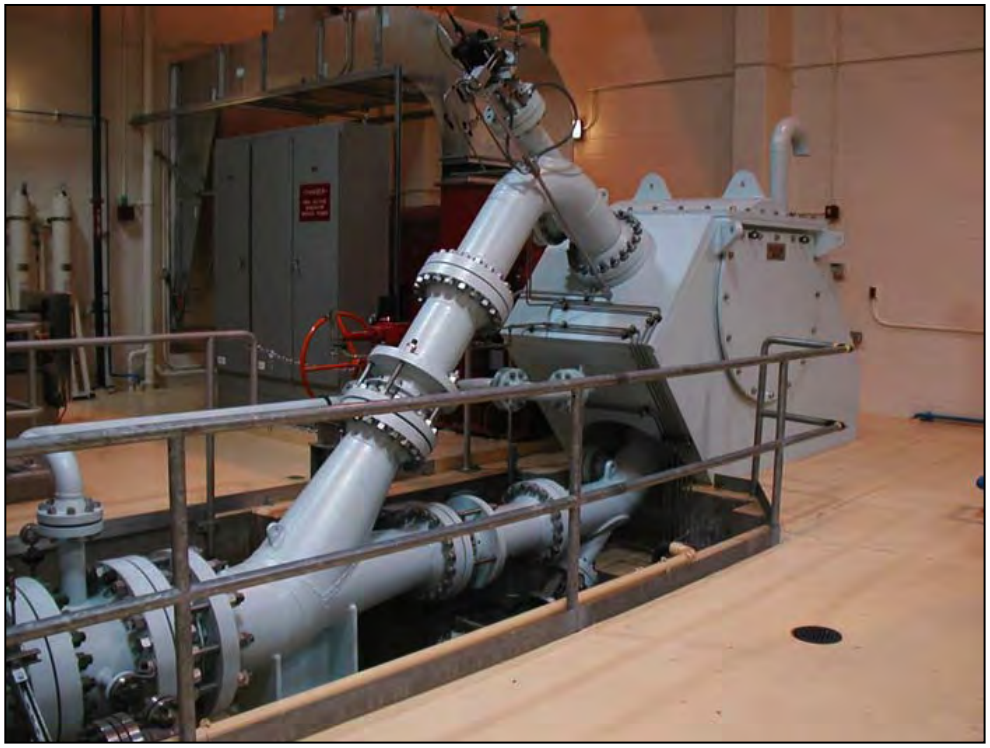
After much new negotiation, City and Forest Service staff came to agreement on language to present to City Council in 2009. However, the Council had apparently decided it had reached a limit with the Forest Service demands and declined to approve the new terms of the easement, establishing the City view that the 2001 easement agreement is binding.

Lakewood Hydro Plant

Prior to the reconstruction of the Lakewood Pipeline, energy from the falling water was dissipated by its high velocity, as well as by a pressure-reducing valve at the Betasso Water Treatment Plant. The Pipeline's reconstruction as a fully-pressurized pipe made it possible to use the pressure to drive a turbine and generator at a new hydroelectric plant—the Lakewood Hydro.

Construction of the Lakewood Hydro Plant was started in 2003. Once the Lakewood Pipeline reconstruction had been completed, in 2004, this newest of the hydro plants was put into service. It's located in the same building as the Betasso Hydro Plant, on the grounds of the Betasso Water Treatment Plant.

Plant	In Service	Treated/Raw	Penstock
Lakewood	2004	Raw	24" – 9.8 miles long (from an elevation of 8,180 feet at Lakewood Reservoir to 6,340 feet at the Betasso Water Treatment Plant)



The Lakewood hydroelectric turbine and generator followed on the heels of the Lakewood Pipeline reconstruction. Photo courtesy City of Boulder

Boulder, through its Water Utilities Fund, now owns and operates a total of eight hydroelectric plants. Generation of hydroelectricity is secondary to operation of the water system to meet the City's municipal water demands. The revenues from these plants are used to offset a portion of the water utility operating costs, resulting in lower water rates for customers.

Water System Security Improvements

Much of American life changed on September 11, 2001 when terrorists flew airplanes into the Twin Towers in New York, the Pentagon, and a Pennsylvania field. Even though the tragedies seemed far away from Boulder, the events of that day changed operating procedures at the Water Utility and other City departments. The U.S. Department of Homeland Security was formed and, along with many other State and Federal agencies, it gave directions to cities for security upgrades for critical public infrastructure.

In 2003, a consultant was hired to help City staff complete a federally mandated Vulnerability Assessment for the water supply system. During several closed-door conference sessions, City staff surprised themselves with the number of creative ways they could identify to harm the system, given their background and

knowledge. The experience was invaluable for identifying where to direct resources available for water security improvements. City staff formed a Group for Utilities Security (GUS) headed up by Brad Segal and Joe Taddeucci, with support from Bob Harberg, to guide improvements. In 2005, various projects were prioritized for implementation at the City's major water assets. In the following years, the City upgraded video surveillance equipment, fencing, locks, and fiber-optic communication links among many other unmentioned improvements. They also stepped-up security procedures at the water treatment plants and other key facilities and updated emergency response plans.[208]

Water Treatment Improvements

In 1993, an incident far from Boulder would affect the way that water utilities throughout the country would treat drinking water in the future. Over the span of two weeks in late March and early April of 1993, 403,000 of the 1.6 million residents of Milwaukee, Wisconsin, became ill with stomach cramps, fever, diarrhea and dehydration. At least 104 deaths occurred mostly among the elderly, as well as among people with compromised immune systems, such as AIDS patients.209 This largest-waterborne-disease outbreak in U.S. history was traced to a tiny (5 micron) protozoan known as Cryptosporidium that passed through the filtration and chlorination systems of one of the City's water-treatment plants. Initially thought to have come from upstream cattle pastures or runoff, the Cryptosporidium was eventually traced to a sewage treatment plant outlet 2 miles upstream in Lake Michigan.[210]

The Milwaukee incident led to increased knowledge about water-borne pathogens that are highly resistant to disinfection, such as Giardia and Cryptosporidium. At the same time, knowledge was increasing about the byproducts that could occur when disinfectants reacted with natural materials in water. In 1996, the U.S. Congress passed Amendments to the Safe Drinking Water Act that led to requirements for more protection against pathogens, especially Cryptosporidium, while minimizing the risk of disinfection-byproducts. In addition to improvements in filtration and chlorination processes, the requirements established a new way of looking at water treatment— known as the Multiple Barrier Approach—as reaching from the source water, through the treatment plant, to the distribution system.[211] Boulder would need to make improvements to its water treatment processes to meet the new regulations, but the City already was familiar with source water protection because Boulder's forward-thinking leaders had, 90 years earlier, purchased and closed the Silver Lake Watershed.

In 2001, the City completed work on improvements to the settling basins and coagulant mixing at Betasso Water Treatment Plant. The project also included improvements to the residuals' drying beds and backwash system Annie Noble coordinated this work.[212]

Changes also were made at the Boulder Reservoir Plant. Prior to 2005, its treatment processes were similar to those in the Betasso plant. In 2005, however, the flocculation/sedimentation process at the Boulder Reservoir plant was changed to use a dissolved air flotation (DAF) system.

At the Boulder Reservoir Water Treatment Plant, residuals are scraped off of the water's surface. Pettem photo, 2013.

Unlike at the Betasso plant, where clear water spills off the top of settling basins and the residuals settle to the bottom, at the Boulder Reservoir plant, clear water is drawn from the bottom of three basins (two added in 2005 and the third in 2010). The residuals are floated to the top of the basins using injected air, then scraped into a solids collection system for disposal. The clear water then moves on to filters.

Disinfection at the Boulder Reservoir Water Treatment Plant was accomplished using chlorine gas until 2004, when (to be safer) an on-site-mixed-oxidant-generation system replaced the chlorine gas. In 2010, a liquid sodium hypochlorite disinfection system was installed to replace the mixed-oxidant system because of performance issues. Also in 2010, a carbonic acid feed system was installed to stabilize pH for alkalinity control and to promote good coagulation.

Both of the City's water treatment facilities have disinfectant feed points before (pre-chlorination) and after (post-chlorination) filtration. Prior to summer 2006, the pre-filtration chlorine was added to the raw water before flocculation and sedimentation. This practice resulted in high disinfection-byproducts levels. The City modified its disinfection practices to eliminate routine pre-chlorination in 2006 and now applies free chlorine to the settled water.

Dealing with Drought

In April 2002, Craig Skeie watched the snowpack levels drop in the Silver Lake Watershed. Usually these levels increase during April from spring upslope storms. But, in 2002, strong winds blew across the snowpack throughout April without any snowstorms at all. By the end of the month, there was no snow to be found at the lower elevations of the Silver Lake Watershed—a first since records had been started in 1938. In fact, when compared to the records, the April 1, 2002 snowpack levels had been one-third of average. Meanwhile, Carol Ellinghouse was down in Boulder, worriedly watching Boulder Creek. Normally, streamflows start picking up in April as the snowpacks begin to melt. But that year, the creek remained a trickle even as the snowpack dwindled and the winds carried the moisture away. Finally, on May 1, 2002, snowcourse readings confirmed what both Skeie and Ellinghouse already knew—the situation was bad.

The upper elevations in the Silver Lake Watershed had less than 25 per cent of the average levels of snowpack and had one-third of the amount seen in the previously worst-case-drought year on record of 1954. Later, a streamflow record recreated from tree-ring studies would show that 2002 was the driest year the area had seen since 1706. The only bright spot was that the City had been able to acquire an additional 3,686 acre-feet of reservoir storage space with the purchase of Barker Reservoir just a year previously (in addition to the 8,000 acre-feet of space Boulder had already been using in Barker), and streamflow conditions had allowed Boulder to fill that space full of water in 2001.

The reliability criteria that the City Council had approved in 1990 would finally come into play. Since it had been planned that water use reductions would occur in drought years, Boulder avoided much of the debate about *if* restrictions should be imposed and focused on *how much* water use should be restricted. The City requested voluntary water use restrictions from its customers in early May of 2002 and imposed mandatory restrictions for all City water users in early June. Landscape watering was restricted to twice a week for no more than 15 minutes in any sprinkler zone or area. Irrigation was further limited to the hours of 6 p.m. through 9 a.m. Restrictions were also put in place for other water uses such as car washing, swimming pools, and fountains.

A lot of residents were unhappy with Boulder’s mandatory water use restrictions, but almost all complied. During the irrigation season from May to October, outdoor use dropped by 50 per cent and indoor use by approximately 10 per cent. This indoor use reduction continued throughout the winter of 2002-2003 and remained at that level in subsequent years. The restrictions reduced overall demand by approximately 20 per cent from May 1, 2002, through April 30, 2003.

At first other Colorado Front Range cities were surprised by Boulder's announcement of water use restrictions in May, but by July and August every

area city had done the same. Many, like Denver, openly admitted they had waited too long. City staff would then field lots of questions from other cities about water planning using reliability criteria.

Fortunately, the drought turned out to be a one-year event, instead of a multi-year drought, such as had occurred from 1954 to 1957, or in the mid-1960s. As often happens in Colorado, one snowstorm can completely change the water-supply picture. On March 17, 2003, the snowpack in the Silver Lake Watershed was at 82 per cent of average. On March 20, after a massive spring blizzard had shut down the Eastern Slope from the Continental Divide to the eastern state line, the snowpack in the Watershed was above the average level for that date. Approximately 20 per cent of the total annual snowpack had fallen in three days.

Based on what was learned in 2002, the City developed a Drought Plan, in 2003, to provide guidance for recognizing when a drought is severe enough to affect the City's water supply and for responding suitably.[213] The Drought Plan established Drought Alert Stages corresponding to the severity of shortages in water supplies, and to the particular actions that might be taken to respond to each stage. The Drought Plan was updated in 2010 to incorporate drought response actions that were made possible by the implementation of a water-budget-rate structure in 2007. The Drought Plan is separate from the City's Water Conservation Plan, which was developed in 2008 and addresses the City’s on-going efforts to promote wise water use during non-drought periods.[214]

Expansion of treated water deliveries from Boulder Reservoir

One outcome of the 2002 drought was a direct demonstration of the need to expand the capacities of the Boulder Reservoir Water Treatment Plant and the treated water transmission line that carried that water into Boulder. The City knew an expansion would be needed by the time that the water service area was fully developed, since all of Boulder's Colorado Big Thompson Project (CBT) water supplies would be needed then to meet demands. The expansion would allow most of the CBT water to be treated at the Boulder Plant instead of relying so heavily on the Boulder Creek exchange to trade CBT water for more water diverted to the Betasso Water Treatment Plant.

The shortage of physical water supply from the Boulder Creek water sources in 2002 made it clear that the expansion was needed then, not later. In 2002, Boulder Creek was so depleted that the City had more CBT water to exchange than there was water in the creek available for trading. Even with the Boulder Reservoir Plant running at its maximum day-in-and-day-out capacity, the City had more CBT water than could be treated or could be exchanged. In the midst of a severe drought, Boulder had water that it had no way to use.

Following this stark demonstration that the need was now, not in the future, work got underway in 2003 to expand the Boulder Reservoir Water Treatment Plant from 8 to 16 million gallons per day capacity under normal conditions. The improvements also allowed the plant to produce up to 20 million gallons per day on a short-term emergency basis. The associated high-service pump station at the Boulder Plant was expanded to handle delivery of the higher output into the treated water system.

In 2005, a new twenty-four-inch-diameter-treated-water transmission pipe was built alongside the Diagonal Highway from the Boulder Reservoir west to the Iris Pump Station to allow the City to deliver this water into Boulder's upper pressure zones.[215] By 2010, the Iris Pump Station and the Cherryvale Pump Station had been expanded to transfer 11.9 million gallons per day from zone 1 up into zone 2 on an average summer day, and 13.0 million gallons per day on a low demand day.[216]

PREPARING FOR THE FUTURE

Boulder is now in the enviable position of having sufficient water supplies to meet its future needs when the city is fully built-out, even if moderate changes occur to Boulder's water supplies due to climate change.[217] After completing extensive computer modeling, the City concluded that its water system can withstand streamflow changes without violating its adopted reliability criteria as spring runoff in the mountains starts earlier.[218] Boulder would still be able to avoid water use restrictions on the average of once in twenty years. The City would only have decreased water supplies if climate change also brings very large decreases in total annual precipitation. Since a few of the climate models did show decreased annual precipitation in the Boulder Creek basin ranging from minor to severe, the City is not ignoring potential changes in future water supplies. As a result, the City is preparing for the future by making sure its water supplies are well-managed and its water infrastructure is both reliable and flexible.

Water Budget Rate Structure

A new five-block-water-budget rate structure was approved by the City Council in 2004. The structure still used increasing block rates to encourage water conservation as the City had done for decades, but the new block sizes are based on the customers' individual water needs. A new utility billing system with new programming was needed to implement the change and went into use in 2006. Beginning in 2007, Boulder's water customers began receiving water bills based on their individual water budget. In 2008, budgets were also determined for each city department based on use at individual meters.

The monthly water budget for each customer is based on criteria such as number of people in the household, historic usage and specific irrigable area. The budgets for residential customers are shaped throughout the year to reflect outdoor watering patterns. Water use above a monthly water budget is billed at increasingly higher rates than water use that is within a monthly water budget. The new structure will encourage conservation, but will also be used as a drought management tool by reducing the size of water budgets in drought years.

More Silver Lake Ditch Issues

Even though the Silver Lake Ditch and Reservoir Company had reached a new agreement with the City, in 1965, their uneasy relationship continued. Disagreements erupted again almost 100 years after the first agreement that sold Silver Lake and Island Lake reservoirs to the City was signed in 1906. The City had expected to have full use of the reservoirs for municipal water needs soon after 1906, as Silver Lake Ditch users annexed into the City. But, when the properties that were eligible for use of Silver Lake Ditch water were tabulated for

the 1965 Agreement, it was clear that many had managed to tap into the municipal system while still using Silver Lake Ditch water. This amounted to a double tap on the City water facilities since the Silver Lake Ditch storage water was delivered from City reservoirs.

This situation was magnified during the 2002 drought. Municipal water customers without access to Silver Lake Ditch complained that they were restricted in their water use, but Silver Lake Ditch users, with the same limited use of their municipal water tap, could still irrigate with water from City reservoirs fed through the ditch. The City was contractually required to deliver to the Silver Lake Ditch all of the storage water that the City had been able to place in Silver and Island lakes in 2002 (as it did in many less-severe dry years), making shortages for City water users worse.

The City had attempted to address the inequities caused for municipal water customers through City ordinances that required owners of ditch rights to sell their rights to the City upon annexation or getting a water tap. Although the ordinance with the ditch rights sale requirement had been in place since 1978 (with earlier versions dating back to the early 1960s), the City's use of the ordinance to acquire ditch rights became a heated issue with the Silver Lake Ditch Company in the years following the drought.

By 2007, the number of irrigated acres under the Silver Lake Ditch had dropped to 248 acres, and the amount of storage water to be delivered by the City each year had dropped to 572 acre-feet from 800 acre-feet. The remaining Silver Lake Ditch users were upset at their dwindling supplies. Every time ditch users subdivided their properties and asked for new water taps or expanded use of existing water taps, the City exercised the ordinance requirements and required ditch rights to be sold to Boulder. Negotiations on new amendments to the previous agreements were started, but they did not result in agreement until 2009, after many discussions and a mediation.

The new agreement very clearly spells out when the City can require that Silver Lake Ditch Company shares be offered to the City as a condition of a water tap. The Company agreed to limit the amount of the City's contract water delivery obligation in drought years according to the same reduction levels imposed on municipal water system customers. As a part of the agreement, a new list of eligible Silver Lake Ditch users was created to update the 1965 list and correct errors that had subsequently occurred in ditch-user tabulations.

Carter Lake Pipeline II

In 1997, when the pipeline was built by Northern Colorado Water Conservancy District to carry Carter Lake water to cities in the southern part of the District, Boulder had not been a participant in the project. (Boulder's Colorado-Big

Thompson and Windy Gap water is carried to Boulder Reservoir from Carter Lake through the St. Vrain Supply Canal and the Boulder Feeder Canal, and that was considered to be sufficient at the time.) Following the construction of the pipeline, a new recreational trail was proposed by Boulder County along the Boulder Feeder Canal. That proposal, along with accumulating water quality data showing the level of contamination in the canal, got the City to start looking very closely at the benefits of a new pipeline from Carter Lake.

The canal feeding Boulder Reservoir is an open channel that is vulnerable to contamination by runoff from 43 stormwater outfalls that drain directly into the canal. Land uses in the areas include agricultural (crops and cattle grazing), industrial, and residential, presenting the potential for a variety of water contamination. Water quality testing showed that canal water is the City's most protozoan-contaminated raw water source. The canal also is prone to severe turbidity spikes associated with summer storms. Turbidity may jump dramatically within minutes due to storms that may be located many miles from Boulder Reservoir. Currently the solution is to shut down the Boulder Reservoir Water Treatment Plant until the turbidity spike passes. Another issue associated with use of water from the canal is difficult-to-treat tastes and odors attributed to algae. Delivery of the City's water from Carter Lake directly to the Boulder Reservoir plant in an enclosed pipeline would eliminate these problems.

Discussions of the possibility of development of a second Carter Lake Pipeline with the District and five other northeastern Colorado municipal water providers resulted in the proposed Southern Water Supply Project II (SWSP II). A feasibility study on this project was completed in 2006 by Integra Engineering. A second phase of the pipeline project evaluation, in 2007, focused on permitting and environmental issues.[219] However, the Great Recession, beginning in 2008, tightened the belt and limited funding for the participating water providers. The pipeline project has been put on hold until 2018, at the earliest.[220]

Rebuilding the Betasso Pipelines

As explained on previous pages, Boulder was making great strides at rebuilding old pipelines. Recently, another aging pipeline needed attention—the Betasso Penstock, running from the Boulder Canyon Hydro Plant up to the Betasso Hydro Plant. The City considered simply replacing Betasso Penstock with a similar pipeline just to ensure its reliability, but then realized that other problems could also be solved. Boulder simply needed to recycle old pipelines into new uses, similar to Boulder's reuse of old pipe from the Lakewood Pipeline to build the Silver Lake Pipeline in 1919.

- Problem 1-- Restricted flowrates limiting hydro generation.

Betasso Pipeline was built in 1963, prior to construction of Betasso Hydro. When the pipeline only served the purpose of carrying water to the Betasso Water Treatment Plant, the pipeline's small diameter and rough interior were useful for

removing energy and pressure from the water before it entered the treatment plant. In 1985, after the installation of Betasso Hydro, the Betasso Pipeline was converted into a penstock, feeding the hydro plant before reaching the treatment plant. The large energy loss during the pipeline's run up the steep hill to Betasso was no longer advantageous. The water-pressure drop in the Betasso Penstock reduced the amount of power for turning the turbine, so the generator had never been able to reach its full capacity. This would change if the reconstructed Betasso Penstock had a larger diameter and smooth interior lining.

- Problem 2 -- Deteriorated Orodell Pipeline

The Orodell Pipeline carries treated water down the hill from Betasso Water Treatment Plant into the City. Sections of the Orodell Pipeline installed in the 1950s were rusting through, requiring emergency repairs. The possibility of reconstructing the Betasso and Orodell pipelines at the same time presented an opportunity to fix yet a third problem.

The Boulder Canyon Hydro Plant is viewed from the Betasso Water Treatment Plant, over the re-vegetated Betasso Penstock. Pettem photo, 2013

Problem 3 – Discharging water back to the creek from Betasso
The City had no way to discharge water from the Betasso facilities back to Boulder Creek when it would help with operations at the treatment plant or the hydro plants. Sometimes overflow releases were made into a nearby gulch when no other option was available to address treatment concerns. In addition, the City was limited in its ability to increase revenue from Betasso Hydro since part of the power sales payment is based on monthly hydro capacity tests. Large amounts of water run through the turbine during these tests had to be delivered into the treatment plant, where it disrupted treatment processes. Therefore, hydro capacity tests were often run at reduced levels that decreased revenue. What was needed was a discharge line to carry overflows and capacity test water surges back to Boulder Creek.

A creative solution addressing all of the problems was the installation of a new larger pipeline to replace the Betasso Penstock, then re-plumbing the existing Betasso Penstock to become a new Orodell Pipeline, and then re-using the existing Orodell Pipeline as a discharge line during capacity tests and for overflows. The increase in future hydropower sales will pay for the construction that began in 2008 and was completed in 2010.[221] Approximately 3,400 feet of 20-to-33-inch-diameter steel pipe was installed, along with new pressure-reducing valves for use when the hydros aren't operating.[222]

The Betasso Water Treatment Plant. Pettem photo, 2013

Rebuilding Boulder Canyon Hydro

In 2009, Hydroelectric Manager Jake Gesner came across an opportunity that he couldn't wait to present to other City staff. Under the Federal Recovery Act stimulus funding program, intended to jumpstart the economy out of the Great Recession, the U.S. Department of Energy was offering a grant for modernization of hydroelectric facilities. The one existing Boulder Canyon Hydro turbine-generator that still ran had been installed in 1936. When the City purchased the Boulder Canyon Hydro Project from the Public Service Company of Colorado, in 2001, this generator was not expected to last for more than five years. Jake and his crew had babied and patched the unit to gain four more years, but it was on borrowed time. There didn't appear to be enough money in the City budgets for full rehabilitation of the hydro until at least 10 more years.

The City quickly put together an application for the grant. In late 2009, Boulder received notice of an award of $1.18 million for the project, if the City could come up with $4.3 million of matching funds. The Water Utilities capital project funding was rearranged to take advantage of the grant. The City's investment in construction of the rehabilitated Boulder Canyon Hydro would be recovered from power sales revenues after 10 years of operation with the grant and after 14 years without the grant.

Construction of the Boulder Canyon Hydro Modernization Project began in 2012 and reflected what the Boulder water system does well--melding the old with the new. The project replaced the existing operational 10 megawatt turbine/generator unit (“Unit B”) with a new five megawatt turbine/generator. The existing “Unit A,” which no longer functioned in 2001 when the City obtained ownership, was left in place for historic preservation.

The modernization project was completed in September 2012. The new turbine is more efficient at converting the pressure of water shooting from the nozzles of the Boulder Canyon Penstock into electricity. In addition, the new appropriately sized turbine doesn't have to be shut down at low flow rates, unlike the massive old turbine. Therefore, the new turbine/generator unit, although smaller than the old, generates about 30 per cent more electricity than the old equipment. The new unit will generate about 580,000 megawatt-hours of electricity throughout its 50-year life.”[223]

The City project also replaced ancient, crumbling wiring in the Boulder Canyon Hydro building, improved lightning protection, and installed a remotely operated turbine isolation valve to replace the 1910 valve that was still in use. At the same time as the City's improvements, the Public Service Company’s successor, Xcel Energy, began a project to relocate and replace its relaying and control equipment from within the City’s hydro building to a new dedicated Xcel building constructed outside the hydro plant.

A new generator and turbine, installed the Boulder Hydro Plant in 2012, replaced "Unit B"—one of two units dating from 1936. Pettem photo, 2013

While keeping up with the latest technologies, the future of Boulder's waterworks also builds on its past. This photo of the Boulder Canyon Hydro Plant was taken in 2013. Pettem photo

The electricity generated at Boulder Canyon Hydro had been sold by the City to Xcel Energy since the City's purchase in 2001. However, after much negotiation on a new power sales contract for the newly installed generator, the City and Xcel could not reach an agreement. In 2012, the City entered into an agreement with Tri-State Generation to sell the electricity generated at Boulder Canyon Hydro. A new era had begun.

The Thousand-Year Rain

In September 2013, Boulder and the surrounding area experienced a “1,000-year rain”—an event with a one in 1,000 probability of happening in any given year. Between September 11 and 18, more than 17 inches of rain fell on the city, equal to 85 per cent of the total amount of precipitation that usually arrives during an entire year. On Wednesday, September 11, more than three inches of rain fell on Boulder. The next day, three times that amount fell. Emergency alert sirens screamed out on Wednesday and Thursday nights with evacuations ordered at the mouth of Boulder Creek. On Thursday night, automated phone system warnings were sent to 8,000 telephone numbers urging residents to move to higher ground.

Water flooded more than 5,800 homes across the city and severely strained the City’s infrastructure. Approximately 1,700 houses were so damaged that they were uninhabitable. One office building was completely demolished by a landslide. The Federal Emergency Management Agency (FEMA) provided assistance, as the cost of damages to city infrastructure was estimated at more than $43 million. The damages extended to more than 50 city buildings/facilities; water, sewer, and stormwater infrastructure; and parks and recreation facilities.

Sediment and debris ran in all 15 creek drainages throughout the city; washed out streets, sidewalks, and trails; and flooded irrigation facilities. It was anticipated that FEMA would reimburse the City for 75 per cent of the costs to repair municipal-owned structures, and the State of Colorado would reimburse another 12.5 per cent. Debris removal would take months and full repairs were expected to take years.

The City's water supply system fared better than other structures throughout Boulder, but still was impacted. Water deliveries were able to continue throughout the storms. The Betasso Water Treatment Facility suffered minimal damage, but it had to operate on an emergency generator until power was restored by Xcel Energy. The highway in Boulder Canyon was damaged, so fuel and chemical deliveries to Betasso were difficult until the road was restored in early October.

In addition, the Boulder Reservoir Water Treatment Plant lost power during the flood. The plant then had to remain shut down due to the large amount of

sediment that had washed into Boulder Reservoir from the local drainages, as well as damage to the Boulder Feeder Canal that delivers water from Carter Lake. Turbidity levels in Boulder Reservoir dropped enough for the treatment plant to go back into operation by early October using water pumped from the reservoir. The Feeder Canal would require repair and the influent pipe from the canal to the treatment plant needed sediment removal before it could be used again.

Both of the treated water transmission pipelines in Boulder Canyon were impacted by flood erosion and unstable slopes. The Boulder Canyon Pipeline was taken offline until stabilization work could be completed in November 2013. Dams, diversion, and source water pipelines were inspected for damage and confirmed safe and operable. Hydroelectric facilities were inspected for damage and quickly brought back online. Several access roads suffered damage from erosion, the most serious being the road leading up to the Booten water storage tank. Wittemyer Ponds had significant damage to the berms between the ponds and to the Howell Ditch diversion structure.

The local irrigation ditches didn't survive the floodwaters as well. Headgates on the creeks were washed out, and stormwater flooded into ditch channels in many locations, filling ditches with debris and breaking through ditch banks. Repairs to local ditches were expected to take years.

Looking Ahead

By 2008, the City provided water to approximately 113,000 residents, both inside and outside the city limits. Residential single-family users make up most of the 28,500 connections in the service area. The City's total daily per capita water use has varied from year to year, from a low of 148 gallons per day in 2004 and 2007 to a high of 209 gallons per day in 1988.

According to the Boulder Planning Department's publication, "Existing and Projected Housing Units, Population, and Employment: 2008, 2030 and Build-Out" (that updated population and employment projections for the Boulder service area), the study predicted that the jobs-to-population ratio at build-out in Boulder will be as high as 1.28.

	Population	Employment
2008 Actual	113,100	100,500
Projected 2030	129,600	120,800
Projected Build-out	129,600	166,000

The City of Boulder is nearing its built-out condition, and any additional improvements or additions to its water system will focus more on improving system operating flexibility and performance rather than increasing capacity.

Work began on a comprehensive Water Utility Master Plan in 2010 after the City realized the various master plans and studies for different aspects of the water system needed to be integrated. The plan is a comprehensive analysis and plan for the City's water source, storage, treatment and delivery systems to be used in guiding future water utility decisions. The plan updates the Treated Water Master Plan (2000) with general planning information and updated population projections. In addition, it incorporates the recently completed Source Water Master Plan (2009) and Water Quality Strategic Plan (2009), and consolidates and prioritizes capital improvements identified in the Source Water, Water Quality and Treated Water plans. The City Council accepted the Water Utility Master Plan in September 2011.[224]

The history of the City's waterworks is filled with stories of ambitious efforts that began more than 150 years ago with the first hopeful turn of a shovel to build Boulder's earliest irrigation ditch. As a result, Boulder's current residents and visitors have the ability to turn on a faucet and receive abundant, clear water without giving their actions a second thought. The past few decades have focused the City's efforts on rebuilding many of its water facilities that were created many decades ago, and fine-tuning its operations, while meeting new regulatory requirements for water supplies.

All this was, and is, done with an eye toward Boulder's water needs decades into the future, just as had been done by the City in past decades when our predecessors assured today's water supplies. Future Boulder citizens will continue to enjoy the benefits of the forward-thinking vision and on-going efforts that have resulted in water supplies and a water system worth admiring.

Hopefully, the preceding pages have given readers an appreciation for water—an image conjured up by singer and songwriter Bob Nolan in his 1936 recording of *Cool Water*. The song was made popular, in 1948, by the Sons of the Pioneers, then recorded by many other artists, including Hank Williams, Johnny Cash, Marty Robbins, and Joni Mitchell.

All day I've faced a barren waste
Without the taste of water, cool water.
Old Dan and I with throats burnt dry
And souls that cry for water,
Cool, clear water.

The nights are cool and I'm a fool,
Each star's a pool of water, cool water.
But with the dawn I'll wake and yawn
And carry on to water,
Cool, clear water.

Sons of the Pioneers version on YouTube, http://www.youtube.com/watch?v=We-nX6qjNWQ

APPENDIX

Recent Water Utilities Work Program Staff

Executive Director of Public Works
Mo Rait

Director of Public Works for Utilities
Ned Williams and Jeff Arthur

Finance and Analysis Manager
Carol Linn and Ken Baird

Principal Engineer
Bob Harberg

Water Resources and Hydroelectric Manager
Carol Ellinghouse and Joe Taddeucci

Water Treatment Operations Manager
Jim Carmody and Randy Crittenden

Water Quality and Environmental Services Manager
Chris Rudkin and Bret Linenfelser

Utilities Maintenance Manager
Don Vetterling, Felix Gallo and Joe Cowan

Water Resources Advisory Board (WRAB)

The Water Resources Advisory Board (WRAB) was first seated in 1993 and advises the City Council, Planning Board and city staff on community utilities issues. The board also:

- reviews Capital Improvement Programs for the three city-provided utilities (water, wastewater, and stormwater/flood);
- reviews utilities community and environmental assessment processes (CEAPs),
- reviews utilities master plans; and may provide recommendations concerning policy issues on operating programs.

Throughout the years, the following people have served as the board's chairs:

1993 – Peter Gowen
1994 – Peter Gowen
1995 – Peter Gowen
1996 – Peter Gowen
1997 – Peter Gowen
1998 – Robert Fiehweg
1999 – Robert Fiehweg
2000 – Robert Fiehweg
2001 – Robert Fiehweg
2002 – Robert Fiehweg
2003 – Robert Fiehweg
2004 – Jeannette Hillary
2005 – Ken Wilson
2006 – Ken Wilson
2007 – Jim Knopf
2008 – Bart Miller
2009 – Robin Beyers
2010 – Bill DeOreo
2011 – Bill DeOreo
2012 – Susan Iott
2013 – Chuck Howe

ENDNOTES

[1] The word “Arapaho” can also be spelled “Arapahoe,” but “Arapaho” is preferred for the tribe. Also, according to the U. S. Board on Geographic Names, it is the only correct spelling for North (and South) Arapaho Peak and Arapaho Glacier.

[2] Amos Bixby, *History of Clear Creek and Boulder Valleys, Colorado*, 1880 (Chicago: O.L. Baskin & Co., 1880) 389.

[3] Anne Dyni, *Pioneer Voices of the Boulder Valley, an oral history* (Boulder: Boulder County Parks and Open Space, 1996) Appendix D, Originally from the files of Tom Platt, former District #6 Water Commissioner.

[4] Noel, Mahoney, and Stevens, *Historical Atlas of Colorado* (Norman: University of Oklahoma Press, 1994) 15.

[5] City of Boulder Source Water Master Plan, Section 3

[6] *Colorado Constitution*, Article XVI, section 6.

[7] *Daily Camera*, June 12, 1977.

[8] Phyllis Smith, “The Race for Water; an historical perspective,” *Daily Camera*, October 7, 1984.

[9] Gordon Morris Bakken, *Law in Western United States* (Norman: University of Oklahoma Press, 2001) 153-159.

[10] *The Boulder News and Courier*, May 5, 1882.

[11] Lynn I. Perrigo, *A Municipal History of Boulder 1871-1946* (Boulder: Boulder County Historical Society and City of Boulder) 63; and *Boulder News and Courier,* June 30, 1882.

[12] Boulder Town Minutes, January 10, 1873.

[13] Boulder Town Minutes, November 29, 1872, and *Boulder County News*, January 10, 1873.

[14] *Boulder County News*, January 2, 1874.

[15] Boulder Town Minutes, April 22, 1876.

[16] Boulder Town Minutes, October 5, 1875, and November 25, 1875.

[17] Fred A. Fair Engineering Association, *Water Rights of the City of Boulder, Colorado, Report to E. O. Heinrich, City Manager* (Boulder: 1919) Appendix B, 7.

[18] *Colorado Banner*, October 7, 1875.

[19] Lynn I. Perrigo, *A Municipal History of Boulder 1871-1946* (Boulder: Boulder County Historical Society and City of Boulder) 65.

[20] *Boulder County Herald*, August 15, 1883.

[21] Boulder Town Minutes, October 23, 1879; November, 1879; January 5, 1880; and February 2, 1880.

[22] Lynn I. Perrigo, *A Municipal History of Boulder 1871-1946* (Boulder: Boulder County Historical Society and City of Boulder) 66.

[23] *Daily Camera,* "Ditches in Boulder area with priorities up to 1870 listed," February 15, 1952.

[24] John A. Ellet was mayor at the time. M.S. Whiteley would become mayor in 1899.

[25] *Boulder News and Courier*, July 7, 1882.

[26] *Boulder County Herald*, April 5 and 19, 1882.

[27] *Boulder County Herald*, February 26, 1890 and July 23, 1890.

[28] *Portrait and Biographical Record of Denver and Vicinity* (Chicago: Chapman Publishing Co., 1898) 319-320.

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