Balancing Growth And Water

Broomfield, Colorado's First "Model" City, Follows Fundamental Vision To Create Community

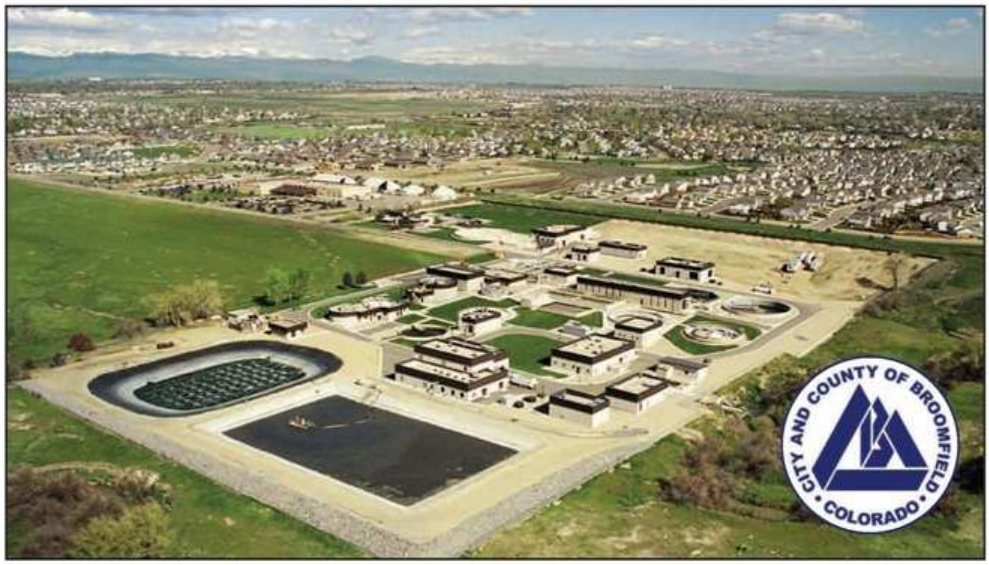
Population growth drives the fundamental need for public works, but it also creates an economy of scale that makes providing a wide range of services on a municipal basis possible. With Colorado's boom and bust history, some of its oldest cities and towns are among the least populated while some of the newest have experienced exponential growth. When the Centennial State celebrated its own centennial along with the nation's bicentennial, City of Broomfield was celebrating a mere 15 years of existence. An expanse of rolling farms for over 80 years in Boulder County, Broomfield was incorporated during a time of prosperity in the United States, a time when it was easy to see growth as a "good" thing.

These days, the logic is not that simple. As always, growth continues with or without prosperity, and bigger is not necessarily better. The late 1950s and early '60s, more than any other period, introduced a futuristic view of the world to Americans where anything was possible. In a very real sort of way, city planners could dream about utopian communities where everyone and everything thrived. Recognizing pitfalls and guarding against them was the planning challenge then as it is today.

The most deadly pitfall for any government is promising what it can't deliver. In Colorado, that means water before growth. Acquiring water rights in the late 1950s was not much easier than it is today – supply limited, demand high. Broomfield's founding architects were able to acquire rights to C-BT water, west slope water from Grand Lake diverted to east slope communities under the Colorado-Big Thompson Project completed in 1957. Today, C-BT water – over 210,000 acre-feet – is provided to 30 front range communities including Broomfield.

As the midway point between Denver and Boulder along US 36, Broomfield's wide-open space naturally attracted developer's interests as far back as 1950, when construction of the former toll road began. At the time of its incorporation, 1961, Broomfield had about 6000 residents. Population growth led to annexation into Jefferson County in 1969 and Adams County in 1971. After passing its charter to become a home-rule city in 1974, Broomfield gained the authority to impose its own sales and use taxes and set about electing its first mayor and City Council.

Growth, now managed from within, would be slow and steady for Broomfield, with population not



Aerial view of Broomfield's Wastewater Reclamation Facility. Expansion is getting underway on the north side of the property, shown in the right portion of the photo, that will ultimately increase capacity to 16 MGD.

Two new secondary clarifiers were constructed during Phase 1 of improvements to the Broomfield Wastewater Reclamation Facility. Phase 2, with expected completion in 2010, will add two more. Clarifiers separate the active sludge biomass from the secondary effluent through settling while oil and other floating contaminants are skimmed from the surface.

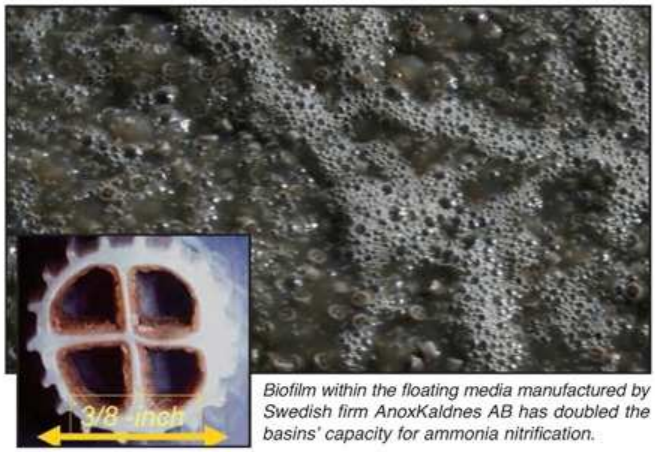
topping 10,000 until the early 1980s. While developers paid the cost of linking their new developments to the City's water and sewage infrastructure, Council limited the annexation of property until treatment capacity would allow such services to be fully provided. With expansion of the City's wastewater treatment facility in 1988, the plant's third upgrade since its original construction in 1954, Broomfield annexed into Weld County, making it the only city in the State to span parts of four counties. Broomfield was now on the cusp of unprecedented growth that would coincide with commercial development of the US 36 corridor. Population climbed from 24,638 in 1990 to over 40,000 by November 2001, when City of Broomfield became City *and County* of Broomfield.

In 1996, Broomfield embarked on an effort to update its wastewater treatment master plan through 2020, and public participation was encouraged and became an integral part of the process. The new Wastewater Utility Plan determined the need for an ultimate treatment capacity of 16 MGD, and a two-phase approach to expand plant capacity to 12 MGD was approved by Council in 2000. At the time, the rated capacity of the Broomfield Wastewater Reclamation Facility was 5.4 MGD, but it could only provide biological ammonia removal (i.e., nitrification) for about 4 MGD. Phase 1 was completed in December 2004, increasing total treatment capacity including compliance with tighter ammonia limits to 8.0 MGD. Phase 2 expansion to increase capacity to 12 MGD began in October and is expected to be completed in October 2010. Black & Veatch Corporation is the design engineer for both phases.

"Our wastewater treatment facility has been under almost constant change for the last 10 years," says Broomfield Wastewater Superintendent, Ken Rutt. "We've increased the quality of the final effluent in response to more restrictive regulatory requirements and we've added extensive odor control improvements. Phase 2 expansion will create treatment capacity for development now happening in the northeast sector, including Anthem, Northlands and a new Children's Hospital."

Prior to Phase 1, the biological treatment process consisted of a plastic media biotower followed by a single-stage of activated sludge treatment. In Phase 1, the biotower, which was a source of odor complaints, was demolished. The heart of the new liquid stream treatment train is a three-stage activated sludge process that provides for biological nutrient removal (BNR). Each stage or environmental zone within the activated sludge process is designed to meet specific effluent quality objectives. In the oxic zone, aerobic bacteria consume organic matter and convert ammonia, which is toxic to aquatic life, to nitrates. The anoxic zone is designed to be devoid of dissolved oxygen, which allows nitrate to be reduced to nitrogen gas and vented harmlessly to the atmosphere, which is approximately 80 percent nitrogen. The anaerobic zone is configured so there is no dissolved oxygen nor nitrates, which promotes biological removal of phosphorus.

Perhaps the most innovative



Biofilm within the floating media manufactured by Swedish firm AnoxKaldnes AB has doubled the basins' capacity for ammonia nitrification.

part of the plant upgrade is the use of buoyant plastic media to make the oxic zone an integrated fixed film activated sludge, or IFAS, reactor. Broomfield, encouraged by favorable results of a pilot study, felt comfortable being the first community in North America to utilize this form of IFAS technology on a full-scale basis.

"The high-density polyethylene media," explains Mark Maxwell, P.E., project manager for Black & Veatch Corp., "essentially doubles the amount of treatment organisms that can be sustained within a given volume by providing surfaces for them to adhere to while suspended in wastewater. This has allowed Broomfield to double nitrification capacity to 8 MGD without adding more aeration volume to the oxic zone while minimal new mixed but unaerated tankage was required to create the anaerobic and anoxic zones."

To accommodate IFAS, however, existing aerobic basins needed minor modifications, including media-retaining sieves and a new stainless steel diffused aeration system. The media manufacturer supplied the necessary in-basin equipment.

"One of the City's community-wide goals is to conserve fresh water supplies by increasing the reuse of reclaimed wastewater," Rutt continues, "and reuse water regulations require lower levels of nitrogen than typical stream discharge. With IFAS, most of the slow-growing bacteria that convert ammonia to nitrate inhabit the free-floating media, helping provide the required degree of treatment using less volume than would otherwise be needed. For stream discharge, ammonia levels are strictly mandated by the EPA. Although there are not yet similar surface water standards for total nitrogen and phosphorus, we expect them to be issued in the near future."

With the first of two reconfigured train basins working properly in late 2002, media were added in small installments over a two-month period to allow for evaluation of effects on the aeration basin, air distribution system, hydraulic flow pattern and micro-organism population. Media were added until a volumetric fill fraction of 30-32 percent was attained. Six weeks after the first bags of media were added, the BNR system began achieving complete nitrification. As plant loadings increase, more media can be added if needed to sustain a high level of performance and capacity. While the media can be pumped out of the IFAS basin should that be required for maintenance purposes, a "bulletproof" stainless steel diffused aeration system was installed to minimize the need for entry into the IFAS tanks.

Broomfield water samples, from left: raw, biologically-treated, reuse and tap.

Grit removal, above, and new, covered clarifier. Existing basins will be covered during Phase 2 as odor control efforts will become complete.

First work on Phase 2 at Broomfield WRF involves excavating for construction of new secondary clarifiers. Salida-based Moltz Construction Inc. is the general contractor.

The second Phase 1 treatment train conversion came online in 2003 while operators continued to tweak the BNR process. An important operational issue with BNR systems is the management of the dissolved oxygen content throughout the various environmental zones.

"High DO is the norm in the oxic basins," Maxwell says. "One reason for that is the high oxygen transfer efficiency of the diffused aeration system, which creates complete mixing of the media which, in turn, shears air bubbles and increases the length of time during which they are in contact with the wastewater. In addition, higher DO concentrations are required to sustain the aerobic biomass suspended in the liquid and attached to the media."

Part of the BNR process relies on the recycle of nitrate-rich mixed liquor from the oxic zone to the anoxic zone, necessitating an allowance for residual DO in the nitrate recycle stream, which was allowed for by Black & Veatch. Operators, however, must still balance having sufficient DO in the oxic zone with not compromising the reduction of nitrates in the anoxic zone. A pre-anoxic zone was installed to protect the anaerobic zone from influent nitrates, the presence of which is unusual for domestic wastewater, and any DO that may be present in the return activated sludge.

Ken Rutt, Wastewater superintendent, Dan Mayo, water resource administrator, and Dave Dalsoglio, Utility Operations superintendent, make up the core of Broomfield's water reuse team. Rutt has been with Broomfield for over 20 years, while Mayo and Dalsoglio are in their 21st and 22nd years, respectively, with the C&C.

"So far," Maxwell continues, "these efforts have been very successful, as the Broomfield BNR process achieves over 95 percent removal of ammonia and 70 percent reduction in total nitrogen. "

Over more than four years of operation, the BNR process, with IFAS technology for the oxic zone, has consistently met treatment objectives for reducing biochemical oxygen demand, total suspended solids, ammonia, nitrates and phosphorus. A comparison of system performance before and after the IFAS retrofit clearly reflects dramatic improvement in removing ammonia.

"Before IFAS," says Rutt, "we could not consistently maintain stable rates of ammonia removal. Improvements made during Phase 1 centered on implementing the new IFAS technology and have allowed us to maximize treatment capacity without increasing the overall size of the plant."

Phase 1 construction, performed by Sheridan-based Lillard & Clark Construction Co., added a primary settling basin, two secondary clarifiers, additional treatment basins and further odor control improvements. Furthermore, the facility's ultraviolet light disinfection equipment was replaced with a new system in a new building. In addition, chemical feed, filtration and supplemental chlorine disinfection facilities were installed to produce 6 MGD of reuse water for irrigation of major greenbelt sites throughout the City and County.

Construction of the Phase 2 improvements is being performed by Salida-based Moltz Construction Inc. and will include new screening, pumping and degritting facilities; a new 4-MGD BNR complex including IFAS basins and two new secondary clarifiers; and expansion of the odor control system. ●

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With Quality A Given, Key To Water Reuse Success Is Distribution

Parks and other greenways create natural beauty and have always been important to achieving a sense of community in urban development. Planners plan them in and agencies budget funding annually for their maintenance. In Colorado, keeping such areas naturally green and full of life requires faithful irrigation, and communities here continue to lead the way in the reuse of water by supplying treated wastewater for this purpose instead of discharging it into the watershed.

But which comes first – the treatment or the supply? For City and County of Broomfield, it all started back in 1991 when a master plan to distribute treated wastewater for irrigation was hatched.

New pump station at Broomfield's water reclamation plant was completed in 2003 along with distribution pipelines to provide non-potable water for direct irrigation reuse or storage at Great Western Reservoir.

Raw water from 3500-acre-foot-capacity Great Western Reservoir has been channeled through a system of ditches for irrigation purposes since the 1950s. In order to begin reusing its treated wastewater, Broomfield needed to link treatment and storage.

"We constructed a pipeline from the wastewater treatment facility on the east side to the reservoir on the west side," explains Utility Operations Superintendent, Dave Dalsoglio, who oversees the inspection, maintenance and construction of the City & County's water collection, transmission and storage infrastructure. "We began at the treatment facility and charted a high-pressure trunkline through the older parts of the City to Great Western Reservoir that connects parks and other areas for irrigation along the way."

A new pump station at the WWTF provides the pressure necessary to move the non-pot into a

Broomfield is extending its distribution pipeline for non-potable irrigation water to correspond with expansion of the wastewater reclamation facility that will increase treatment capacity. The City and County is utilizing new technology developed by Underground Solutions Inc. that allows C-905 pipe sections to be fused together, eliminating joints and the need for joint restraints. BTrenchless, a division of BT Construction, performed the HDD installation this summer.

4-million-gallon aboveground storage tank at Great Western. Excess supply, typically accumulated over winter months, is dechlorinated and discharged into the reservoir for future irrigation use. With the trunkline complete in 2003, Broomfield began reusing its water with the ability to feed service lines from either direction – the plant via pumps or the reservoir/tank via gravity.

Dalsoglio and his team are now directing their attention to providing non-pot distribution to newer areas of development. This past summer, Broomfield embarked on its Sheridan Reuse Extension project to extend distribution along Sheridan Boulevard between 136th and 144 avenues. Dalsoglio investigated utilizing new technology he had seen at a conference in Vail.

"The pipeline changes from the west side of Sheridan Boulevard to the east side at 144th Avenue," Dalsoglio says. "Horizontal directional drilling was obviously the best way to avoid tearing up the streets. We asked the pipeline contractor, BT Construction, if they could provide the fusible PVC pipe we had seen at Vail."

BTC contacted the manufacturer, Underground Solutions Inc., and was able to provide optional pricing for utilizing the company's patented Fusible PVC™.

"Our Fusible PVC has distinctive properties that allow for full-strength fusion joints," explains Susan Pilgram, Boulder-based regional sales manager for UGSI. "Our patented process incorporates a specially formulated PVC compound and a unique combination of heat, pressure and time to fuse pipe sections together. The pipe meets the AWWA, NSF and ASTM standards for both potable and non-potable water use."

Fusible PVC™ from Underground Solutions has distinctive properties that allow for full-strength butt fusion joints under a patented process.

The process uses standard industry fusion machines with minor modifications. A dual cutting head faces and squares both pipe ends simultaneously before the heating plate forms a bead of fusible material at each end. Pipe ends are then brought together and held under pressure until the newly-formed joint cools.

"The fused joints are fully restrained without having to use mechanical joint restraints or cast concrete thrust blocks," Dalsoglio points out. "And there are no gaskets. The pipe costs a little more but dollars are never the only factor."

BTC's BTrenchless Division performed two 800- and one 300-ft.-long pulls of 24-in.-diameter C-905. Buried utilities were as deep as 15 feet and potholing was performed to confirm location and elevation to ensure deep enough drilling. The design pressure of the pipe is 90 PSI.

"We've been so pleased with the product and its ease of installation," Dalsoglio concludes, "that we are definitely considering it again for Phase 2 of the project, which will begin in spring. We're also looking at it for use in open trench projects." ●

BTrenchless crews pull the 24-in.-diameter C-905 pipe back through the horizontally-drilled hole in the trenchless installation performed along Sheridan Boulevard during summer 2007.