BY STUART JEFFCOAT,
DOUGLAS BAUGHMAN,
AND P. MICHAEL THOMAS

Total water management

strategies for utility master planning

AS DEMAND FOR WATER ESCALATES, SUSTAINABLE APPROACHES FOR WATER MANAGEMENT ARE IMPERATIVE.

Many utilities and municipalities do not have the luxury of identifying, procuring, or using first-use raw water sources for their potable water supplies. Instead, water reuse or the use of a raw water supply that includes return flows from agriculture, industry, and municipalities are the only options available. Therefore, it is imperative that utilities improve the management of their watersheds to ensure the quality and quantity of their water supply. A total water management (TWM) approach integrates management of the watershed, water supply sources, land-use practices, and related resources to provide sustainable supplies while considering equitable economic and social considerations and promoting a healthy ecosystem.

The Clayton County Water Authority (CCWA) in Atlanta, Ga., has implemented a TWM plan for its water system. This article examines how this approach has been used successfully by CCWA to meet its long-term water supply and wastewater management needs even during excessive drought conditions.

TWM HELPS UTILITIES DEVELOP SUSTAINABLE PLANS

Increasing demands on water resources and the associated stresses of continued population growth, land-use changes, and climate uncertainty require water managers to employ more innovative approaches to long-term water management planning. TWM offers an effective method for develop-

Clayton County Water Authority has a strong history of using natural treatment systems for disposal of treated wastewater effluent. The utility ultimately elected to convert from land application to disposal into constructed wetlands that recharge CCWA's water supply reservoirs.

ing sustainable and integrated water resource management plans (Patwardhan et al, 2007). TWM integrates the functions of the built and natural water cycles so that the entire water system (from source water to wastewater treatment and ecosystem flows) can be planned and operated to provide more sustainable water supply solutions. A TWM approach facilitates long-term planning, promotes consistency and efficiency, optimizes uses of all water sources, provides flexible solutions, and enhances community involvement in and support for long-term water planning (Freas et al, 2008).

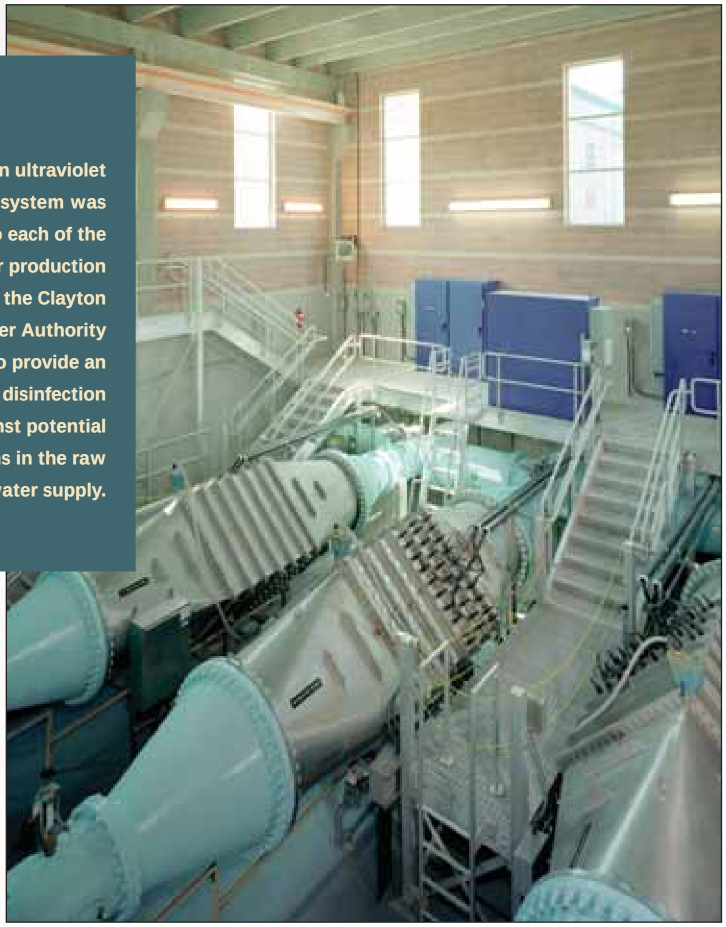
TWM comprises the following six elements (Freas et al, 2008; Patwardhan et al, 2007):

- define goals and objectives of the TWM plan,
- collect and analyze data to support plan development,
- evaluate and select alternatives to be analyzed by the plan process,
- select models to perform TWM analyses,
- conduct impact assessments of the plan including stakeholder involvement, and
- develop the implementation plan, monitor results, and establish institutional framework.

APPLYING TWM TO CCWA

Although many utilities have applied some of these elements in their water and wastewater planning, few have applied this planning process as successfully as CCWA. Located on the south side of metropolitan Atlanta, Ga., CCWA provides water and sewer services to Clayton County and portions of adjacent counties. CCWA's needs for water supply and wastewater treatment continue to increase with population growth despite the limitations on water supply and assimilative capacity. Continued conflicts with neighboring states for water resources and total maximum daily load requirements in the area have made it even more difficult to obtain new or expand existing water supply withdrawal and wastewater discharge permits (Baughman et al, 2005; Thomas, 2005).

As do most water utilities, CCWA develops and regularly updates master plans associated with its long-term capital improvement plans (CIPs) to evaluate changes in growth patterns, regulatory requirements, and other conditions. CCWA initiated a TWM approach to water resource planning in its 2000 master plan and subsequently reinforced TWM in the preparation of its 2005 master plan update. Concurrent with the facility master planning process, CCWA was developing and implementing a watershed management approach to ensure the maintenance of water quality in its water supply watersheds as well as in the streams throughout the county. CCWA's rationale for using TWM was to



An ultraviolet disinfection system was added to each of the three water production plants in the Clayton County Water Authority system to provide an additional disinfection barrier against potential pathogens in the raw water supply.

maximize its limited water supply and maintain compliance with increasingly stringent federal and state regulations while achieving customer service goals at a reasonable cost to CCWA consumers.

The following discussion demonstrates how CCWA implemented the six elements of the TWM approach as part of the overall system master planning process to achieve its water management goals.

Element 1: Define goals and objectives of the TWM plan. A strategic planning workshop was held with key CCWA staff to establish the authority's vision for its future as a utility, identify the critical success factors for water management planning, and develop criteria to evaluate alternatives for TWM planning that directly align the plan with the utility's vision for the future. Defining goals and objectives for CCWA's water planning was critical to evaluating alternatives and prioritizing the implementation of the recommended projects and improvements. The goals and objectives identified during the strategic business planning session included the following:

- make best use of emerging/proven technologies;
- make cost-effective and financially justified decisions;
- improve customer relationships/satisfaction;
- anticipate and respond to pending, current, and emerging regulations;
- ensure the use of best asset management practices;
- protect the environment;
- maintain current and future capacity needs; and
- consider safety and security.

Element 2: Collect and analyze data to support plan development. Extensive data were collected and analyzed to develop recommendations for a CIP and master plan that would focus on innovative water management for sustaining future system demands. The data analysis included population projections, historical and future demands, regulatory considerations, and system evaluation. Population projections from various agencies, including the Atlanta Regional Commission, Clayton County Community Development, and the Metropolitan North Georgia Water Planning District, were analyzed to best estimate the future population of Clayton County.

The primary assumption regarding population projections in Clayton County for water management planning purposes is that growth has been underestimated as a result of rapid growth on the south side of the metropolitan Atlanta area and in the northern suburban county because of the affordability of homes in these areas. Upon review of population data for Clayton County, a projected population of 350,000 in 2030 was used for the CCWA system master plan.

While population continues to increase in Clayton County, per-capita water use has been decreasing, resulting in no net increase in water demand in recent years. This trend likely results from statewide outdoor watering restrictions, higher-density housing trends, low-flow plumbing fixtures in new homes, reduced water use in response to rate increases, and limited use of residential irrigation.

This relationship between population growth and projected demand is expected to continue based on analysis of historical data. On the basis of this expectation, CCWA must prepare for a future with an increased customer base and flat-lined water demands. If consumption trends change dramatically, CCWA will have underpredicted future water demands. However, if typical population and water consumption increases are used to predict future water demand, CCWA may overpredict future water demands, potentially resulting in unnecessary capital expenditures. Therefore, additional demand projection modeling was required to further analyze account data and to help predict future water demands by considering consumption per account for different account types and growth of the individual account types.

The identification and development of additional water supply resources were very important in the master planning process.

A comprehensive regulatory analysis was performed to assess current and future regulations focused on potable water, wastewater, stormwater, and water reuse regulations. Anticipating that reuse would be significant among the alternatives considered to manage water supply, those who conducted the regulatory analysis focused on treatment and water quality requirements that accompany reuse. For example, the need for additional treatment at CCWA's water and wastewater treatment facilities could arise if the quality of source water degrades as more treated wastewater is indirectly reused in the system and as more stringent nutrient-removal requirements are put in place at CCWA's wastewater treatment facilities because of downstream water quality in Lake Jackson.

In addition to water and wastewater regulatory developments, the need for additional stormwater management has become an important regulatory driver for CCWA. This stems from a requirement by a state regulatory agency that local utilities complete watershed assessments and develop watershed management plans to address the existing water quality issues and to ensure that water quality conditions would be maintained as local communities continue to grow.

Analyses of existing water treatment and distribution as well as wastewater collection and treatment infrastructure in the CCWA system were also performed as part of the data collection and analysis step. The analyses resulted in the preparation of a list of improvements required to adequately and optimally operate the overall system. The key benefit of this system evaluation was a thorough assessment of the overall system, which ensured that the appropriate infrastructure was in place for long-term sustainable water and wastewater management.

Element 3: Evaluate and select alternatives to be analyzed during the plan process. The data analyses described in element 2 identified alternatives for system improvements to sustain future water and wastewater flows, maintain compliance with future regulations, and improve the treatment, collection, and conveyance infrastructure in the overall system to ultimately achieve customer expectations. As part of evaluating alternatives and selecting improvements, water management strategies were identified to allow

Stormwater utility funding helped Clayton County Water Authority leverage grant funding for watershed restoration projects designed to improve water quality and habitat conditions.

CCWA to maximize its limited water resources. Alternatives were identified and evaluated based on the criteria established during the strategic planning session described in element 1.

Most of the alternatives focused on options for providing sufficient treatment capacity for projected water and wastewater flows while protecting source water and treated water quality and sustaining a reliable water supply. These alternatives included identifying specific water production and wastewater treatment plants that could be expanded to sustain projected demands. Additional alternatives were also considered for the replacement of aging infrastructure at CCWA's treatment facilities to ensure reliable water treatment in the future, and they were assessed based on staff preferences and economic factors such as the cost of the equipment.

The identification and development of additional water supply resources were important in the master planning process. CCWA is located at the top of its watershed and has limited resources to sustain the projected demands on its potable water system. The alternatives evaluated for additional water supply included:

• exploring the use of groundwater sources;

• returning CCWA wastewater flows, which are treated by other utilities, back into the CCWA system so that the wastewater could be treated at CCWA facilities and discharged back into the surface water supply reservoirs; and

• purchasing potable water from other utilities.

In addition, alternatives for disposing of treated wastewater effluent were considered. Constructing treatment wetlands was proposed rather than continuing with land application for the disposal of treated wastewater effluent, a process that CCWA implemented in the 1970s.

The proposed conversion to wetland treatment for the disposal of wastewater effluent would result in direct discharge from the treatment wetlands into the surface water supply reservoirs. Therefore, alternatives were proposed to provide additional treatment at CCWA's water production plants so that a multiple barrier approach to pathogen protection could be achieved. Two technologies that could provide additional pathogen protection were evaluated—ultraviolet (UV) disinfection and ozonation.

Elements of the stakeholder involvement program included distributing educational materials during community events and holding targeted stakeholder meetings.

To address the additional requirements for stormwater management and ensure protection of source water quality, CCWA evaluated alternatives for long-term watershed management across its service area. Two alternatives included continuing the existing approach with responsibilities divided among CCWA, six cities, and the county and consolidating stormwater management services under CCWA.

On the basis of a collaborative process that included representation of each local government, CCWA assumed responsibility for developing and implementing a new stormwater utility (SWU). The goal of the SWU was to provide a mechanism to implement a more comprehensive stormwater management program and allow the county to adopt a "proactive" approach that meets regulatory requirements and infrastructure repair and maintenance needs.

Element 4: Select models to perform TWM analyses. CCWA collected extensive data and selected a wide array of alternatives to evaluate for its overall water management approach, as discussed in elements 2 and 3. Modeling was an integral part of the TWM approach and allowed CCWA to thoroughly analyze the data collected, evaluate the proposed alternatives, identify benefits and differences among the proposed alternatives, and streamline the selection of alternatives to recommend improvements for CCWA's implementation plan. Models were developed to facilitate the following analyses:

• projection of future water and wastewater demands,

• identification of water distribution system improvements to sustain future potable water demands in the overall system,

• analysis of water quality in CCWA watersheds associated with the proposed conversion from land application to constructed treatment wetlands, and

• evaluation of CCWA's financial resources to develop a rate structure for the most cost-effective implementation of alternatives.

As part of the modeling associated with assessing future water and wastewater demands, historical consumption and account data for CCWA were used to determine recent trends in the growth of number of accounts and change in consumption per account for each customer class. The model allowed the user to input the annual growth of

Shamrock Lake, a water supply reservoir, is an example of how the implementation of the treatment wetlands and an indirect reuse program helped to maintain available water supplies during excessive drought conditions in Georgia.

customer accounts per customer class, the annual change in consumption per account per customer class, weather data, and demand elasticity. Projected consumption was calculated by multiplying the projected number of accounts by the projected consumption per account for each customer class. A mid-year adjustment was used to estimate the number of "billable" accounts throughout the year, using the average of the beginning and ending number of accounts for each calendar year.

Wastewater flows were predicted by determining the indoor water use per customer class. This was estimated by examining the historical data and the running annual average of historical data by customer class. The difference between the running annual average and the summer peaks was considered to be outdoor water use. In addition to the customer class contribution, infiltration/inflow (I/I) was considered in wastewater flow projections. For planning purposes, I/I was projected to be 20% of the total wastewater collection system flow (MNGWPD, 2003).

To evaluate distribution system improvements, a hydraulic and water quality model was developed for the CCWA distribution system that allowed analysis of current and future demand scenarios. Several criteria were used to evaluate distribution system performance, including system hydraulic parameters such as system pressure, water velocity through the pipes, and head losses in the pipes. Existing and future conditions were modeled under the following five scenarios for the planning period: average daily demand, maximum daily demand, reservoir/tank refill, peak-hour demand, and maximum daily demand plus fire flow.

Water quality was also analyzed as part of the modeling process to assess the effects of the proposed distribution system improvements on water age and levels of disinfection by-products. The water distribution system modeling effort, as part of the overall system master planning, resulted in recommendations that would improve system pressure and water quality under the scenarios analyzed. The results from the modeling effort also provided recommendations for distribution system improvements to meet the increased potable water demands on the system during the planning period.

To evaluate the potential watershed management alternatives, CCWA selected the pollutant loading application (PLOAD) model, which is part of the US Environmental Protection Agency Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) program. The choice was made based on the model's capability to simulate average annual pollutant loads under varying combinations of future land use conditions, stormwater best management practices, and point source pollutant loadings. In addition, the PLOAD model was used to estimate annual pollutant loadings under various combinations of wastewater treatment and disposal alternatives, including use of land application, direct discharge, and wetlands treatment. Watershed modeling results were used to refine the combination of nonpoint source (stormwater) management practices and wastewater discharge alternatives to maintain or improve water quality conditions throughout the county.

A financial model was developed to further evaluate the proposed alternatives to identify any bond issues and rate increases required to meet all of CCWA's projected expenses, including operating expenses, capital improvement projects, and debt service payments. The operating results for CCWA, including projected revenues, expenses, debt service, and debt service coverage, were projected over the planning period as part of the financial modeling effort. Revenues were projected on a conservative basis, and expenses were estimated based on historical spending patterns factored by anticipated price increases and changes in service delivery methods.

The proposed alternatives were evaluated as part of the financial plan modeling by developing scenarios for capital improvement projects that addressed the alternatives proposed. The scenarios developed were critical in identifying the total funding required to implement the proposed alternatives over the planning period. Results of the financial modeling indicated that CCWA would have to adjust rates and undertake bond issues during the planning period to fund the recommended improvement projects. The size of the rate adjustments and frequency of bond issues determined as part of the financial modeling effort allowed the financial effect of the proposed alternatives to be considered so that the ultimate recommendations for the TWM plan could be financially justified.

Element 5: Conduct impact assessment on the plan including stakeholder involvement. The evaluation of the potential effects of each option on the TWM planning effort focused on the watershed assessment studies and the overall goals for source water quality protection in the drinking water supply watersheds. A detailed evaluation of existing stressors (both point and nonpoint) was completed as part of the watershed assessments.

Existing land use and associated conditions (impervious surface, water quality, habitat, and biotic integrity) were evaluated to develop an integrated impact assessment for each major watershed in the county. This impact assessment included existing water withdrawals and wastewater discharges. Assessment results were linked to the final selection of wastewater management alternatives. For example, the modeling of potential loadings to the water supply watersheds under the existing conditions, including land application at existing treatment levels, indicated the potential for future eutrophication problems without additional treatment. This finding further supported the alternative for conversion of land application to wetlands treatment prior to discharge to the water supply reservoirs.

During the watershed assessment process, CCWA implemented an extensive public education and involvement process to ensure that local stakeholders understood the key issues and to get feedback on the recommended watershed protection measures and the future water resource management alternatives. Elements of the stakeholder involvement program included distributing educational materials during community events and holding targeted stakeholder meetings. Results of this process were incorporated into the final watershed protection plan, which included recommendations for management of both point source and nonpoint source pollutant loadings.

Element 6: Develop implementation plan, monitor results, and establish institutional framework. The alternatives proposed as part of element 3 were evaluated in elements 4 and 5 of the TWM approach. This ultimately led to recommendations for the improvements required for CCWA to implement a plan that would achieve its TWM vision.

To accommodate future wastewater demands, it was recommended that CCWA expand—over time as demands in the system increase—two of its wastewater treatment facilities: the W.B. Casey Water Reclamation Facility (WRF) and the Northeast WRF. Similarly, it was recommended that the W.J. Hooper Water Production Plant (WPP) and the Hicks WPP be slated for expansion to sustain future potable water demands in the CCWA system. Improvements were also recommended at all treatment facilities in the CCWA system to improve operational efficiencies and promote best management practices, such as improving solids handling and eliminating the storage of chlorine gas at all CCWA

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facilities. The recommendations for expanding and improving these water and wastewater treatment facilities considered best available technologies to maintain compliance with current and future regulations. Additional recommendations for improvements in the water distribution and wastewater collection systems were made to account for growth in the system over time.

In terms of evaluating wastewater disposal options, it was recommended that the existing land application sites be converted to wetlands treatment systems (see photo on page 57) for the following reasons:

- amount and cost of land required to expand the land application sites as compared with wetlands,
- ability to treat more wastewater per acre of land with wetlands as opposed to land application,
- significantly decrease operations and maintenance cost of wetlands,
- desire for continued reliance on natural treatment systems, and
- more direct recharge of water supply sources and the resulting improvements in water supply reliability.

As this alternative was evaluated, it was noted that conversion to wetlands treatment for wastewater effluent disposal directly aligned with several strategic criteria developed in element 1. To further maximize recharge of the surface water supply reservoirs with treated wastewater effluent, it was recommended that CCWA construct a pump station and force main at the two connection points to other utilities in its wastewater collection system so that the wastewater could be conveyed back into the CCWA system. This would allow for treatment at one of CCWA's water reclamation facilities and ultimate disposal into the constructed treatment wetlands.

Associated with the indirect discharge of treated wastewater effluent into the potable water sources is an increase in the potential for occurrence of pathogens as well as microcontaminants. Surface water modeling of the overall CCWA system indicated that the percent of reclaimed water to native waters varies from 5% in one reservoir to approximately 70% in another reservoir. The estimated total reuse water in all reservoirs is approximately 23%. To address the increased percentage of reclaimed water in the raw water supplies, it was recommended that additional treatment be provided at each water production plant in the CCWA system to provide an additional barrier of disinfection (Jeffcoat et al, 2006). Ultimately, it was recommended that UV disinfection rather than ozone be implemented, because of its lower capital and operation costs and its effectiveness in meeting the primary objective of providing additional pathogen protection (Swaim et al, 2004). A typical UV system installation in the CCWA system is illustrated in the photo on page 58.

The recommendations made as part of the planning process were formulated into an implementation plan for the recommended improvements using the strategies developed as part of element 1. This overall implementation plan was developed to ensure that CCWA could sustain its projected system demands while maintaining compliance with all regulations and performing these improvements in a financially responsible and justified fashion. The results from the implementation plan are monitored every five years as part of the update to the overall CCWA master plan.

A key element of CCWA's overall TWM implementation plan was establishing an institutional framework for an SWU to support the required watershed and stormwater management programs (associated with their National Pollutant Discharge Elimination System Wastewater and Municipal Separate Sewer System Phase I stormwater permits) as well as the repair and replacement of aging stormwater infrastructure. Implementation of the SWU required development of a new department within CCWA to focus solely on stormwater management. This new department was established at the same time CCWA implemented the water and wastewater master plan and associated CIP elements. The additional funding generated by the SWU has allowed CCWA to enhance its ongoing water quality monitoring programs and leverage additional grant funding to support much-needed watershed restoration and retrofit programs. For example, projects such as the East Jesters Creek stream restoration program (see photo on page 59) have provided significant reductions in sedimentation and erosion, resulting in improvements in stream habitat and biotic integrity conditions.

BENEFITS FOR CCWA AS A RESULT OF TWM

Drought conditions throughout Georgia and particularly in the metropolitan Atlanta area have been well documented over the past two years. During the most extreme periods of the drought, forecasters indicated that the water level in Lake Lanier—the primary water supply source for the metropolitan Atlanta area—was approaching approximately three months of storage (Armistead, 2007). However, by implementing an aggressive plan to foster a TWM approach, the water authority maintained a water supply in its surface water reservoirs in excess of 200 days throughout the drought conditions and did not compromise water quality in the watershed or in the distribution system following treatment.

Currently, CCWA recharges its water supply reservoirs with approximately 10 mgd of reclaimed wastewater. The implementation of

the water authority's TWM approach includes expansion of its constructed wetlands treatment system to a capacity of 26 mgd. This boost in capacity will increase the amount of reclaimed water returned to CCWA's water supply reservoirs and create a "drought-proof" system. The success of this integrated TWM program has been clearly illustrated during the excessive drought that Georgia experienced in 2006 and 2007. Although the major water supply storage reservoirs for the metropolitan Atlanta area were at record low levels, CCWA reservoirs, such as the Blalock Lake reservoir (see photo on page 61), remained at near-full pool levels.

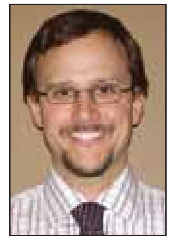
By taking on the responsibility for stormwater and watershed management for the entire county (including six cities), CCWA has gained long-term control of water quality and quantity management. By becoming the one-stop authority for all water management—water supply, wastewater, and stormwater—CCWA can continue to have an effective program for TWM.

CONCLUSION

The TWM approach to managing water resources is intrinsically linked to all master planning processes implemented by water utilities. The analysis of projected flows, utility financing, water supply options, and treatment of water, wastewater, and stormwater as part of the TWM approach allows utilities to develop comprehensive, sustainable solutions that will allow them to achieve their visions as individual utilities. Most important, use of the TWM approach, as illustrated by the success of CCWA's plan, can result in an integrated water resources management program that meets a utility's long-term water and wastewater needs in a cost-effective and sustainable fashion.

This was clearly demonstrated over the past two years as CCWA's water supply reservoirs remained full and water quality conditions were maintained during an extensive period of drought in Georgia. Reclamation of approximately 10 mgd for potable water supply has been the key to a sustainable and reliable water supply for Clayton County. Considering all aspects of water resources management through the TWM approach allows utilities to protect and sustain their most valued asset—water.

ABOUT THE AUTHORS



Stuart Jeffcoat (to whom correspondence should be addressed) is regional technology manager for CH2M HILL, 1000 Abernathy Rd., Ste. 1600, Atlanta, GA 30328; Stuart.Jeffcoat@ch2m.com. He received BS and MS degrees in civil engineering from Auburn University, Auburn, Ala., and a PhD in civil and environmental engineering from the Georgia Institute of Technology, Atlanta. He has more than 10 years of experience in the water resources and water treatment field working with various municipal clients to solve their water supply and water treatment challenges. Douglas Baughman is a senior environmental scientist for CH2M HILL, Atlanta, and P. Michael Thomas is general manager for the Clayton County Water Autority, Morrow, Ga.

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