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Managing Wastewater in a Changing Climate

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SUMMARY

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The technical appendix to this report is available on the PPIC website.

California's wastewater sector, which plays a crucial role in protecting public health and the environment, is at a turning point. Water supply and demand conditions are being affected by population growth, technology and policy changes, and drought. Climate change will bring new challenges.

Wastewater agencies are tasked with reliably removing pollutants from water discarded to sewers, even as the quantity and quality of the water they treat declines. Of the multiple climate pressures that are likely to affect wastewater management, drought poses the biggest challenge for the sector. The unusually hot drought of 2012–16 provided a vivid demonstration of conditions that may become more common as the climate warms, and was a wake-up call for wastewater agencies.

Many wastewater agencies are pursuing specific changes to their operations, infrastructure, or finances in response to the cascade of challenges they experienced during the latest drought. A PPIC survey of wastewater agencies done as part of this study found a high degree of concern in the sector about adapting to a changing climate. This report recommends policy and management changes to help build resilience in three broad areas:

- **Maintaining water quality in the face of changing water use.** Wastewater management is challenged by short-term water conservation during droughts and longer-term reductions in water use from indoor efficiency measures—conditions which are largely beyond the sector's control. Reductions in indoor water use can damage infrastructure and reduce the effectiveness of existing treatment processes. Such challenges may grow as severe droughts become more frequent with climate change and as water efficiency increases. Better coordination and information sharing with water suppliers, and sector-wide planning for future droughts, are key to addressing these changes.
- **Making smart recycled water investments.** Wastewater agencies produce highly treated water that is increasingly being reused as a water supply. Coordination among wastewater and water supply agencies is essential to respond to the increasing demand for recycled water. Formalized planning for recycled water projects at the regional level will likely lead to more efficient processes and better outcomes. New investments must be responsive to changing water use, climate change, and pending regulations.

- **Balancing conflicting objectives within watersheds.** Most wastewater treatment plants discharge treated water into inland watersheds. Adapting to declining water use and meeting increased demand for recycled water may conflict with environmental objectives and the demands of downstream users. Rivers and streams are expected to experience lower flows and higher temperatures, which will heighten threats to aquatic ecosystems. Resources to identify areas most at risk of conflict over the use of treated wastewater are needed, as are tools to evaluate the impacts of water recycling projects on the environment and downstream water users. The state should also analyze its policies to identify tradeoffs and resolve conflicts between its water supply, water quality, and environmental goals.

Advancements in engineering and technology can help wastewater agencies adapt to a changing climate—but shifts in policy and planning will facilitate a more efficient and effective path toward building resilience. The latest drought provided a window into the looming challenges facing the wastewater sector. Forging new partnerships and evaluating the full range of climate-related risks will help the sector determine the best adaptations and policy improvements needed to prepare the wastewater sector for a more volatile future.

Introduction

California's climate is changing. Climate projections show that extremely high temperatures, loss of snowpack, and record-low streamflows are likely to become more common (Mount et al. 2018; Bedsworth et al. 2018). "Precipitation whiplash"—when extremely wet years follow droughts—is also likely to become more common (Swain et al. 2018). To avoid unwanted social, economic, and environmental consequences, the state's water systems—including its wastewater sector—will need to adapt to greater climate extremes and growing water scarcity.

The wastewater sector plays a crucial role in protecting public health and the environment. Hundreds of public agencies are responsible for collecting, treating, and disposing of water polluted by human uses, and maintaining a vast system of pipes and plants to collect, treat, and dispose of this water. Most treated wastewater is discharged into various water bodies around the state, including the Pacific Ocean, estuaries, and inland rivers and streams. Treated wastewater is also the source of recycled water. The demand for recycled water is growing as local water supply agencies look to build resilience and diversify their supplies. In addition, the sector has had to adapt to an ever-changing suite of laws and regulations designed to protect human and environmental health.

The 2012–16 drought provided a clear example of how reduced water use can affect the sector. Urban water supply utilities saw historic declines in water use, first in response to voluntary calls for savings and then to Governor Brown's 2015 conservation mandate, which set water use reduction targets for each utility (Mitchell et al. 2017). Reduced flows to sewers can increase costs of collection and treatment, and in some cases damage infrastructure (California Urban Water Agencies 2017).

Longer-term changes in water use, such as increasing indoor water use efficiency, will affect the sector as well. A changing climate means that water bodies currently receiving treated wastewater will be under more stress, making it harder to protect water quality. In addition, high precipitation events, floods, and sea level rise will challenge the sector and require investments that increase flexibility of existing systems and enable managers to adapt to quickly changing conditions.

This report begins by highlighting how climate pressures will complicate wastewater operations. We then describe how the wastewater sector is linked to water use and supply trends, including the growing use of recycled water. Finally, we recommend policy and management changes to help build resilience in three broad areas: maintaining water quality in the face of changing water use, making smart recycled water investments, and balancing conflicting objectives within watersheds.

This work is informed by a survey of California wastewater agencies. The 133 agencies that responded are broadly representative of the sector in terms of geography and utility size. We also received valuable input from state and local officials through interviews and focus group discussions. Details of the survey and more background information on California's wastewater sector are provided in the Technical Appendix.

Glossary

Environmental flows: Water in rivers and streams that support freshwater aquatic ecosystems. A significant portion of streamflow in some parts of the state is provided by wastewater discharge.

High-tradeoff watersheds: Areas where wastewater effluent makes up a significant amount of the flow that supports ecosystems and downstream users. In these areas, a reduction in wastewater effluent flow or quality could result in conflict among urban, agricultural, or environmental water uses.

Stormwater runoff: A portion of the influent to wastewater treatment plants in the few places that have combined sewers. It can include waste that is washed off the streets, such as food, animal waste, sediments, litter, and chemical pollutants. In most systems in California, stormwater is collected separately and not treated before being discharged.

Total dissolved solids (TDS): An indicator of water quality that primarily measures minerals, salts, and very small organic molecules.

Wastewater agency: A public entity that owns and manages some combination of wastewater collection, treatment, and disposal systems for homes and non-farm businesses.

Wastewater effluent: Treated wastewater that is discharged from a treatment plant. This is the fundamental output of the wastewater treatment process.

Wastewater influent: The water used by households and businesses that is discharged to sewers and conveyed to treatment plants. This is the fundamental input to the wastewater treatment process.

Water quality: An indicator of the concentration of pollutants. More generally used to describe the ability of water bodies to support specific uses, and therefore may also be measured in terms of water temperature or amount of flow.

Wastewater recycling: Some treated wastewater is used to supplement water supplies. When used for purposes other than drinking water supplies it is called **non-potable recycled water**. When purified and reused for drinking water supplies it is called **potable recycled water**. Currently this happens indirectly, by supplementing supplies in groundwater basins and some surface water reservoirs. Direct reuse of potable recycled water is currently under consideration by state regulatory agencies.

How Climate Change Affects Wastewater Management

California already has large year-to-year swings in precipitation, which appear to be increasing in magnitude (He and Guatam 2016). Projections point toward a significant increase in the frequency of "whiplash events," when extreme dry and extreme wet years occur in succession. PPIC has identified five climate pressures that will influence water management in California: rising temperatures; shrinking snowpack; shorter, more intense wet seasons; more volatile precipitation; and rising seas (Mount et al. 2018).

In general, the first four pressures combined will lead to hydrologic changes that will affect water resources across the state. Local impacts will vary, but the wastewater sector can expect the following key challenges:

- Short-term indoor water conservation from more severe droughts can affect influent quantity and quality. Sudden decreases in indoor water use can lead to complications in operations, damage to systems, and increased costs. Reduced influent also reduces the volumes available for recycled water.
- Shifts to alternative water sources during droughts can affect influent quality, especially if more saline sources are tapped. Increased salinity poses unique challenges for wastewater treatment plants, which are currently not designed to remove high concentration of salts. It also affects water quality for receiving water bodies and downstream users.
- Rivers and streams are expected to experience lower flows and higher temperatures, further stressing aquatic species and ecosystems. Additional pressures on aquatic ecosystems will increase water conflict. The interaction of higher temperatures in rivers and streams with wastewater effluent may also lead to additional water quality concerns, such as harmful algal blooms.
- California is likely to see a rise in the number of "atmospheric rivers"—intense, warm storms—and greater potential for large, damaging floods (Dettinger 2013). These extreme wet events increase the risk of flood damage to wastewater treatment plants and unplanned releases into receiving waters.[1]
- Sea level rise will present unique challenges for wastewater treatment plants located on the coast, especially on San Francisco Bay (Box 1).

Box 1. Sea Level Rise and Wastewater

Depending on the level of greenhouse gas emissions, mean sea level is expected to rise between 0.5 and 1.2 feet by mid-century relative to the year 2000, with much larger rises after 2050 (Sweet et al. 2017). This will affect coastal wastewater treatment plants. Thirty-six existing wastewater treatment plants in California are at high risk from a 55-inch sea level rise; 30 of these plants are located in the San Francisco Bay Area (Hummel et al. 2018).

Sea level rise poses many challenges to wastewater facilities. For example, saltwater intrusion from storm surges can corrode treatment equipment and reduce treatment efficiency. The flow of seawater back into wastewater treatment plants can flood them. And vulnerable lagoons used to store solid waste can be inundated, bringing contamination risks and public health concerns.

Adapting existing wastewater infrastructure to sea level rise will be a huge undertaking; these are complex, tightly regulated, and expensive systems. Furthermore, unlike other utilities such as the power grid, the wastewater network does not have a distributed or redundant structure. Therefore, the outage of one wastewater plant leaves the entire population served by the system vulnerable (Hummel et al. 2018). An outage in the infrastructure at the coast could also threaten service upstream.

[1] For example, a multiday atmospheric river storm in February 2019 inundated the city of Healdsburg's wastewater treatment facility. Flood waters knocked out pumps, motors, and electrical equipment. The same storm pushed more than five times the normal flow of wastewater and runoff into the city of Santa Rosa's Laguna de Santa Rosa plant—the highest inflow ever recorded at the site.

Of all these climate pressures, drought poses the biggest challenge for the wastewater sector. The unusually warm drought of 2012–16 provided a vivid illustration of conditions that may become more common as the climate warms, and was a wake-up call for many wastewater agencies. Nearly two-thirds of our survey respondents are concerned about the impacts of a changing climate on sewer and treatment plant design and operations. More than half of respondents say they are concerned about the impact of climate change on their ability to comply with treated wastewater quality standards. The next section describes how wastewater treatment is linked to water use and water supply, and the impacts of reduced water use and drought on the sector.

Wastewater Is Linked to Water Use, Supply, and Watersheds

The modern wastewater sector arose from stringent federal and state laws enacted around 1970.[2] Since then utilities have made significant investments in infrastructure to comply with regulations that set water quality standards for each water body in the state. Regional Water Boards create and implement water quality plans within nine regions and issue permits for the discharge of treated wastewater to surface water and groundwater basins (Figure 1).[3] These standards can include criteria for specific pollutants, discharge monitoring requirements, and may also consider biological and recreational goals, such as environmental flows for salmon or other fish. The standards are updated periodically through the basin planning process or when a wastewater treatment plant permit is updated. This framework is designed to be flexible to address changing conditions in the receiving water body or to meet new quality standards. The State Water Board has the authority to protect water quality for all beneficial uses of water and can review decisions made by regional boards. It also has regulatory jurisdiction over the exercise of all water rights.

Most wastewater agencies around the state perform all three of the core wastewater management functions—collection, treatment, and disposal—but some focus on just one of these. In addition, some wastewater agencies are part of larger governance structures that include local water supply. To a lesser extent, wastewater agencies also provide services such as stormwater management, parks and open space management, energy production, and watershed management. Like any locally managed issue, every agency faces different circumstances and challenges in meeting its mandates—but nearly all wastewater agencies are closely linked to other parts of the water system. Next, we explore how wastewater management can be affected by changes in water use and the increasing demand for recycled water, and how those changes affect downstream users across watersheds.

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[2] Water pollution control laws by the state (the Porter-Cologne Act of 1969) and federal (the Clean Water Act of 1972) governments set the framework for regulating wastewater treatment and disposal. These laws address issues including the disposal of raw and undertreated sewage into freshwater and saltwater ecosystems.

[3] Permits issued under the Porter-Cologne Act are called waste discharge requirements (WDRs). Surface water discharge permits under the federal Clean Water Act are called NPDES permits, because they implement the National Pollutant Discharge Elimination System. Permits that implement both state and federal law are classified as combined WDR/NPDES permits.

FIGURE 1

California's nine Regional Water Boards help regulate the discharge of wastewater to water bodies

SOURCES: Cal Fire CalWater 2.2 Watersheds (Regional Water Board boundaries).

Reductions in Indoor Water Use Affect Wastewater Management

Wastewater management is challenged by two types of reduction in indoor water use—both of which are largely beyond the control of wastewater managers. **Short-term conservation** is the periodic reduction of water use during drought, mainly from changes in behavior. **Indoor water use efficiency** is the long-term, sustained reduction in per-capita water use, mainly from the adoption of low-flow plumbing fixtures and appliances. Conservation and efficiency can reduce both indoor and outdoor water use, but it is the changes in indoor water use that affect the amount and quality of water entering the wastewater system.

Wastewater agencies are tasked with removing pollutants from influent with a high level of reliability. Agencies must ensure that they have the equipment and processes in place to accommodate changing conditions while maintaining their assets and meeting water quality standards. Collection and treatment systems are designed to anticipate likely fluctuations in influent volume and quality over time.

Reductions in indoor water use pose several challenges for managing wastewater. Collection systems are compromised when flows are no longer sufficient to carry sewage to treatment plants. Concentrations of pollutants in influent can increase as consumers use less water for washing, bathing, flushing toilets, and other activities that produce wastewater. Major changes in influent quality may overwhelm the treatment capabilities of wastewater systems, resulting in damaged treatment equipment and the inability to meet water quality objectives. Adaptations to reductions in water use vary by agency.

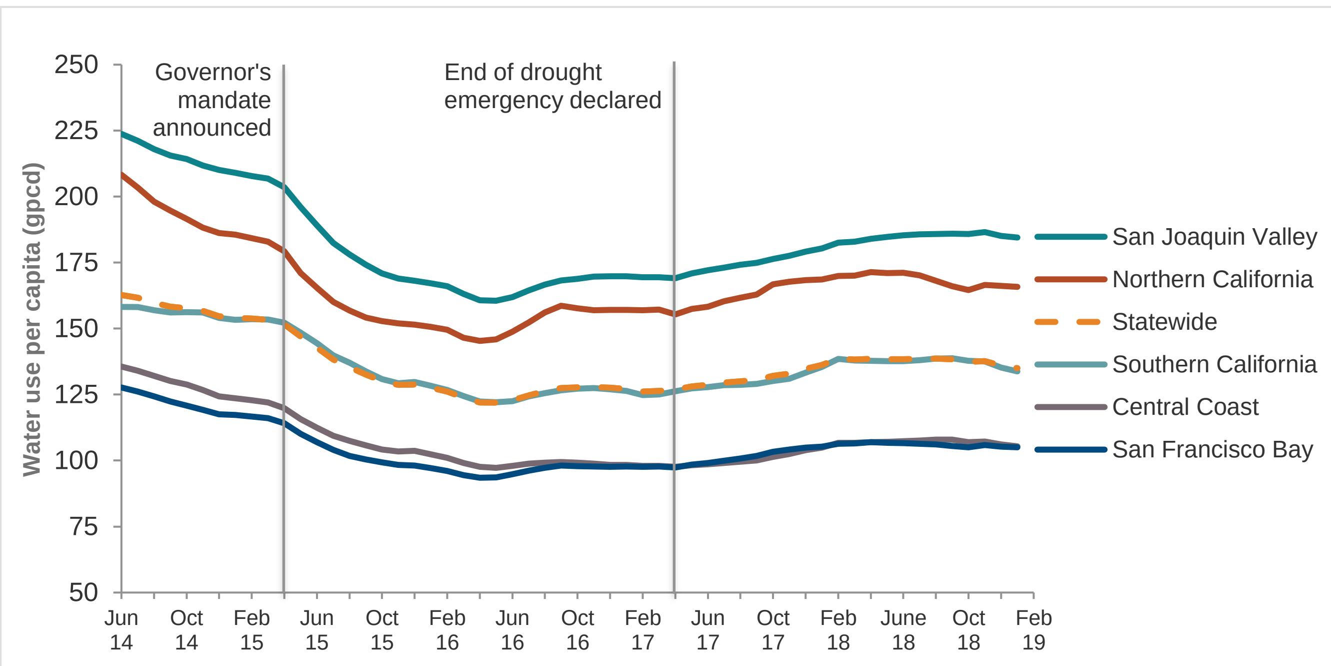
Wastewater agencies are not required to plan for rapid changes in indoor water use. Many wastewater agencies rely on forecasts of long-term trends in indoor water use to determine the size and location of new infrastructure investments. Agencies are not required to prepare these plans, though long-term planning is considered a best management practice. In contrast, urban water supply agencies are subject to an array of state requirements related to preparing for drought emergencies. Urban water suppliers are also required by the state to prepare long-term plans that forecast future supply and demand conditions.

Short-term conservation

During droughts, local water supply agencies implement a variety of demand management measures to encourage temporary reductions in their customers' indoor and outdoor water use. For instance, during the 2012−16 drought, nearly every urban water supplier used some combination of messaging, conservation incentives, and water use restrictions to compel short-term water savings (Mitchell et al. 2017). State and media messaging on drought and household water conservation also played a major role in the reduction of urban water use during this drought (Mitchell et al. 2017, Quesnel and Ajami 2017). The net result was a water use reduction of nearly 25 percent statewide (Figure 2).

FIGURE 2

Urban water use rapidly declined during the latest drought and has not returned to pre-drought levels



SOURCE: Updated from Mitchell et al. (2017).

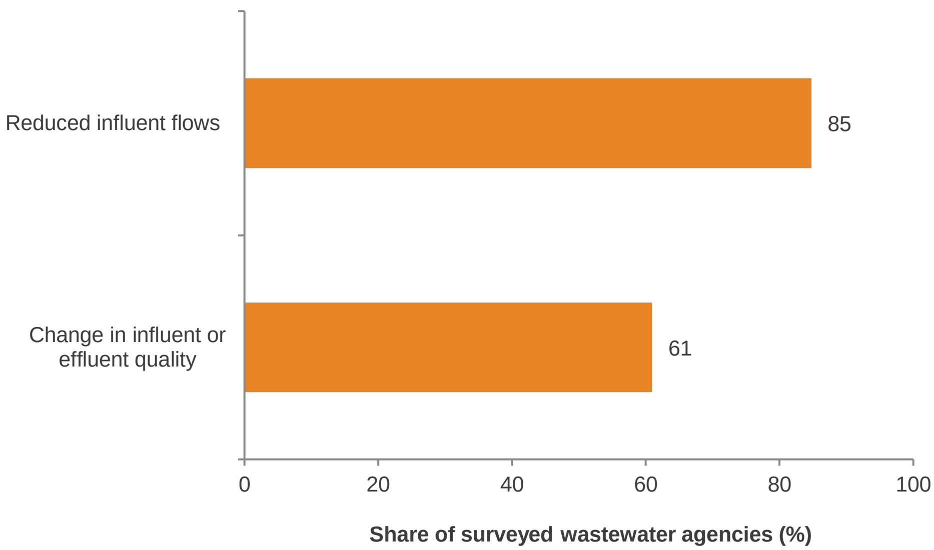
NOTES: Governor Brown declared a drought emergency in January 2014 and called for voluntary water savings of 20 percent. He announced the statewide conservation mandate in April 2015, calling for average savings of 25 percent. The State Water Board assigned state-mandated reduction targets to each agency in May 2015 and the conservation standards became effective in June 2015. In June 2016, the state authorized water suppliers with adequate supplies to revert to locally developed conservation standards. Governor Brown officially ended the statewide drought emergency in April 2017.

Both indoor and outdoor water use declined during this period. While a significant portion of the savings was likely derived from reductions in outdoor use, customers also cut back on indoor water use.[4] The rapid reduction in indoor water use resulted in declining influent flows and more-concentrated influent—setting off a cascade of challenges for wastewater agencies, including the following:

- **Declining influent quantity and quality:** More than 80 percent of agencies reported reductions in influent flows to their wastewater treatment plants (Figure 3). Most experienced reductions of between 10 and 25 percent, and nearly 10 percent reporting 25–50 percent reductions. As discussed in focus groups, large reductions in influent volume caught some managers by surprise. More than 60 percent of agencies reported a change in the quality of influent or effluent. Wastewater managers noted increases in biological oxygen demand (BOD), nutrient concentration, ammonia loading, total suspended solids (TSS), solids, and salinity (TDS) in wastewater influent. These increases reflect the fact that residential consumers used less water for bathing and toilet use.

FIGURE 3

Most wastewater agencies experienced declining influent flows during the latest drought



SOURCE: PPIC California Wastewater Agency Survey 2017.

NOTE: Overall sample size: 105.

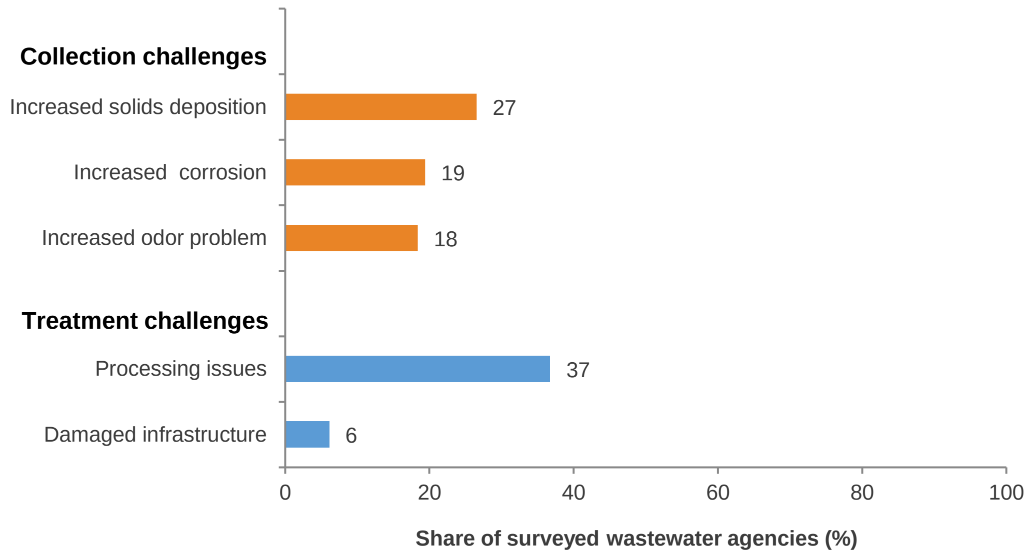
- **Collection system challenges:** When flow rates decline, solids begin to build up in sewer pipes, and wastewater can become stagnant in the collection system. Stagnation results in oxygen-poor conditions, which encourage the growth of anaerobic bacteria that generate acids and odorous gases such as hydrogen sulfide. These acids contribute to deterioration of the concrete and steel collection pipes. The increased residence time of influent in the collection pipes during the drought made influent septic—more corrosive, odorous, and concentrated. More than one-quarter of agencies observed increased deposition of solids in their collection systems (Figure 4). One-fifth indicated increased corrosion of collection systems due to declining influent quality. Corrosive influent led to physical deterioration of some wastewater collection

[4] Mitchell et al.'s (2017) comparison of statewide monthly urban water use in 2013 and 2015 suggests that water savings during the drought derived from reductions in outdoor and indoor water use. The usual peak in summer use was substantially lower in 2015, suggesting that much of the savings came from reduced landscape irrigation. But urban areas also used less water in the winter of 2015 compared to the same period in 2013. Winter water use—when landscape irrigation demands are lower—is indicative of indoor water use.

systems, likely shortening the useful lifetime of wastewater collection pipes.[5] In response to these changes, managers stepped up their monitoring and management of solids to keep influent moving to treatment plants, which added to operational costs.

FIGURE 4

Some wastewater agencies had problems with their collection and treatment systems during the drought



SOURCE: PPIC California Wastewater Agency Survey 2017.

NOTES: Overall sample size: 98. Limited to respondents reporting reduced influent flow or quality during the drought.

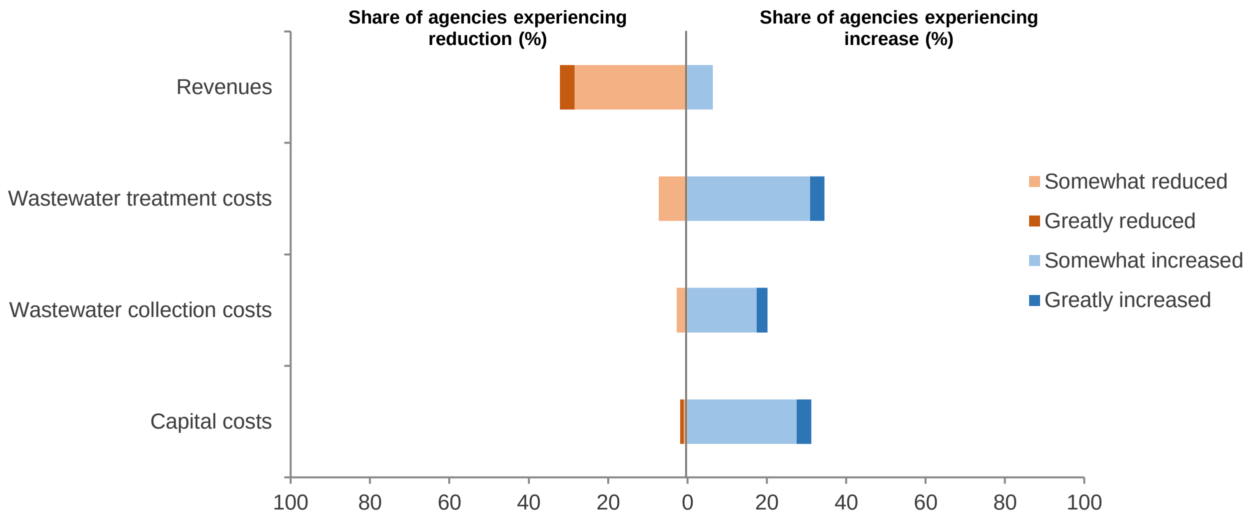
- **Treatment complications:** Treating influent with higher concentrations of pollutants proved difficult for some agencies. More than one-third of our survey respondents reported problems in the treatment process as a result of reduced influent flow or changes in influent water quality (Figure 4). Corrosive influent damaged equipment in treatment plants. Treatment processes optimized to treat and disinfect wastewater were less effective at treating higher-concentration influent. Managers were able to overcome many of these challenges by modifying aspects of the treatment process, including applying more chemicals or increasing the intensity of aeration and sludge removal. Many of these adaptations resulted in increased costs for labor, materials, and energy.
- **Impacts on revenues and costs:** Overall, around one-third of wastewater agencies reported at least some increase in costs for treatment, operations and maintenance, or capital improvements during the drought (Figure 5). Revenues also declined for some, especially for agencies that get at least some portion of their revenues from volumetric or variable rate structures (Box 2).

For many wastewater agencies, the drought highlighted vulnerabilities and provided an opportunity to examine changes that might improve their ability to cost-effectively manage risks related to short-term reductions in water use that will occur in the future.

[5] The intrusion of tree roots into sewer pipes was also mentioned in focus groups as a concern for some wastewater agencies during the drought. Tree roots seek water to survive and sometimes tap into leaky sewer pipes. Root intrusion can exacerbate existing weaknesses in wastewater collection pipes, increasing the severity of leaks and blocking the passage of influent to treatment plants.

FIGURE 5

Some wastewater agencies experienced reduced revenues and increased costs during the drought



SOURCE: PPIC California Wastewater Agency Survey 2017.

NOTES: Sample sizes varied by response category: revenues (N = 109), treatment costs (N = 110), collection costs (N= 109), and capital costs (N = 109). Just over two-thirds of respondents observed increases in other operational and maintenance costs that were not directly associated with treatment or collection (N = 111).

Indoor water use efficiency

Even before the 2012–16 drought, per capita water use had been declining because of investments in water use efficiency, and further declines are likely as a result of both state and local policies. Although these longer-term shifts do not result in the same type of abrupt changes as those experienced during droughts, they also have implications for the wastewater sector.

In 2010, average urban daily water use was 180 gallons per capita, down from 244 in 1995.[6] Indoor water savings contributed to this overall decline in water use, especially with the adoption of water-efficient plumbing fixtures and appliances in households.[7] State water-efficiency building standards and local water-use efficiency programs have both played a role in this shift. Since the early 1990s, water-saving toilets and showerheads have been required in new building construction and encouraged in older buildings through rebate programs. Single-family homes in California reduced indoor water use by an estimated 13 percent between 1997 and 2011 (DeOreo et al. 2011). Plumbing codes and appliance standards will continue to drive indoor water savings into the future.[8] In addition, local water suppliers will continue to fund water-efficiency incentive programs for homes and businesses in an effort to diversify their water supply portfolios and accommodate growth. Many urban water suppliers experienced increasing demand for these programs during the 2012–16 drought, which may have dampened rebound in water use since the end of the drought (Figure 2).

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[6] Average daily urban water use was calculated using the Department of Water Resources' *California Water Plan Update 2018 (Public Review Draft).*

[7] Water used for toilets, showers, faucets, and clothes washers accounts for 80 percent of residential indoor use (M.Cubed 2016). Businesses have also been reducing their water use, which has likely contributed to a decline in flows to wastewater treatment plants (Hanak et al. 2018).

[8] A 2016 study on indoor water use efficiency in California projected that plumbing codes and appliance standards would reduce municipal and industrial per capita water use by 9–10 gpcd by 2040 (M.Cubed 2016).

Box 2. Paying for Wastewater Management

Roughly $10 billion is spent annually to maintain and operate wastewater systems around the state (Hanak et al. 2018). The majority of this funding comes from local wastewater rates. Many local agencies use municipal bonds to help finance large infrastructure investments, but these are repaid with local revenue.

There are three main categories of wastewater rates: variable or volumetric rates based on the quantity of influent produced per customer, a flat rate per customer, or a combination of the two. Industrial rates almost always have a volumetric component. Very few California residences are metered for wastewater, so if an agency uses a volumetric rate for households it is typically based on water consumption.

Rate structure and the ability to raise rates to make needed investments is an important part of an agency's ability to adapt to changing conditions. Nearly 60 percent of respondents to our survey said that their wastewater service revenues are based at least partially on volumetric charges. But the portion of revenues that is based on volumetric charges varies, and it is often quite small (for details, see technical appendix Figure A10).

Beyond local funding, state and federal funding also supports wastewater management. For example, federal financial assistance initially played a large role in helping utilities comply with the Clean Water Act. The federal government covered up to 85 percent of the required investments in the first generation of new wastewater treatment plants and associated facilities. However, the role of federal funding has significantly declined in recent decades (Hanak et al. 2014).

California's Clean Water State Revolving Fund (SRF) is the state's main tool for funding wastewater infrastructure. It offers low-interest financing options to local wastewater agencies. Since its inception in 1987, the SRF has disbursed more than $8 billion to wastewater, water recycling, and stormwater projects.

The SRF is periodically recapitalized with state and federal funds. For example, Proposition 1 (passed in 2014) made available $260 million through the SRF for grants to small community wastewater systems, with priority given to disadvantaged communities. Proposition 1 also made available $580 million in grants and loans for local recycled water projects. And Proposition 68 (2018) made available $80 million for funding water recycling and wastewater projects (State Water Board 2018). However, the SRF is over-subscribed, with a backlog of projects seeking support. The State Water Board regularly considers new criteria for evaluating projects seeking funding, to help prioritize the allocation of scarce funds.

At the federal level, the primary funder of wastewater projects is the US Environmental Protection Agency. The agency's funds are mainly distributed to the SRF. The Water Infrastructure Finance and Innovation Act (WIFIA) also provides matching loans to eligible wastewater infrastructure projects. The US Department of Agriculture and the US Bureau of Reclamation also provide some grants and loans to local agencies for wastewater and recycled water projects.

Recent state policy changes, based on reforms suggested as part of the state's Making Water Conservation a California Way of Life initiative, are also likely to reduce per capita indoor water use (State of California 2017). In 2018, Governor Brown signed AB 1668, which requires the State Water Board and the Department of Water Resources to establish urban water use efficiency standards by June 2022. The new policy establishes an interim indoor water use standard of 55 gallons per capita per day (gpcd), to be lowered to 50 gpcd by 2030.[9] Currently indoor water use is not systematically measured in California, creating some uncertainty about the local impacts of the new standard. But it is likely to contribute to further reductions in per capita indoor water use in many

[9] The interim indoor standard of 55 gpcd is based on the provisional standard for residential indoor water use as codified in the California Water Code by SB X7-7 (2009). The national average indoor water use is currently estimated at 59 gpcd (Water Research Foundation 2016).

communities. The new policy requires the Department of Water Resources and the State Water Board to evaluate the benefits and impacts of the indoor water use standard on wastewater and recycled water systems. This provides an important opportunity to evaluate the relationship between declining water use and more-concentrated influent, and to strengthen the interconnection between urban water suppliers, wastewater agencies, and water quality.

Many wastewater agencies have observed changes in influent quantity and quality that reflect long-term declines in per capita indoor water use. Nearly one-third of wastewater agencies are experiencing long-term declines in influent volumes even where service area populations are stable or increasing. Our survey found that reduced influent flow is a persistent trend for one-quarter of wastewater agencies. These agencies observed reduced influent flows in the decades before the surge of water conservation resulting from the 2012–16 drought, as well as both during and after the drought emergency.

A recent study of wastewater treatment systems in Southern California illustrates the effect of long-term declines in indoor water use on influent and effluent. Effluent from most of the wastewater treatment plants in the study exhibited long-term increases in salts (TDS) (LeClaire 2018). The research suggested that indoor water efficiency and conservation contributed to increases in TDS in wastewater effluent. The other major factor driving the increase is higher levels of salts in water supplies. Regardless of the source, higher salinity represents a unique challenge for utilities, as standard wastewater treatment infrastructure is not designed to remove salt. If this issue grows in severity, agencies may be forced to incorporate a desalination step into wastewater treatment, which is likely to add cost and complexity.

The consequences of indoor water use efficiency for wastewater management are not yet fully understood. One scenario is that the acute challenges that wastewater agencies experienced during the 2012–16 drought will be incrementally felt as per capita indoor water use continues to decline. With adequate lead time and planning, agencies should be able to assess how changes in indoor water use and influent will affect their operations. In some cases, adjusting to the decline in influent may require significant investments in new collection and treatment equipment. And unanticipated changes in influent could make it difficult to meet effluent water quality standards.

One important question is whether some of California's cities and suburbs are approaching a practical limit on indoor water savings—the point when no additional water savings can be achieved by households and businesses without harming public health or the economy. If so, wastewater agencies serving these communities may not face significant further reductions in influent. However, for areas where higher indoor water use is still the norm, there is room for additional indoor water savings—with attendant changes in influent flows and quality—over the next several decades.

Changes in Wastewater Management Motivated by the 2012–16 Drought

Our survey found that many wastewater agencies are now pursuing specific changes to their operations, infrastructure, or finances in response to the cascade of challenges they experienced during the drought. PPIC's survey of wastewater managers collected examples of specific changes made in response to the latest drought. Several themes emerged, including:

- **Change operations and maintenance routines:** Wastewater agencies with responsibility for collection systems are increasing the frequency of service-line cleaning. Managers are anticipating the need for increased power consumption, chemical usage, and more frequent replacement of equipment. Some managers are evaluating options for increasing operational efficiency in an effort to reduce long-term costs of operations and maintenance.

- **Modify wastewater system design:** Agencies are evaluating options to increase their ability to convey and treat more-concentrated influent. This includes purchasing equipment for moving solids through the collection system and diverting solids in the treatment process. Some agencies may be pursuing more efficient and effective treatment processes designed to accommodate influent with higher concentrations of pollutants.
- **Monitor for changes in influent and effluent:** Some agencies are taking steps to increase monitoring of source water, influent, and effluent water quality. Increased monitoring of water quality allows for detection of short- and long-term trends, which could be useful in guiding responsive actions or future upgrades to equipment.
- **Adjust rates:** Nearly one-fifth of wastewater agencies considered changing their rate structure as a result of experiences during the drought. For some agencies, this means increasing the fixed charges on wastewater bills—the portion of the bill that does not vary based on customer usage. This change will insulate revenues from temporary changes in water use that will occur in future droughts. A small number of agencies are also evaluating rates that reflect different levels of influent strength—with higher rates for more-polluted influent.

Demand for Recycled Water Is Growing

Another longer-term trend that was intensified during the 2012–16 drought is increasing demand for recycled water. This, too, has significant implications for wastewater management, as it highlighted the need to improve the wastewater sector's ability to meet increasing demands for recycled water. Treated wastewater was once mainly regarded as something to get rid of, but that mindset is changing. Interest in water recycling has been increasing nationally, including in California (US Environmental Protection Agency 2018). While some treated wastewater has been reused in California for many years, there has been a significant uptick in demand over the past two decades. A survey by the State Water Board found that California used 714,000 acre-feet per year of recycled water in 2015, nearly three times the volume used in the late 1980s (Figure 6).

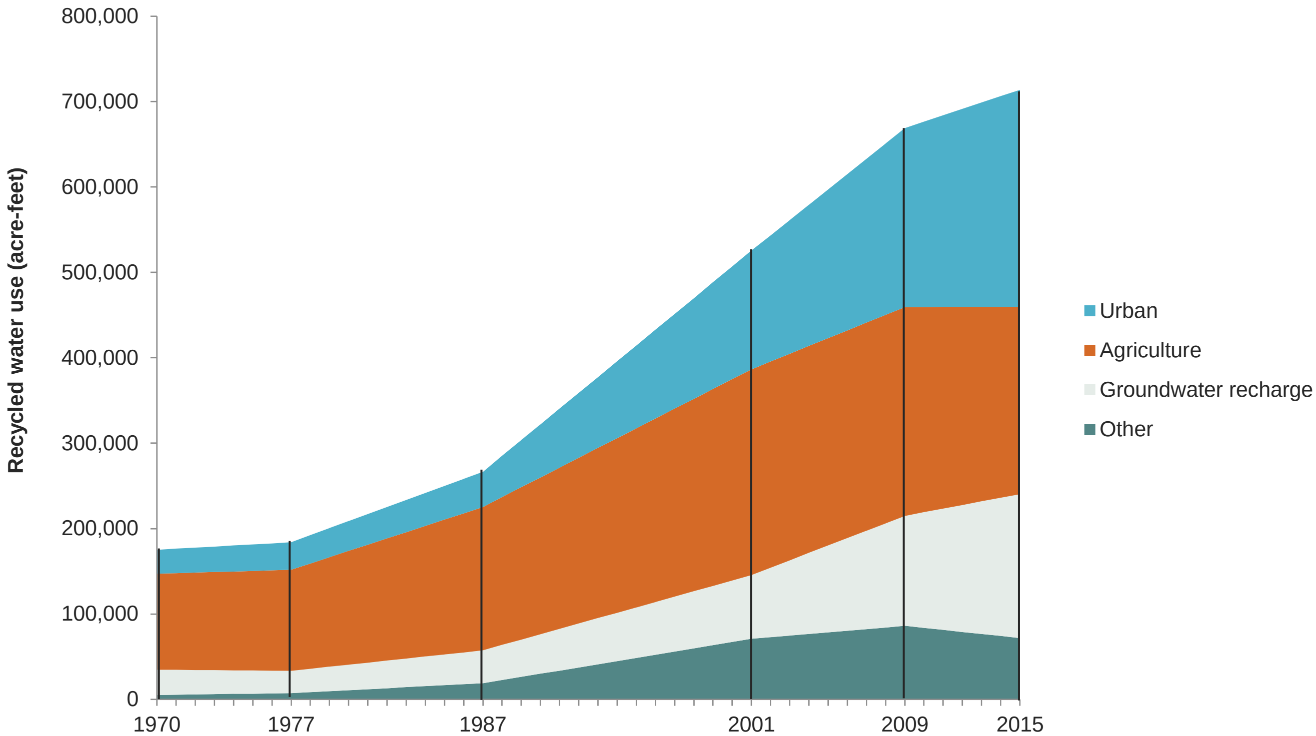
The types of demand for recycled water are also changing. Historically, recycled water was used for irrigated agriculture and, to a lesser extent, urban landscape irrigation.[10] In recent years, wastewater agencies in urban areas have increased the amount of recycled wastewater used for public landscape irrigation, golf courses, industrial cooling, and groundwater recharge (State Water Board 2017a). Advances in technology and improved regulations have increased opportunities to reuse wastewater locally. As the majority of the population (and hence most wastewater) resides far from agricultural land, there are practical advantages to using recycled wastewater locally for municipal and/or industrial uses rather than delivering it to farms. Water quality standards for recycled water that supplements drinking water supplies are generally higher than standards for recycled water used for irrigation on urban landscapes or farms. Accommodating the increased use of recycled water for drinking water may require upgrading treatment equipment to meet higher standards.

While more than half of wastewater agencies in our survey are already recycling wastewater, others are considering making investments in recycled water systems for the first time. Some agencies have more demand than supply, and place recycled water customers on waitlists until new supplies come online. Nearly half of wastewater agencies observed increased demand for recycled water during the latest drought (Figure 7).

[10] Prior to 2001, agricultural irrigation accounted for more than 60 percent of recycled wastewater use; in a 2015 survey, it was 31 percent. The primary use of recycled water in the Central Valley is for agricultural irrigation.

FIGURE 6

The amount of recycled water use is increasing



SOURCE: State Water Board (2017b) and authors' calculations.

NOTES: Volumes of recycled water use are from six surveys about recycled water use in the state. Given the limited number of data points over time, we calculated values in between survey points using linear interpolation. Actual trends in recycled water use between survey years may vary. Urban use refers to landscape and golf course irrigation, commercial use, and industrial use. Groundwater recharge use refers to groundwater recharge for potable reuse and seawater barriers. Other uses of recycled water include natural systems restoration, recreational impoundment, and geothermal energy production.

This trend has motivated many agencies to consider building new water recycling projects or expand capacity of existing projects.[11] One-quarter of wastewater agencies continued to see an increase in demand for non-potable recycled water after the drought. Nearly all of them indicated that they are considering new treatment or distribution systems to meet growing demand. This includes increasing rates of production, building storage for recycled water, constructing new distribution systems, and encouraging on-site reuse.

Agencies making recycled water investments must consider many variables to ensure that their projects provide long-term benefits. The most successful investments match the quantity and quality of recycled wastewater to the long-term demands of their customers. This requires predicting how long-term demands in a region may change over time and incorporating these predictions into the design of the system. Location is an important factor as well. The demand for recycled water (including for groundwater recharge) is not always near current treatment plants, and may require conveyance to places of use.[12] Gathering the information to "right size" and "right locate" recycled water projects requires inputs from neighboring wastewater and water supply agencies and stakeholders that do not typically coordinate their decision making (Tran et al. 2016). Improved coordination between wastewater and water supply agencies is key to developing effective responses to long-term demand trends.

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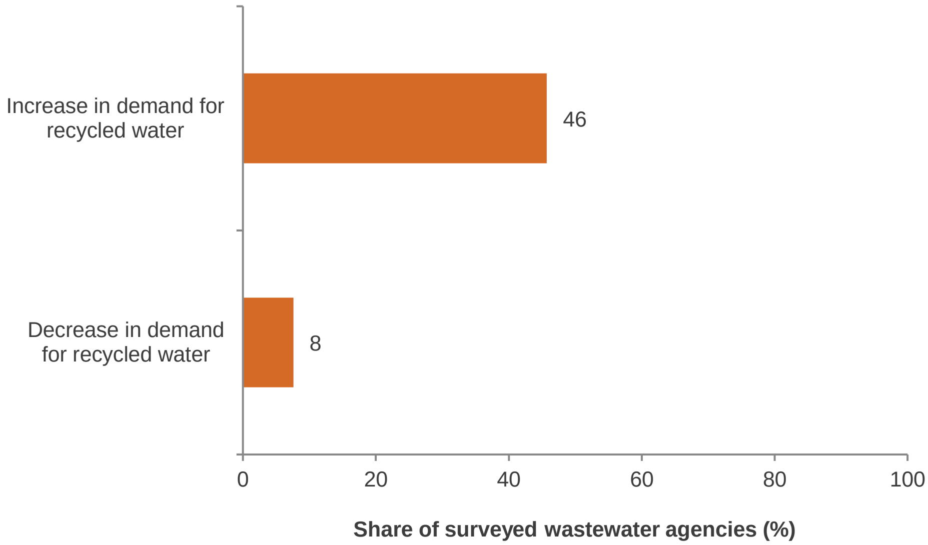
[11] Since the end of the drought in 2016 the State Water Board has received a dozen petitions to change wastewater operations for recycled water projects. Details can be found here.

[12] For example, a pipeline was recently built to connect the City of Modesto with the Del Puerto Water District to transport recycled wastewater. This east-west conveyance system allowed the districts to circumvent conveyance through the Delta (Hanak et al. 2019).

FIGURE 7

Nearly half of wastewater agencies observed increased demand for recycled water during the latest drought



SOURCE: PPIC California Wastewater Agency Survey 2017.

NOTES: Overall sample size: 105. Increasing demand for recycled water includes non-potable and potable recycled water. Decrease in demand for recycled water includes non-potable recycled water only. Less than 10 percent of respondents experienced a decrease in demand for recycled water during the drought. The state's mandatory conservation targets applied only to potable water use. However, some water agencies in our survey reduced the use of non-potable recycled water for irrigating public landscapes—despite sufficient supplies—due to public perception that this constituted a waste of water during the drought.

Using recycled wastewater to replenish groundwater or augment surface water sources is one way that wastewater agencies can effectively link their recycled water production to long-term demand. For example, Orange County's Groundwater Replenishment System, a partnership between the Orange County Water District and the Orange County Sanitation District, recharges a local groundwater basin with highly treated wastewater. This innovative project has been a model for six other urban groundwater recharge projects in the state.

Another important consideration in increasing production of recycled water is reduced influent quantity and quality. The latest drought demonstrated how influent quantity and quality can change significantly when water use declines. The reduced quality of influent during the drought also limited opportunities for reuse. In our survey, roughly 40 percent of agencies producing recycled water reported that reduced influent flows impaired their ability to produce recycled water. This was especially true for wastewater systems that experienced increasing salt (TDS) in influent during the drought. Recycled water with elevated salt levels may not be suitable for some outdoor irrigation uses like golf courses or lawns.

Recycled water projects require proponents to navigate a complex regulatory framework. State recycled water regulations and technologies are still developing, with the biggest questions surrounding direct potable reuse and on-site wastewater or decentralized reuse. California's Recycled Water Policy established rules for how treated wastewater may be reused to ensure protection of human health. The State Water Board has updated this policy over time to reflect new uses of recycled water—most recently, in December 2018. California has adopted reuse rules that provide detailed criteria for treatment processes, contaminants to monitor, and how long treated water must remain underground before being used in urban water supplies. In 2018, the state also finalized regulations that allow highly purified recycled water to enter into drinking water reservoirs.

The next phase of this regulatory process is to adopt uniform water recycling criteria for potable reuse through raw water augmentation (recycled water that is conveyed to drinking water treatment plants). AB 574, enacted in

2017, requires the State Water Board to develop these regulations by 2023. Having an expanded set of options for potable reuse may increase the opportunities for recycled water use in many communities. But until these regulations are finalized, agencies are making decisions in the face of uncertainty. Agencies that made investments under past recycled water regulations—for example, separate recycled water distribution pipes—may find those investments obsolete if future regulations allow recycled water to be distributed in the same pipes as drinking water supplies.

Demand for on-site reuse has also been growing—for example, the installation of graywater systems that reuse water from sinks, washing machines, and showers for toilet flushing or landscape irrigation. SB 966, enacted in 2018, requires the State Water Board to develop water quality standards for on-site treatment and reuse of non-potable water. This new policy may result in more on-site reuse projects.[13] The potential benefits of on-site reuse vary significantly based on local characteristics. For instance, in a community where the costs of transporting recycled water from a centralized treatment plant are very high, this can be a cost-effective way to reuse water. In contrast, in some areas buildings with on-site wastewater treatment systems may lower the quantity and quality of influent sent to sewers, with negative impacts to existing wastewater infrastructure. There is also concern in the wastewater sector that on-site reuse will dampen demands for larger regional recycled water projects.

Wastewater Management Has Downstream Impacts within Watersheds

With the exception of the facilities that discharge directly to the ocean, most wastewater treatment plants are designed to discharge treated effluent into rivers, streams, and estuaries. In some cases, discharged effluent can play an important role in these watersheds—especially when it serves as a source of water for vulnerable aquatic ecosystems and downstream water users. Significant increases in effluent quality over time have largely minimized the negative impacts of polluted sewage on the environment and public health. But decreases in effluent flows caused by changing water use patterns, drought, and recycled water demands may leave less water in rivers and streams. In high-tradeoff watersheds, where a reduction in wastewater effluent flow or quality would result in conflict among urban, agricultural, or environmental water uses, wastewater managers and regulators may face difficult decisions.[14]

Despite significant reductions in water use during the 2012–16 drought and record low flows in rivers and streams, wastewater managers were largely able to avoid conflicts with environmental and downstream users. In PPIC's survey, very few wastewater agencies reported challenges in meeting discharge requirements to rivers and streams. However, avoiding negative downstream impacts might be more difficult in the future as indoor water use declines and as climate change puts additional pressures on water supplies and the environment.

Recycled water projects illustrate some of the conflicts that may arise with declining effluent flows. In some cases, reusing treated wastewater may harm environmental quality, particularly in effluent-dominated water bodies that provide habitat for endangered species. One example is the Coachella Valley, where increased use of recycled water would decrease flows to the already shrinking and vulnerable Salton Sea.[15] Decreasing effluent

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[13] The law is intended to create regulatory clarity for local jurisdictions by creating a statewide framework for local implementation of on-site treatment and reuse programs. Local jurisdictions will be required to adopt these standards.

[14] Some high-tradeoff areas have already been identified and institutions are in place to understand and facilitate decision making. The clearest example of this is the Santa Ana Watershed Project Authority (SAWPA), a joint-powers authority established in 1974 to manage water supply and water quality in the Santa Ana River watershed. After many years of conflict over changing demands for water quality and supply, the five large water districts that serve the watershed developed SAWPA to integrate management of water supply, waste and stormwater treatment, and environmental objectives.

[15] Coachella Valley Water District submitted a wastewater change petition in 2017 to upgrade one of its treatment plants to produce non-potable recycled water for irrigation purposes. This petition is still pending as the district analyzes the environmental impacts to the Salton Sea. Efforts to reuse water in the Coachella and Imperial valleys will mean less water draining into the Salton Sea, which is already receding more rapidly under a farm-to-city water transfer deal.

flows can also reduce water for downstream surface water users and groundwater replenishment projects. Wastewater agencies will need to balance their decisions to recycle water against such potentially negative impacts. Although resolving these issues is not impossible, it requires coordination between water suppliers, wastewater agencies, and downstream water users.

The state also plays a role in mitigating downstream impacts from wastewater management decisions. From the perspective of quality, the State and Regional Water Boards ("water boards") regulate the discharge of pollution through the discharge permitting process. From the perspective of quantity, the State Water Board is responsible for ensuring that recycled water projects do not negatively affect the environment and other downstream users. California Water Code Section 1211 requires approval from the State Water Board for recycled water projects that decrease effluent flows to a water body. This provides an opportunity to evaluate whether the proposal harms other users in the watershed. This process usually includes input from other entities such as the Regional Water Boards and the California Department of Fish and Wildlife.

The State Water Board is tasked with balancing multiple objectives that sometimes conflict. It seeks to encourage recycled water projects while also protecting human health, safeguarding the environment, and minimizing conflicts over water rights that could result from recycled water projects. There is a need for effective and timely tools to assess the downstream tradeoffs, especially for the environment, from declining effluent at the project level. These tools will become even more valuable over time as indoor water use declines and recycled water demand continues to grow.

Recommendations for a More Resilient Wastewater Sector

The wastewater sector is at a turning point. Water supply and demand conditions are being affected by population growth, technology and policy changes, and drought. A changing climate will accentuate existing challenges and bring new risks. How these trends influence wastewater management practices will in turn affect downstream ecosystems, cities, and farms. The sector must address three linked challenges:

- Maintaining water quality in the face of changing water use;
- Making smart recycled water investments; and
- Balancing conflicting objectives within watersheds.

Like the challenges themselves, actions to prepare for and address them are strongly linked and build on each other.

Maintaining Water Quality in the Face of Changing Water Use

Wastewater agencies face the difficult challenge of providing consistent effluent water quality even when the quantity and quality of influent falls. Changing influent characteristics during the 2012–16 drought damaged infrastructure and reduced the effectiveness of existing treatment processes. Such challenges may grow as severe droughts become more frequent and indoor water efficiency increases.

Recommended Actions

Wastewater management is heavily influenced by patterns of water use that are generally beyond the control of wastewater managers. Better coordination and information sharing with water suppliers are important tools for addressing short- and long-term changes in water use.

Increase information exchange

Having information on demand management strategies being employed by water suppliers would reduce uncertainties about short- and long-term changes in influent characteristics for wastewater agencies. Wastewater managers would benefit from knowing which demand management strategies are deployed, when and where the strategies are being implemented, and how much indoor water savings are expected over time. About two-thirds of respondents to our survey said they would like to see increased coordination with water suppliers. The Department of Water Resources and the State Water Board could help facilitate better exchange of information and provide guidance for integrating water supply and wastewater planning.

Improving drought response. Timely and accurate information about urban water suppliers' water conservation strategies can help wastewater managers anticipate where and when to expect short-term changes in influent characteristics. Water suppliers may also be able to estimate how much savings will be achieved. Such information allows wastewater managers to anticipate potential damage to wastewater infrastructure, plan for adaptations in operations and treatment, and prepare to mitigate the impacts of declining effluent quality or quantity on the environment and downstream water users.

At present, there are no formal requirements that water suppliers coordinate with wastewater agencies during times of drought. Water suppliers should be required to share information with wastewater agencies to help them adapt to rapid declines of influent. For example, the state could require or request that urban water suppliers share annual water shortage assessments directly with wastewater managers.[16] Another way to facilitate coordination would be to require water suppliers to notify wastewater agencies when their Water Shortage Contingency Plans (WSCP) are triggered or change stages.

Adapting to long-term indoor water use efficiency. Wastewater managers would benefit from knowing how water suppliers intend to achieve long-term water savings in response to new state urban water efficiency standards—particularly, how much savings are expected from indoor water use efficiency. This information would allow wastewater managers to adjust long-term operations and investment plans to better reflect expected changes in influent quality and quantity.

As required by AB 1668, the Department of Water Resources and the State Water Board must now consider the impacts of changing indoor residential water use standards on wastewater management, including impacts to operations, infrastructure, and recycling systems.[17] In addition to evaluating impacts, the state agencies could develop formal recommendations for wastewater planning to complement new indoor residential water use standards. These recommendations could include guidance on how wastewater and water supply agencies can use information exchange to overcome future challenges.

Plan for future droughts

Wastewater managers should be required to have drought response plans describing operational, financial, and technical adaptation measures to address changes in influent characteristics. Wastewater drought plans could be modeled on the WSCP—a plan prepared by every urban water supplier documenting supply and demand management actions taken in response to various levels of water shortage. Wastewater drought plans would similarly define several stages of reduction in influent quality or quantity based on the demand management

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[16] SB 606, enacted in 2018, requires urban water suppliers to prepare and submit a water shortage assessment to the Department of Water Resources on or before June 1 each year. The assessment is based on an evaluation of the water supplier's supply and demand conditions. Agencies detecting a shortage are expected to describe it and list actions that are likely to be taken to address it.

[17] This bill, along with SB 606, implements aspects of the state's Making Water Conservation a California Way of Life initiative. AB 1668 establishes new indoor water use standards and requires DWR and the State Water Board to evaluate the benefits and impacts of the new indoor residential water use standards on water and wastewater management.

actions of the water suppliers serving their customer base. Plans would define a suite of strategies for mitigating damages or adapting processes at each stage. For example, strategies could include increased cleaning of solids in the collection system or modifying treatment processes.

Wastewater agencies that are not responsible for collection systems need to coordinate their planning with those agencies that do the collection to prepare for the changes in both the quantity and quality of influent entering wastewater treatment plants.

One option for implementing this recommendation is through new legislation requiring wastewater agencies to prepare and periodically update drought response plans. Another option is for the State Water Board to embed drought planning requirements as a condition for effluent discharge permits.

Improve understanding of wastewater system vulnerability

During the latest drought, some wastewater agencies experienced damage to their wastewater collection and treatment systems due to the declining quantity and quality of influent. Wastewater treatment during the drought also required increased power consumption and chemical usage in order to accommodate more-concentrated influent. These experiences motivated some wastewater agencies to assess how their operations and infrastructure must change to prepare for droughts of the future. However, many agencies—especially those that did not experience acute challenges during the 2012–16 drought—have less-developed awareness of their system's vulnerability to future challenges such as drought, large precipitation events, and sea level rise. All wastewater agencies should conduct holistic assessments of their vulnerability to major climate pressures. These assessments will inform agency plans for upgrading collection and treatment systems so that they can operate effectively under future conditions.

The state could play an important role in developing and disseminating this knowledge. For example, the State Water Board could allocate a small portion of funds currently dedicated to wastewater and recycled water system upgrades to research on wastewater system vulnerabilities. Research grants could be awarded to wastewater agencies for identifying and describing vulnerabilities. The resulting recommendations would be useful to the State Water Board and the wastewater sector as a whole.

Making Smart Recycled Water Investments

Demand for recycled water is increasing across the state, and water supply and wastewater managers are considering further investments in recycled water infrastructure. No two recycled water projects are the same, as they reflect unique local circumstances such as distance to end users and characteristics of long-term demands. Any new or expanded recycled water system requires significant upfront investment and customer buy-in. Therefore, projects should be based on a careful consideration of local demands and costs, and also how well the investment fits into the overall regional supply of water for both human and environmental uses.

Recommended Actions

Strong coordination between wastewater and water supply agencies will be essential to respond effectively to the increasing demand for recycled water. Formalized planning for recycled water projects at the regional level will likely lead to more efficient processes and better outcomes. New investments should be responsive to changing water use, climate change, and pending regulations.

Regional plans for recycled water investments are needed

To coordinate and integrate decision making, wastewater and water supply agencies should partner with cities and stakeholders to develop master plans for their regions. Regional assessments of the current infrastructure, such as existing recycled water distribution pipes or capacities of various treatment plants, can improve decision making for new investments.[18] Regional plans could identify opportunities for local utilities to improve how their systems work together. This includes investing in regional interconnections and sharing recycled water. Regional plans would also allow for strategic decisions on the most appropriate use of decentralized wastewater treatment and recycling facilities—for example, areas that are difficult to reach with the existing sewer system or where it may be more cost-effective to recycle water closer to the demand.[19] Making these investments in coordination with neighboring agencies would help to maximize the benefits and reduce the costs of recycled water.

Regional plans and investments could also help mitigate downstream tradeoffs. With the exception of facilities that discharge directly to the ocean, most wastewater treatment plants discharge effluent into watersheds. Individual recycled water projects could affect the ability of agencies downstream to use or recycle water. Regional plans could help coordinate investments between agencies and review watershed-level impacts for both human and environmental uses. And as previously recommended, these plans would be strengthened by increased information sharing on changing water use characteristics.

Focus on flexible recycled water investments

State regulators and the wastewater sector assume that California will continue down a path of increased water reuse. But there is no one-size-fits-all recycled wastewater project. Each circumstance will need a uniquely engineered solution to reflect the attributes of the region and its customers. However, all systems will need to accommodate some combination of changing water use patterns and demands, new regulations, and a range of climate pressures.

There are different ways to accomplish this. For example, recycled water demand changes seasonally or annually. Combining a recycled water project with a storage component (e.g., groundwater replenishment or reservoir augmentation) increases flexibility to use the water when it is most needed. The cost of recycling wastewater for potable reuse is generally considered high relative to other potable water supplies. However, if this water can be stored and used as a drought reserve, the value of the water would be higher and might help offset the cost. For example, the Metropolitan Water District of Southern California, in partnership with the Sanitation Districts of Los Angeles County, is planning a regional recycled water program that would produce up to 150 million gallons daily. Purified water from the advanced treatment facility at the Joint Water Pollution Control Plant would be delivered through 60 miles of new pipeline to four groundwater basins in Los Angeles and Orange counties. To accommodate flexibility to pending regulations, the system is also being designed to be upgraded and connected to the full water supply infrastructure once raw water augmentation is approved.

Investments are also needed to test new technologies and designs that allow for more reliable operations under changing water use patterns, especially during droughts. After the latest drought, agencies are looking for infrastructure that is better able to process more-concentrated influent and lower influent flows. And some managers are considering investments in equipment and staff to more closely monitor influent and effluent characteristics—allowing them to better respond and adapt to changing conditions.

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[18] For example, agencies in Santa Clara County are undertaking a Countywide Water Reuse Master Plan, to be completed in 2019. One key question for that region is what to do with its extensive network of recycled water distribution pipes. Since new recycled water investments will likely allow the distribution of recycled water in water service pipes, pipes built exclusively for distributing recycled water could become an expensive stranded asset.

[19] When asked about constraints encountered in meeting recycled water demands and expanding water recycling infrastructure, half of our survey respondents indicated that the lack of infrastructure to deliver recycled water was a constraint.

Currently, funds are available from state and federal programs to assist local agencies with their recycled water projects. Decisions on eligibility for funding assistance should consider whether proposed recycled water systems are designed with enough flexibility to withstand evolving conditions.

Balancing Conflicting Objectives within Watersheds

Adapting to declining water use and meeting increased demand for recycled water may conflict with environmental objectives and downstream users in some watersheds. Wastewater agencies will increasingly need to balance their management decisions against potentially negative impacts to these other uses. The changing climate exacerbates these conflicts. As drought severity increases, rivers and streams are expected to experience lower flows and higher temperatures, increasing threats to aquatic ecosystems. More severe droughts are also likely to increase competition for scarce water resources, adding to pressures on aquatic ecosystems and increasing tensions among water users.

Recommended Actions

To help alleviate such conflicts within watersheds, it will be necessary to identify areas vulnerable to changes in wastewater management, build decision-making tools, and ensure that various state policies affecting wastewater management are consistent.

Identify watersheds vulnerable to changes in wastewater management

Conflicts over declining wastewater effluent flows are most likely where discharged wastewater makes up a significant amount of streamflow that supports vulnerable aquatic ecosystems and downstream users. A better understanding of where high-tradeoff areas occur will enable the water boards to know where to focus their regulatory actions.

Identifying high-tradeoff areas will require better information on watershed characteristics. In addition to existing monitoring efforts, the water boards will likely need to collect and analyze additional data on wastewater discharge volumes, streamflow characteristics, aquatic ecosystems, and downstream users. Collecting and analyzing additional data will require coordination with other agencies, including the Department of Fish and Wildlife. This coordination will become easier as recent efforts to improve data sharing mature.[20]

Knowing where effluent-dependent ecosystems are located will allow the water boards to anticipate the highest risks to the environment and downstream users during drought. Developing this knowledge will also help identify where recycled water projects are most likely to bring negative consequences. The State Water Board could use this information to prioritize its recycled water permitting efforts, even developing a streamlined process for recycled water projects outside of high-tradeoff watersheds.

As the principal authorities for regulating wastewater discharge quality, the nine Regional Water Boards are most familiar with characteristics of wastewater effluent and the water bodies to which they discharge. Identifying high-tradeoff watersheds could be incorporated into the water boards' basin planning processes.

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[20] Investments in additional data collection, such as stream gages, would help make this effort more effective. California lacks any state or federal stream gages on half of the rivers and streams that support critical habitat (McCann and Escriva-Bou 2017). The Nature Conservancy's recent report on the stream gage gap suggested that 86 percent of the state's rivers and streams are poorly gaged (The Nature Conservancy 2018).

Develop science to support management and regulatory decisions

In high-tradeoff watersheds where changing water use or increased investments in recycled water are likely to cause conflict, tools are needed to help weigh the benefits of management decisions against the costs to aquatic ecosystems and downstream water users. Regional water recycling plans, as previously recommended, can help illuminate tradeoffs and potential for collaboration among agencies, but better information is needed to evaluate the impacts of water recycling projects on the environment. The State Water Board can facilitate this process by requiring that agencies in high-tradeoff watersheds work together to develop decision-making tools. One example of this is happening in the Los Angeles River watershed (Box 3).

Box 3. Collaborating on Flows for the Los Angeles River

Treated wastewater is critical to the flow of the Los Angeles River. Local agencies are considering investments in recycled water projects that will reduce this flow. The State and Regional Water Boards, the City and County of Los Angeles, and the Sanitation Districts of Los Angeles County are collaborating with the Southern California Coastal Water Research Project (SCCWRP) on a two-year study to determine the potential ecological and recreational effects of diverting treated wastewater effluent and runoff from the river for recycling purposes.

The study, launched in October 2018, marks a groundbreaking effort by California's water-quality management community to document how vulnerable species and habitats along this urban, 45-mile stretch of the lower LA River could be affected by potential effluent flow reductions. SCCWRP will also document effects on recreational uses of the river, such as kayaking. One goal is to consider how these impacts could be offset by other investments, such as river restoration projects.

Researchers plan to develop recommended flow targets by season and section of the river. They will seek to balance the need to protect the river's ecological and recreational uses with local agencies' desire to capture, divert, and recycle more of the river's flows. The study also will help inform various ongoing LA River planning efforts, including One Water LA and the LA River Revitalization Master Plan.

The water boards will be responsible for evaluating hundreds of requests as local agencies seek to modify their systems. Investing in scientific tools that provide rapid metrics for determining how flow changes will affect ecosystems can help regulators make more informed decisions more quickly. Developing these scientific tools locally, with the participation of stakeholders, can result in more buy-in on resulting regulatory decisions (Mount et al. 2016).

Evaluate the interplay of state policies to identify tradeoffs

The State Water Board and Department of Water Resources must evaluate the impacts of the new indoor water use efficiency standards on wastewater treatment and recycled water production. This requirement should be expanded to include an evaluation of how the new standards will impact downstream users, including water quality protections for the environment. The state also has a responsibility to evaluate its own policies for areas of conflict between water use efficiency, recycled water production, and environmental flows. The state needs to be clear about the inevitable tradeoffs associated with these goals and help set priorities. For example, any new state goals for recycled water production will need to consider new water-use efficiency policies. This sort of evaluation would send a signal that the state acknowledges the interconnectedness of these priorities, and intends to provide guidance to local agencies as they develop plans for meeting new policies.

Conclusion

The wastewater sector must adapt to changing water use patterns, a growing population, new regulations, and a range of climate pressures in decades to come. Preparing for these changes now will help the sector build resilience under today's conditions and adapt to what lies ahead.

Fortunately, awareness of the scope of the sector's climate challenge is growing, and the state's wastewater agencies are starting to take action. The reforms recommended here—increasing information sharing and coordination with local water suppliers and state agencies, planning explicitly for future droughts, making smart recycled water investments, and developing tools and policies to better manage conflicting objectives within watersheds—will build on this momentum and better prepare agencies to withstand the impacts of reduced water use during prolonged droughts.

The state should help the wastewater sector make these adaptations, which are critical to building a more integrated and resilient water system. State funding in this sector should be targeted toward adaptation investments and support for regional approaches to planning and research. The state also has a responsibility to evaluate its own policies for areas of conflict between water use efficiency, recycled water production, and environmental flows. The state needs to be clear about the inevitable tradeoffs associated with these goals and help set priorities.

The latest drought provided a window into the looming challenges facing the wastewater sector. Forging new partnerships to tackle the full range of climate-related risks will help the sector determine the best adaptations and policy improvements needed to prepare wastewater management—and California's water system as a whole—for a more volatile future.

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