June 4, 2021

Karla Nemeth
California Department of Water Resources (DWR)
1416 9th Street, Room 111-1
Sacramento, CA 95814

SUBJECT: IRWUS Draft Report Comment Letter

Dear Ms. Nemeth,

On behalf of the California Association of Sanitation Agencies (CASA), Central Valley Clean Water Agencies (CVCWA), California Water Environment Association (CWEA) and Southern California Alliance of Publicly Owned Treatment Works (SCAP), we thank you for the opportunity to provide comments on the Department of Water Resources (DWR) Draft Report to the Legislature on the Results of the Indoor Residential Water Use Studies (Draft Report). Attachment 3 to this letter provides a description of the organizations contributing these comments.

At the outset, we recognize, appreciate, and agree that water conservation is, and must be, a way of life with our growing population and the impacts of climate change. We appreciate the State's leadership through DWR and the State Water Resources Control Board (SWRCB) in addressing the current drought emergency. We also commend the State's local and regional drinking water agencies for their investments in conservation and achievements in substantially reducing water usage in their respective service areas.

Within this context, we do have a key overarching concern with the Draft Report. While not the focus of the proposed indoor water use standards, California sanitation agencies will need to mitigate the impacts these reduced flows will have on the operation and efficacy of wastewater collection systems and treatment plants, which are designed for significantly greater flows than those proposed in the Draft Report. Attachment 1 to this letter sets forth a number of material impacts and adverse effects of significantly lower flows on wastewater and recycled water infrastructure. We do not suggest that these potential impacts in and of themselves outweigh the water supply benefits of indoor water conservation. They are, however, important and relevant considerations. These operational, financial, and water quality impacts need to be fully understood and evaluated in order to select appropriate and sustainable standards, avoid unintended consequences, and best plan to provide the funding and support needed to mitigate these ancillary impacts of new indoor water standards.

Toward this point, DWR acknowledges that the Draft Report does not analyze or consider these impacts, which is one of its express limitations. Section 7 of the Draft Report notes adoption of the proposed standards will have an "unknown effect on affordability, unknown effect on the human right to water" and that there has been, "no quantitative analysis of benefits and impacts, [and] no analysis on feasibility of best practices."

If DWR believes that a revised standard should be proposed in the report to the Legislature, any revised standard put forward must be supported by appropriate information from specified studies and investigations reflecting different best practices for indoor residential water use than the current ones.[1]

Absent a feasibility analysis of best practices, and given that the Draft Report would first effectuate a change in the revised standard in 2025, we respectfully recommend that, consistent with the Water Code, DWR incorporate an analysis of the how the changing standard for indoor residential water use will impact wastewater management, recycling and reuse systems, infrastructure, operations, and supplies. This analysis is essential to determine the impacts that would result from a revised standard, and whether those impacts would fit within the definition of "best practices" for indoor residential water use standards.

---

[1] Water Code § 10609.4 (b)(1): The department, in coordination with the board, shall conduct necessary studies and investigations and may jointly recommend to the Legislature a standard for indoor residential water use that more appropriately reflects best practices for indoor residential water use than the standard described in subdivision (a). A report on the results of the studies and investigations shall include information necessary to support the recommended standard, if there is one. The studies and investigations shall also include an analysis of the benefits and impacts of how the changing standard for indoor residential water use will impact water and wastewater management, including potable water usage, wastewater, recycling and reuse systems, infrastructure, operations, and supplies.

The SWRCB currently is overseeing such analyses, which will be available between November 2021 and January 2022. This analysis is part of the Standard Regulatory Impact Assessment (SRIA) being conducted for the SWRCB's forthcoming regulatory proceedings on the long-term water use efficiency standards, and it features empirical analysis of the impacts by economists. Accordingly, we urge against recommending a firm revised standard at this time as part of the Draft Report, and instead, recommend DWR put forth a provisional recommendation taking into account the caveat of additional analytical work being performed to ensure the feasibility of implementing a final recommendation. This recommendation would have no impact on expected water savings in the interim, could avoid unnecessary adverse impacts to water and wastewater management, and would allow the Department to fulfill the statutory requirements to collaborate and analyze the impacts on water management.

Significantly, it should be noted that in the next 5 to 10 years, several potable reuse projects are anticipated to become operational, offsetting potable water demands. However, the proposed indoor conservation standards could reduce influent availability for these projects, which can adversely impact the efficiency and economic viability of these important potable water augmentation projects. Attachment 2 to this letter is a partial list of permitted and planned potable reuse projects in progress totaling over 700,000 acre feet per year. Before proposing a standard that will further reduce flows and water available to those facilities for recycling, such potential impacts and offsets should be thoroughly analyzed.

Conclusion

The 2018 water conservation legislation set a bold usage target of 50 gallons per day per capita (GPCD) statewide by 2030. Remarkably and commendably, with decades of investments, nearly half of urban water suppliers are estimated to have already achieved this target. However, half have not, and they will need support to get there. With the progress already achieved, going further to reduce another 10% below the 2025 target or 16% below the 2030 target, as the Draft Report recommends, becomes exponentially more challenging, in part due to the heightened effects on wastewater collection systems, treatment plants, and recycled water programs.

Accordingly, we encourage your consideration of including such analyses of the actual impacts and costs to our members by harnessing the SWRCB's SRIA analysis. To be sure, our members will need financial assistance and support to address these impacts and, changes in the approach – such as a higher 2025 standard – may provide a better glide path for achieving the targets while also allowing time to make the necessary investments in wastewater infrastructure. However, any approach should be supported by a thorough analysis of impacts to wastewater agencies.

In closing, we express our appreciation to Sabrina Cook and the team at DWR and Charlotte Ely and the SWRCB team for their accessibility, meeting with our coalition, and having in-depth dialogues since the revised standard was unveiled at the end of April. If there any questions about our comments, please do not hesitate to contact Jared Voskuhl at (916) 694-9269 or at jvoskuhl@casaweb.org.

Thank you,

Jared Voskuhl	Debbie Webster	Jenn Jones	Steve Jepsen
CASA Manager of Regulatory Affairs	CVCWA Executive Officer	CWEA Executive Director	SCAP Executive Director

cc: Joaquin Esquivel, SWB Chair
Sabrina Cook, DWR

Attachments: Attachment 1 – Potential Impacts to Wastewater and Recycled Water Infrastructure
Attachment 2 – Potable Reuse Projects
Attachment 3 – Commenting Associations' Descriptions
Attachment 4 – City of San Diego, Case Study: Potential Impacts of Reduced Flows (2018)

Attachment 1 - Potential Impacts to Wastewater and Recycled Water Infrastructure

There are three general areas where material impacts of lower flows are realized on wastewater infrastructure: sewer collection systems, wastewater treatment plants, and recycled water.

(1) For *collection systems and the conveyance of wastewater*, our infrastructure and pipes were designed for specific flows which the 2018 targets already present real challenges and will require steep financial investment for collection systems to prepare. As experienced by our members throughout the state during the last droughts, when sewer lines don't have the flow factors for which they are designed, problems are created. With less flow, there is less velocity, and solids kept in the sewer stream begin to collect and store in pipelines, causing issues with odors, corrosion and blockages that can lead to sewer overflows. Most of these issues can be managed with increased maintenance, such as flushing with potable or recycled water which cuts against the intent to conserve more water. However, some impacts require significant investment in additional infrastructure to amend.

In the state's CIWQS database, all of the nearly 1,200 enrollees' combined collection systems total approximately 205,000 miles, and our members will need assistance and support to minimize the expected impacts to their infrastructure. For example, the City of San Diego, with approximately 3,000 miles of sewers, estimated in their analysis of the impacts of the 2018 Standards that they will incur $125,000 in additional costs annually for odor control chemicals, as well as $3.5 million in accelerated investments to mitigate corrosion. Similarly, a medium sized municipality utilizes siphons in their collection systems, and these are getting more readily clogged because of lack of flow to move solids in the line. This is resulting in more maintenance for the City, and the City is examining whether to undertake capital projects to replace the siphons altogether.

(2) Impacts at *wastewater treatment plants* (WWTPs) also are observed, where higher salinity and concentrations of solids and nutrients in the influent due to conservation result in more costs for chemicals and energy for treatment during the aeration stage. Additionally, conservation can impact a WWTP's ability to comply with its waste discharge requirements. These impacts can intensify with population density and population growth. For example, the City of San Diego estimated nearly $30 million in capital costs for one of its reclamation plants to relocate a pump station and expand the facility due to lower flows and additional treatment needed. Additionally, because conservation flows were different than design conditions, some WWTP's in the Central Valley were not able to meet their nitrogen-based limits (nitrate and/or ammonia) due to the higher concentrations in influent due to treatment design that did not account for these high influent concentrations of nitrogen despite being significantly below the treatment capacity of the WWTP. Finally, salts are more difficult to remove. Salt is a long-term ongoing issue, especially for inland areas without brine lines. Increased salts can impact the ability to discharge into a surface or ground water and recycle water.

(3) For *recycled water,* the impacts of increased salinity are a concern because of treatment processes, but more fundamentally, it is very challenging for our members to plan for decreased flows, which disincentivizes communities investing in water recycling. Some of our members can mitigate for the salinity issue by blending potable water with recycled water, which again cuts against the intent to conserve more water. An alternative for is to use reverse osmosis, a process that removes salt from recycled water, which has a higher cost and higher energy use than traditional Title 22 projects, and results in a concentrate that must be managed and disposed.

Compounding the economic impacts are thornier legal issues because of existing agreements for specified flow for habitat preservation which may be required in order to provide recycle water. For example, a medium sized municipality is part of a recycled water program, and they are in effect paid to recycle water and send it to a nearby canal for the flow. Now with reduced flow, they don't have the supply to meet their obligations. Similarly, another smaller municipality provides recycled water for irrigation and agricultural lands. With conservation, their flows have gone down nearly one million gallons a day, despite a population increase. This has real impacts on the city's local economy to not have that quantity of recycled water supply as this community relies on its agricultural economy. In another instance for a special district, they are struggling to meet their recycled water obligations because flows have already gone down significantly during drought, so they are supplementing with groundwater, and looking for additional sources of water.

In all of these cases, when underlying decisions or agreements were made, recycled water flows were higher when agreements/requirements were made. Now despite the infrastructure investments, decreased flows have resulted in less recycled water thereby stranding assets, or significantly increasing the risk for as much. Additionally, the obligation to release potable water to maintain habitat flows is not lessened, although less water overall is used.

Attachment 2: Potable Reuse Projects

Permitted Potable Reuse Projects

Agency	Purpose	AFY
IEUA - Chino Basin	Groundwater Augmentation	21,000
LA County Dominguez Gap Barrier	Groundwater Augmentation	7,200
LACSD-WRD Montebello Forebay	Groundwater Augmentation	50,000
Monterey Pure Water	Groundwater Augmentation	3,500
Orange County Water District (Injection & Spreading)	Groundwater Augmentation	100,000
Orange County Water District Alamitos Barrier	Groundwater Augmentation	9,000
West Basin West Coast Barrier	Groundwater Augmentation	17,000
TOTAL		**207,000**

Planned Potable Reuse Projects

Agency	Purpose	AFY
City of Escondido	Groundwater Augmentation	9,000
City of Los Angeles	Groundwater Augmentation	30,000
City of Oceanside	Groundwater Augmentation	5,000
City of Oxnard	Groundwater Augmentation	7,000
City of San Diego Pure Water Project	Reservoir Water Augmentation	93,000
City of Ventura	Groundwater Augmentation	4,000
East Valley Water District	Groundwater Augmentation	11,000
Eastern Municipal Water District	Groundwater Augmentation	15,000
Encina Wastewater Authority	Raw Water Augmentation	32,000
IEUA - Chino Basin	Groundwater Augmentation	8,600
LACSD & Metropolitan Water District	Groundwater Augmentation	168,000
Las Virgenes-Triunfo Pure Water Project	Reservoir Water Augmentation	5,000
Orange County Water District	Groundwater Augmentation	31,000
Padre Dam Municipal Water District	Reservoir Water Augmentation	13,000
Palmdale Water District	Groundwater Augmentation	4,000
Santa Clara Valley Water District	Groundwater Augmentation	45,000
Upper San Gabriel Valley Municipal Water District	Groundwater Augmentation	10,000
Water Replenishment District S. CA, GRIP Project	Groundwater Augmentation	21,000
Yucaipa Valley Water District	Groundwater Augmentation	5,000
TOTAL		**516,000**

Attachment 3: Commenting Associations' Descriptions

CASA

The California Association of Sanitation Agencies (CASA) represents more than 125 public agencies and municipalities that engage in wastewater collection, treatment, recycling, and resource recovery, and our mission is to provide trusted information and advocacy on behalf of California clean water agencies, and to be a leader in sustainability and utilization of renewable resources.

CVCWA

The Central Valley Clean Water Association (CVCWA) is a non-profit association of public agencies located within the Central Valley region that provide wastewater collection, treatment, and water recycling services to millions of Central Valley residents and businesses. CVCWA was primarily formed to concentrate resources to effect reasonable local, state and federal regulations impacting entities operating municipal wastewater treatment plants and wastewater and storm drain collections systems in the Central Valley. CVCWA is currently comprised of over 50 public wastewater collection and treatment member agencies, representing over 7 million people in the Central Valley. Additionally, CVCWA has over 20 associate members. Our members are public and private organizations charged with the responsibility for collecting, treating, recycling, and disposing of wastewater in a safe, responsible and economical manner.

CWEA

The California Water Environment Association (CWEA) empowers wastewater professionals as they protect California's most critical resource: water. Since our founding in 1928, we've grown to a community of more than 10,000 members across all facets of wastewater management and resource recovery, from operators to lab techs to engineers. CWEA's mission is to increase the effectiveness of California's water environment professionals through education, certification, and promotion of sound policies to benefit society by protecting the water environment.

SCAP

The Southern California Alliance of Publicly Owned Treatment Works (SCAP) is a non-profit association representing over 80 public water/wastewater agencies in southern California who provide essential water supply and wastewater treatment for approximately 20 million people in the counties of Los Angeles, Orange, San Diego, Santa Barbara, Riverside, San Bernardino and Ventura. SCAP's wastewater members provide environmentally sound, cost-effective management of more than two billion gallons of wastewater each day and, in the process of protecting public health and the environment, convert wastewater into resources for beneficial uses such as recycled water and renewable energy.

City of San Diego

CASE STUDY //

Potential Impacts of Reduced Flows

FINAL | APRIL 2018 (revised June 2018)

table of contents

Brown AND Caldwell

Table of Contents

LIST OF ABBREVIATIONS

AWPF	advanced water purification facility
BOD	biological oxygen demand
BSO	bad sewer odor
CCR	California Code of Regulations
City	City of San Diego
CUWA	California Urban Water Agencies
DWR	Department of Water Resources
EO	Executive Order
EO Agencies	Collectively: the California Department of Water Resources, State Water Resources Control Board, California Public Utilities Commission, California Department of Food and Agriculture, and the California Energy Commission
GHG	greenhouse gas
gpcd	gallons per capita per day
H_2S	hydrogen sulfide
mg/L	milligrams per liter
mgd	million gallons per day
MPS	Moreno Pump Station
N/A	not applicable
NCPWF	North City Pure Water Facility
NCWRP	North City Water Reclamation Plant
NPR	non-potable reuse
NPV	net present value
O&M	operations and maintenance
RCP	reinforced concrete pipe
R-gpcd	residential gallons per capita per day
RO	reverse osmosis
SBWRP	South Bay Water Reclamation Plant
SCSC	Southern California Salinity Coalition
SSO	sanitary sewer overflow
TDS	total dissolved solids
TOC	total organic carbon
Total N	total nitrogen
TSS	total suspended solids
WUE	water use efficiency

Executive Summary

Motivated by the most recent drought, new regulations for indoor and outdoor usage are currently under development to ensure water supply reliability and resiliency for California. However, these regulations could contribute to declining flows in the urban water cycle, leading to potential economic, environmental and social impacts. This case study aims to leverage the historical data of City of San Diego's (City's) unique integrated water, wastewater, and recycled water system to understand the potential impacts of those declining flows.

Background and Objective

With climate change expected to exacerbate the frequency and intensity of future droughts (USGCRP, 2017) and deepen the need for a resilient water supply, California is working to better manage its finite water resources. Achieving lasting water supply reliability in the state of California requires collaboration between state regulators and local municipalities and an understanding of the interconnected nature of our water systems.

California water agencies continue to prioritize wise water use through both short-term conservation efforts (i.e., in response to a drought or emergency) and long-term water use efficiency (WUE) strategies for lasting, sustainable effects. Understanding how wise water use can affect an interconnected water supply system is critical to optimizing future water management. **This case study leverages observations from the City of San Diego (City)—a leader in integrated water resources management, water use efficiency, and water supply diversification—to help inform and optimize an important aspect of future water management in California.**

Making Conservation a California Way of Life

In 2016, Governor Brown issued Executive Order (EO) B-37-16 to reinforce key strategies addressed in the California Water Action Plan, namely *Making Water Conservation a California Way of Life*. Through this EO, the Governor directed state agencies to develop a long-term WUE framework and improve planning to support California's water supply reliability and resiliency. In April 2017, the EO Agencies released the final report, *"Making Water Conservation a California Way of Life,"* which specifies the process for urban water suppliers to meet new, long-term water use targets (California Department of Water Resources [DWR], 2017).

The report proposes setting water use targets as an aggregate total of three per capita water use budgets: residential indoor use, outdoor irrigation use, and distribution system water losses (DWR et al., 2017).

Supplier water use target = (indoor water use budget)

+ (outdoor water use budget) + (water loss budget)

The "residential indoor water use standard," represented as residential gallons per capita per day (R-gpcd), is defined as "the volume of residential indoor water used by each person per day, expressed in gpcd" (DWR, 2017). This standard is used to calculate a water supplier's "indoor water use budget," which is a function of the total service area population; i.e.:

Residential indoor water use budget = (service area population)

x (residential indoor standard) x (number of days in a year)

Invested in Water Supply Reliability

With a population of 1.3 million people, the City is the eighth largest city in the United States. The City provides drinking water, wastewater, and recycled water services, managing 9 surface water reservoirs and 3 water treatment plants. The City provides wastewater treatment services for a population of 2.2 million people over a 450-square-mile area that currently generates approximately 140 million gallons per day (mgd) of wastewater. They transport and manage the wastewater through their miles of wastewater pipelines, three wastewater treatment plants, and biosolids treatment facility (Figure ES-1).

Local water availability has always been an issue for the City due to its location in the dry Mediterranean climate of coastal southern California. On average, the City imports approximately 85 percent of its water from other areas, specifically Northern California and the Colorado River. Thus, the importance of water supply reliability, resiliency, and diversification has always been paramount in the City's water supply strategy.

Figure ES-1. The City provides wastewater services to 2.2 million people and treats up to ~140 million gallons of wastewater per day.

The City's Continued Commitment to Conservation

The City, recognizing the vital role that conservation plays in its water supply strategy, and has been a leader in promoting conservation and WUE measures. The City manages a "San Diegans Waste No Water" campaign, which informs individuals about the state's current water use restrictions and explains how consumers can reduce their water use. Figure ES-2 illustrates the steady decline in R-gpcd in the City over the past decade. Since June 2015, the City has realized a cumulative water savings of 16.2 percent (compared to 2013 values).

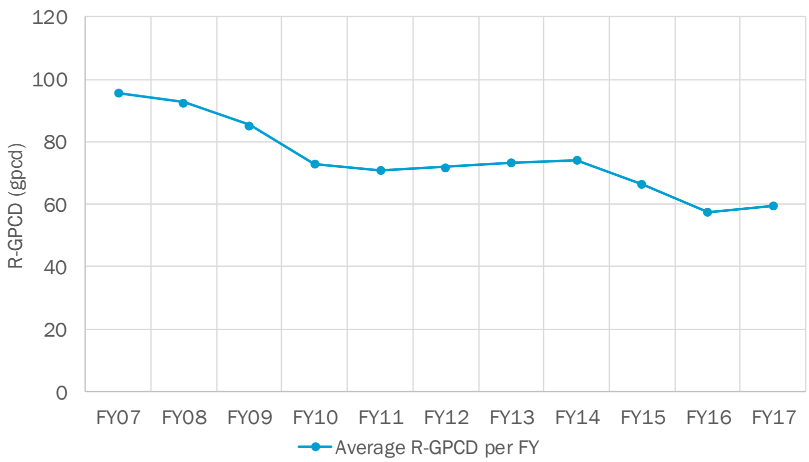


Figure ES-2. They City's average R-gpcd per year has steadily declined from 2006.

However, while WUE is an important element of water management programs, it is not in itself sufficient to manage all future water demands. State and local agencies recognize that it is only part of a multi-faceted strategy for water supply reliability. Increased conservation and water use efficiency can also contribute to declining flows in the urban water cycle. These declining flows, coupled with increasing contaminant concentrations, can have implications on the City's integrated water, wastewater, and recycled water systems. To best support water supply reliability, the City is taking a proactive, holistic planning approach that examines and considers these impacts.

Better Understanding the Potential Impact of Declining Flows in the City of San Diego

The interconnected nature of the water system means that change in one part of the cycle will have a ripple effect, both positive and negative, on other parts of the system. A recently published white paper by the California Urban Water Agencies (CUWA), titled "Adapting to Change: Utility Systems and Declining Flows," examined the impacts of declining flows through the observations of utilities impacted by emergency conservation measures in 2015 and 2016, and used these observations to provide insight and inform the state's long-term WUE policies. A survey conducted by CUWA indicated that impacts are widespread across the state in all parts of the engineered water system (Figure ES-3).

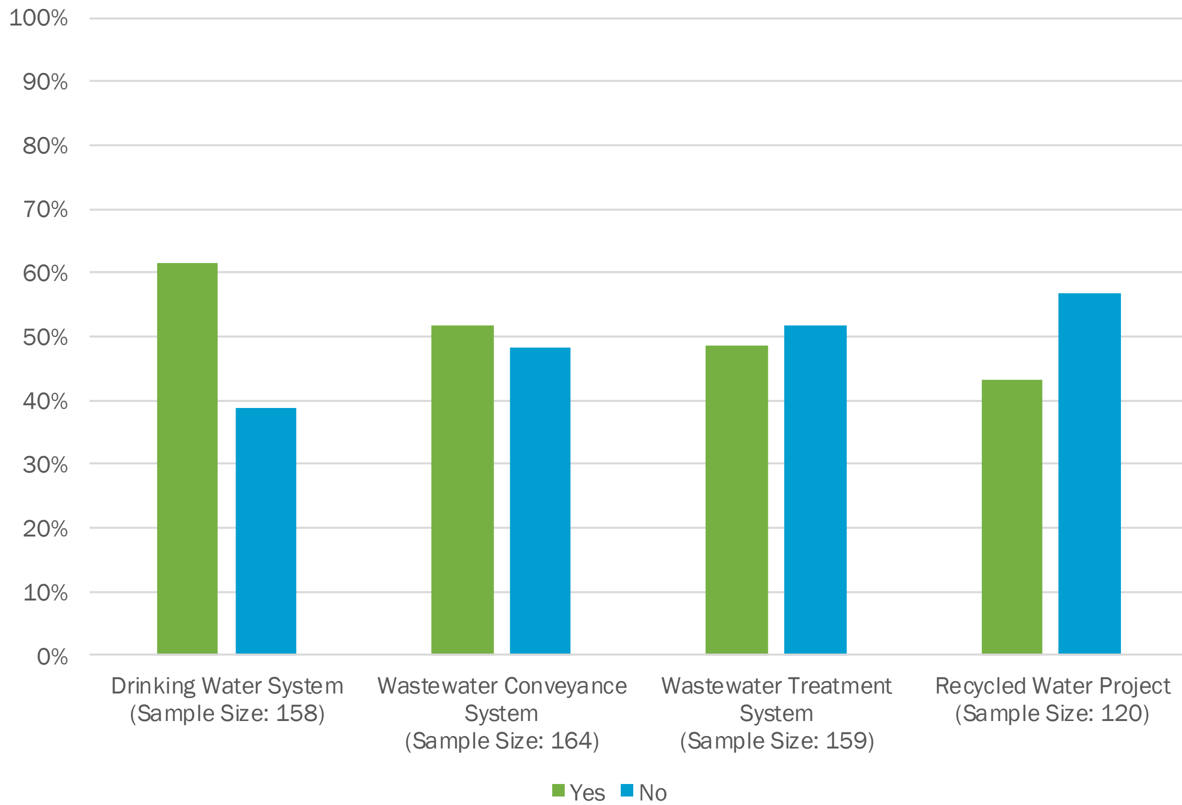


Figure ES-3. Survey respondents experienced impacts of water conservation in all system types.

Source: CUWA, 2017

The objective of this project is to build upon CUWA's research and leverage the City's historical data to better understand and quantify the potential impacts of declining flows within the context of the City's integrated plan for greater supply reliability.

The Methodology

This case study leverages 10 years of historical data to evaluate the potential impacts reduced flows may have on the City's water, wastewater and recycled water systems. Two scenarios were evaluated—a baseline and reduced flow scenario—to assess projected impacts including financial, social, and environmental considerations.

Defining Two Comparative Scenarios

The Baseline scenario represents existing conditions including implementation of the Pure Water Program as designed. The Reduced Flows scenario represents a theoretical situation where flows are dramatically reduced through a combination of WUE strategies, as well as other consumer behavior adjustments such as greywater or decentralized reuse.

Evaluating Impacts through a Triple Bottom Line Context

To provide a holistic perspective, this case study examines each potential impact identified as part of the comparative analysis through a triple bottom line lens. This means that each impact is reviewed from an economic, environmental, and social perspective (Figure ES-4).

Baseline

The Baseline scenario will be the design criteria established for the Pure Water Program, which includes an R-gpcd starting at 55 and reducing to 52 gpcd by 2035.

Reduced Flows

The Reduced Flows scenario assumes an R-gpcd of 35 which considers intensified WUE strategies and other consumer behavior adjustments that will reduce the amount of flows into the wastewater system.

Figure ES-4. Each impact was reviewed through a triple bottom line context, which considers economic, environmental, and social perspectives.

Impacts of Declining Flows on the Urban Water Cycle

CUWA's white paper on *Adapting to Change: Declining Flows and Utility Systems (*CUWA, 2017*)* researched the potential impacts of declining flows on the interconnected water systems, including drinking water distribution, wastewater conveyance, wastewater treatment, and recycled water projects (Figure ES-5).

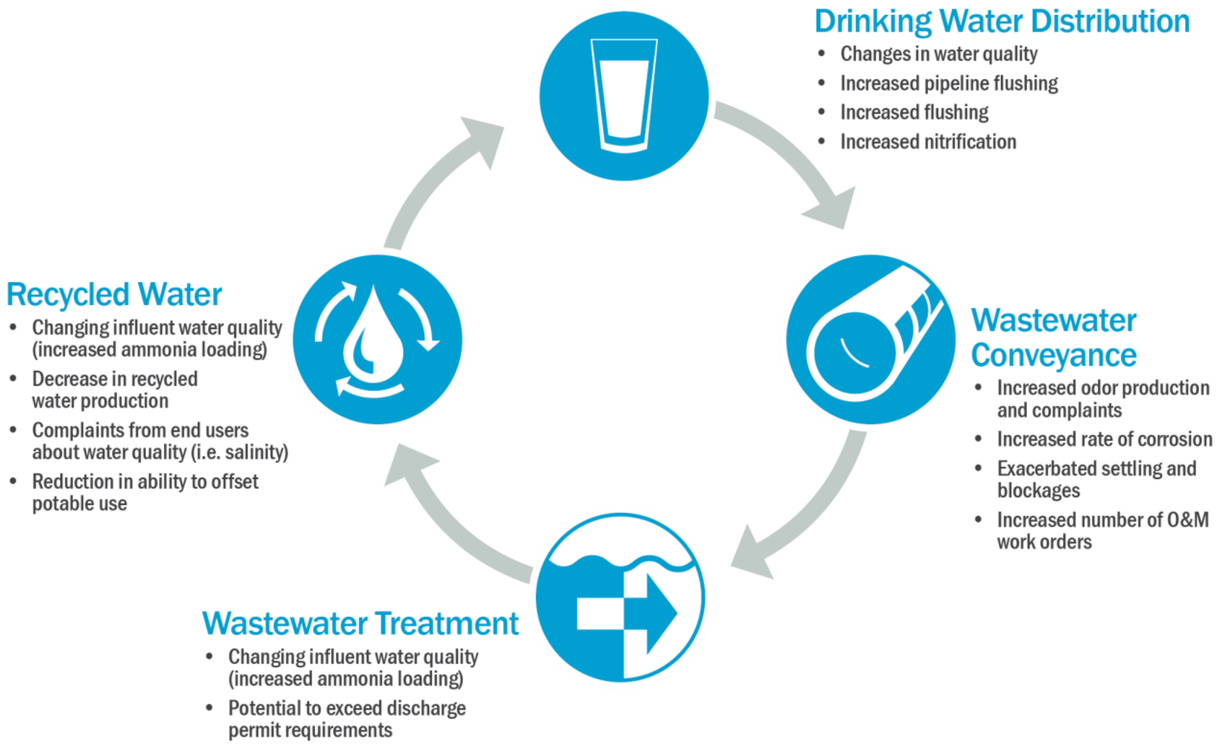


Figure ES-5. Declining flows in the urban water cycle can potentially impact all areas of the cycle.

Source: CUWA, 2017

Leveraging Historical Data to Identify Impacts in San Diego

Historical data and research conducted within the North City sewershed were analyzed to identify any impacts the City may have experienced due to declining flows observed over the past decade. The datasets analyzed and impacts identified (as applicable) are summarized in Table ES-1.

Limitations of the Analysis

This high-level assessment consists of reviewing pertinent datasets that might demonstrate the potential impacts identified through CUWA's research. It's important to highlight the limitations of this assessment, as it draws upon correlation to identify impacts caused by declining flows. Correlation does not equal causation. However, for the sake of this high-level assessment, the correlations that appear will be leveraged and quantified (as appropriate) to provide an order of magnitude perspective on the potential social, environmental, and economic impacts of declining flows.

Table ES-1. Summary of Impacts on the Wastewater Conveyance, Wastewater Treatment, and Recycled Water Systems					
System	Potential Impact due to Declining Flows	Type of Analysis to Quantify Impact	Quantitative	Qualitative	
			Economic	Environmental	Social
Wastewater Conveyance System	Increase in odor production, leading to an increase in bad sewer odor work orders.	Minimal correlation was observed between declining R-gpcd and BSO work orders.	N/A	N/A	N/A
	Increase in odor production, leading to an increase in odor control chemical, Bioxide® use and trucking.	Used observed correlation to calculate increase in Bioxide® purchase.	Increased Bioxide® purchase: $125,000/year	Increased GHG emissions from increased trucking for Bioxide® injection.	Increased odors in communities.
	Acceleration in the rate of corrosion, leading to accelerated degradation of the City's concrete manholes.	Used theoretical equations to estimate the accelerated rate of corrosion.	Capital expenditures to rehabilitate manholes earlier than expected: $850,000/year more than baseline for 4 years	Increased construction for manhole rehabilitation requires additional equipment, leading to an increase in GHG emissions.	Increased rehabilitation of manholes disrupts local communities.
Wastewater Treatment System	Increase in TSS and BOD concentrations and mass loading, requiring additional capacity at the NCWRP.	Increasing TSS and BOD trends are observed.	The cost of increased capacity at the NCWRP: $8,600,000 (limited to a one-time capital expenditure)	Increased GHG emissions from increased trucking and power production.	Undermines the Pure Water program, which serves as a reliable and sustainable source of drinking water.
	Declining flows reduce the flows at the current MPS site, leading to a loss of 6 mgd of source wastewater.	The MPS could be relocated to recover those lost flows.	Cost of MPS relocation: Capital - $20,500,000 (one-time cost) Increase in O&M - $50,000 (annual)	Relocation of the MPS would require a tunnel crossing under the san Diego River, which impacts the surrounding environment.	The additional two miles needed for the MPS relocation would result in more disruption to surrounding communities.
		However, the MPS is unlikely to be relocated due to site constraints, leading to a loss of 4.8 mgd (assuming 70% recovery) of purified water.	Value of lost 4.8 mgd: $4,500,000/year		Undermines the Pure Water program, which serves as a reliable and sustainable source of drinking water.
Advanced Water Purification Facility	Increases in constituents (TDS, TOC, Nitrogen) in the RO permeate.	Impact not observed.	N/A	N/A	N/A

BOD = biological oxygen demand; BSO = bad sewer odor; GHG = greenhouse gas; mgd = million gallons per day; MPS = Moreno Pump Station; N/A = not applicable; NCWRP = North City Water Reclamation Plant; RO = reverse osmosis; TDS = total dissolved solids; TOC = total organic carbon; TSS = total suspended solids.

Net Present Value (NPV) Analysis of All Economic Impacts

Each of the economic impacts was imported into a net present value (NPV) calculation to quantify cumulative impacts from 2017 through 2035, and the life cycle cost of ownership for this option is $102,000,000 (i.e. the NPV is negative $102,000,000). Table ES-2 summarizes these impacts.

Table ES-2. Economic Impacts of the Reduced Flow Scenario		
Economic Impact	**Value**	**One-Time Cost or Annual**
Wastewater Conveyance		
Increase in Bioxide® Purchases	$125,000	Annual
Accelerated Investment due to Corrosion	An increase of $850,000 per year for four years.	Not Included in NPV
Wastewater Treatment		
Increase in NCWRP Expansion	$8,600,000	One-Time
Relocation of the MPS (Capital)	$20,500,000	One-Time
Relocation of the MPS (Operations)	$50,000	Annual
Value of the 6 mgd	$4,5000,000	Annual
NPV Total (through 2035)	($102,000,000)	

BSOs = bad sewer odors; mgd = million gallons per day; MPS = Moreno Pump Station; NCWRP = North City Water Reclamation Plant.

Conclusions and Next Steps

As water use targets and standards are currently in development, it is vital to understand the impacts of these policies on the interconnected urban water cycle. As utilities continue to invest in programs and infrastructure that support water supply reliability, it is important to consider how different water supply reliability strategies, like WUE and water supply diversification, can impact each other. The City, as a leader in both strategies, can serve as a valuable case study to provide insight into what those impacts may be.

This case study reveals that significantly reduced flows could cost the City on the order of $102,000,000 through 2035, in addition to environmental and social impacts within the region. **These impacts underscore the importance of a holistic analysis of the urban water cycle to ensure development of the best water management plan, as each utility's experience is unique to its water supply situation. This uniqueness also highlights the importance of flexibility in statewide water use standards.**

It's important to note that there are some benefits and impacts of reduced flows that were not quantified in this case study, but are important and should be investigated further. The benefits include:

- Reduced use of water (including imported and desalinated), and the related financial savings and environmental benefits.
- Reduced energy and chemical use in drinking water and wastewater conveyance and treatment.

This report also focused on the impacts of reduced flows from indoor residential use as those flows remain within the interconnected urban water cycle. However, there may also be impacts from reduced outdoor irrigation use including the loss of areas landscaped with irrigated plants, which provide benefits like improved aesthetics, mitigation against the heat-island effect, and increased property values.

Ultimately, increasing water use efficiency has both benefits and potential impacts on water, wastewater, and recycled water systems, which can be balanced through informed policy. A holistic, one-water approach can benefit smart policy and provide the best solutions in managing California's water resources.

SECTION 1

Background and Objective

Water is an invaluable and finite resource in California, and sustainable water management is a collaborative effort between state regulators and local municipalities. Motivated by the most recent drought, new regulations are currently under development to ensure water supply reliability and resiliency for California.

1.1 Supporting Sustainable Water Management in California

With climate change expected to exacerbate the frequency and intensity of future droughts (USGCRP, 2017) and deepen the need for a resilient water supply, California is working to better manage its finite water resources. The Governor's California Water Action Plan provides a roadmap for sustainable water management throughout the state. The plan encourages several actions associated with achieving greater water supply including but not limited to making conservation a California way of life (Action No. 1), and increasing regional self-reliance and integrated water management across all levels of government (Action No. 2).

Achieving lasting water supply reliability in the state of California requires collaboration between state regulators and local municipalities and an understanding of the interconnectedness of our water systems. This case study leverages observations from the City of San Diego (City)—a leader in integrated water management, water use efficiency, and water supply diversification—to help inform and optimize an important aspect of future water management in California.

1.2 Making Conservation a California Way of Life

Encouraging wise water use and strengthening local and regional drought planning are critical to California's resilience to drought and climate change. In 2016, Governor Brown issued Executive Order (EO) B-37-16 to reinforce key strategies addressed in the California Water Action Plan, namely *Making Water Conservation a California Way of Life*.

Through this EO, the Governor directed state agencies to develop a long-term water use efficiency (WUE) framework and improve planning to support California's water supply reliability and resiliency. To achieve the objectives of the EO, several state agencies came together, including the California Department of Water Resources (DWR), State Water Resources Control Board, California Public Utilities Commission, California Department of Food and Agriculture, and the California Energy Commission (collectively referred as the "EO Agencies"). In April 2017, the EO Agencies released the final report, "Making Water Conservation a California Way of Life," which specifies the process for urban water suppliers to meet new, long-term water use targets (DWR, 2017).

The report proposes setting water use targets as an aggregate total of three per capita water use budgets: residential indoor use, outdoor irrigation use, and distribution system water losses (DWR et al., 2017).

supplier water use target = (indoor water use budget)

+ (outdoor water use budget) + (water loss budget)

While the supplier water use target includes three separate considerations, this case study focuses on the indoor water use budget, as these flows remain within the engineering water system. The "residential indoor water use standard," represented as residential gallons per capita per day (R-gpcd), is defined as "the volume of residential indoor water used by each person per day, expressed in gpcd" (DWR, 2017). This standard is used to calculate a water supplier's "indoor water use budget," which is a function of the total service area population; i.e.:

Residential indoor water use budget = (service area population)

x (residential indoor standard) x (number of days in a year)

Senate Bill x7-7 established 55 gallons per capita per day (gpcd) as a provisional residential indoor standard per California Water Code 19608.20(b)(2)(A). The Senate Bill x7-7standard will apply until the new standard for residential indoor water use is established. As standards are developed, the potential impacts of reduced indoor water use on water, wastewater, and recycled water systems are a critical consideration.

However, while WUE is an important element of water management programs, it is not in itself sufficient to manage all future water demands. The California Water Action Plan acknowledges the need for more comprehensive water management and supports making regions more self-reliant through the development of new or underused local water resources. Therefore, new water use targets must be compatible with the goal of expanding recycled water supplies.

1.3 Invested in Water Supply Reliability

With a population of 1.3 million people, the City is the eighth largest city in the United States. The City provides drinking water, wastewater, and recycled water services to its population, and manages 9 surface water reservoirs, 3 water treatment plants, 47 pump stations, and approximately 3,200 miles of water transmission and distribution pipelines. The City also provides wastewater treatment services for a population of 2.2 million people over a 450-square-mile area that currently generates approximately 140 million gallons per day (mgd) of wastewater. They transport and manage the wastewater through their miles of wastewater pipelines, three wastewater treatment plants, and biosolids treatment facility (Figure 1-1).

Figure 1-1. The City provides wastewater services to 2.2 million people and treats up to ~180 million gallons of wastewater per day.

Source: City of San Diego, 2018a

Local water availability has always been an issue for the City due to its location in the dry Mediterranean climate of coastal southern California, where rainfall averages only 10 inches per year at the coast and can vary tremendously from year to year. On average, the City imports approximately 85 percent of its water from other areas, specifically Northern California and the Colorado River. Thus, the importance of water supply reliability, resiliency, and diversification has always been paramount in the City's water supply strategy.

The City's Continued Commitment to Conservation

The City, recognizing the vital role that conservation plays in its water supply strategy, and has been a leader in promoting conservation and water use efficiency measures. The City manages a "San Diegans Waste No Water" campaign, which informs individuals about the state's current water use restrictions and explains how consumers can reduce their water use. They've also set permanent water use restrictions to discourage water waste and funded a variety of programs to incentivize customers to reduce indoor and outdoor water use, including turf replacement rebates and landscape design workshops for homeowners. Figure 1-2 illustrates the steady decline in R-gpcd in the City over the past decade. Since June 2015, the City has realized a cumulative water savings of 16.2 percent (compared to 2013 values).

However, increased conservation and water use efficiency contributes to declining flows in the urban water cycle (Figure 1-3). These declining flows, coupled with increasing contaminant concentrations, can have implications on the City's integrated water, wastewater, and recycled water systems. To best support water supply reliability, the City is taking a proactive, holistic planning approach that examines and considers these impacts.

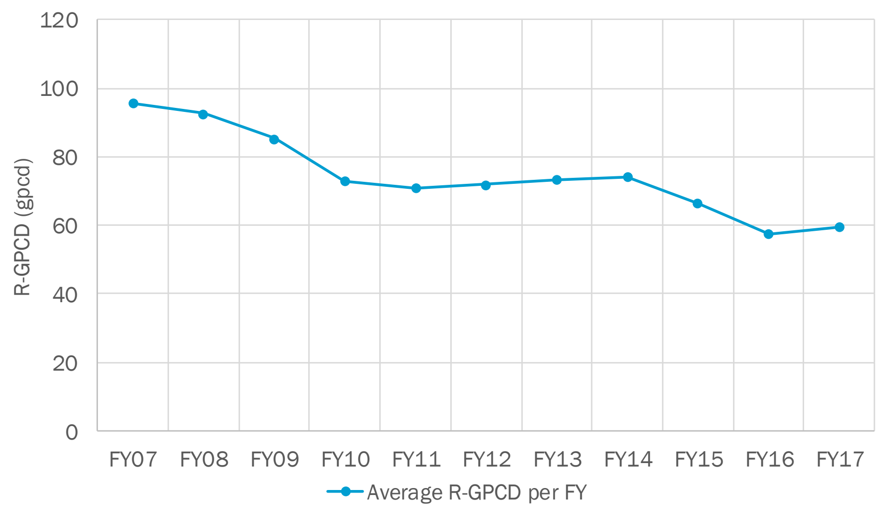


Figure 1-2. The City's average R-gpcd per year declined from fiscal years 2006 through 2017.

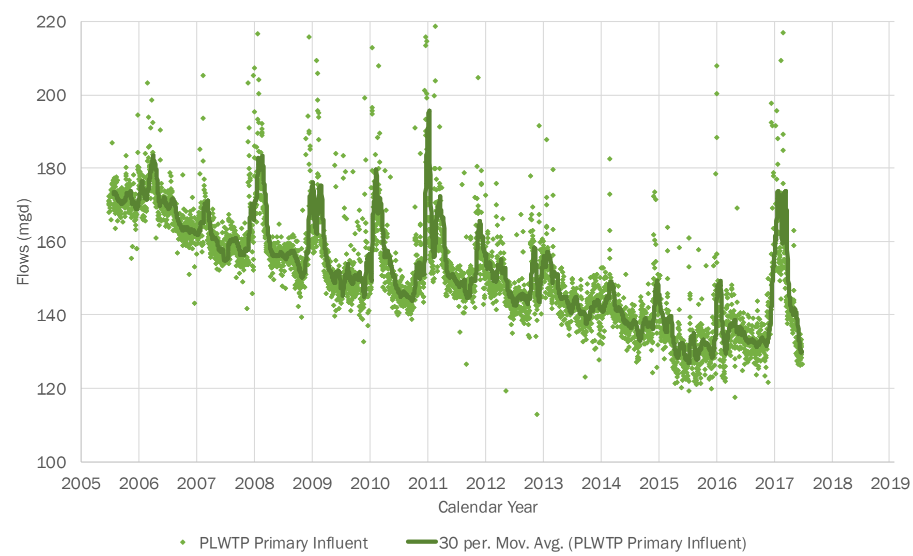


Figure 1-3. Influent flows at the Point Loma Wastewater Treatment Plant (PLWTP) declined24 percent from 2006 through 2017.

Water Diversification is a Critical Component of Water Supply Reliability

While conservation is an important component for sustainable water management, both state and local agencies recognize that it is only part of a multi-faceted strategy for water supply reliability. Given the City's semi-arid location, and that the cost of imported water is forecasted to double in the next 10 years, the City has proactively invested in producing a local supply of water through the Pure Water Program, which treats wastewater for potable reuse. (Figure 1-4). The program is designed to be a phased, multi-year program with the goal of providing one-third of the City's water supply locally by 2035.

The City, as an integrated municipal entity responsible for water, wastewater, and recycled water systems, and as a leader in demand management and water supply diversification, provides an insightful perspective on how best to establish a holistic strategy for supply reliability that considers the interconnectedness of the entire urban water cycle.

Figure 1-4. The Pure Water Program is an important part of the City's water supply reliability strategy.

Source: City of San Diego, 2017a

1.4 Better Understanding the Potential Impact of Declining Flows in the City of San Diego

The interconnected nature of the water system means that change in one part of the cycle will have inevitable impacts, both positive and negative, on other parts of the system. A recently published white paper by the California Urban Water Agencies (CUWA), titled “Adapting to Change: Utility Systems and Declining Flows,” examined the impacts of declining flows through the observations of utilities impacted by emergency conservation measures in 2015 and 2016, and used these observations to provide insight and inform the state’s long-term WUE policies.

The report included a literature review of potential impacts of declining flows, a high-level survey to determine the level and range of observed impacts in California, and case studies based on one-on-one interviews that illustrate the broad range of issues agencies experience and the impact of these issues. Survey results indicate that impacts are widespread across the state in all parts of the engineered water system (Figure 1-5).

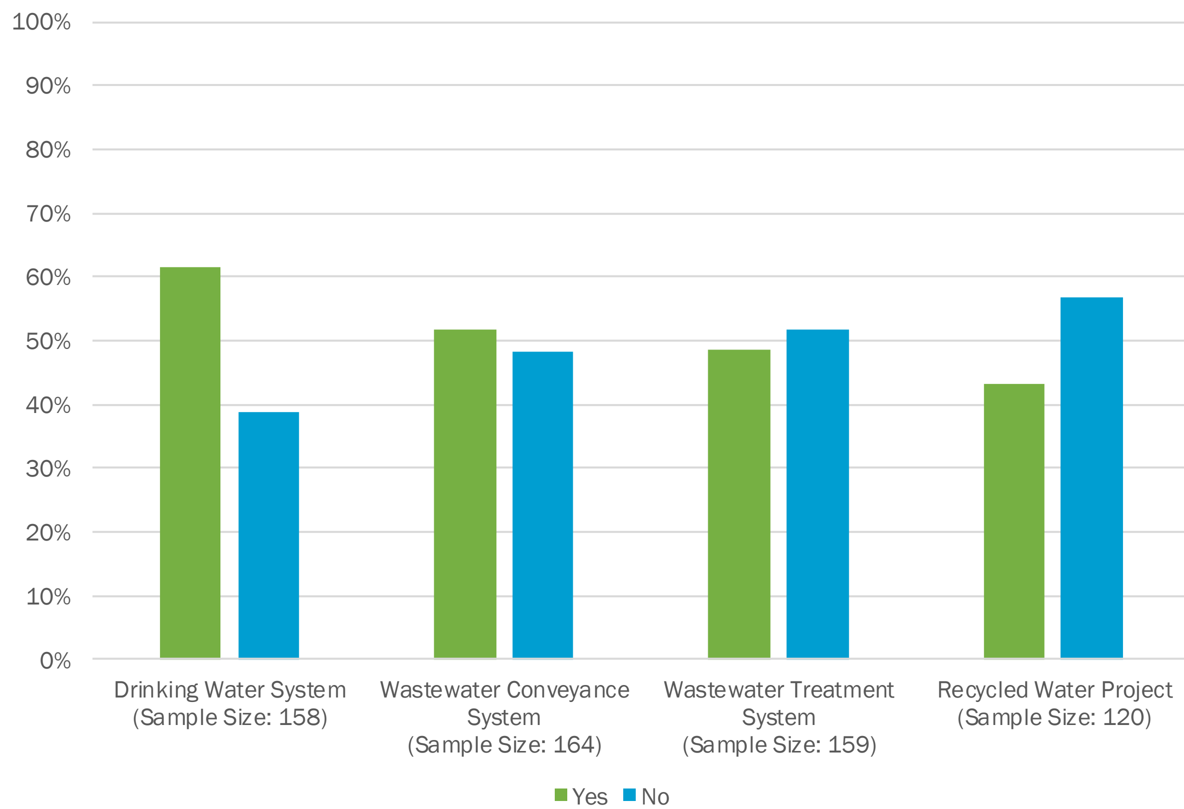


Figure 1-5. Survey respondents experienced impacts of water conservation in all system types.

Source: CUWA, 2017

The potential impacts identified in the CUWA white paper are summarized in Section 3. **The objective of this project is to build upon CUWA’s research and leverage the City’s historical data to better understand and quantify the potential impacts of declining flows within the context of the City’s integrated plan for greater supply reliability.**

SECTION 2

The Methodology

This case study leverages 10 years of historical data to evaluate the potential impacts reduced flows may have on the City's interconnected systems within the context of its broader goals for water supply diversification and greater supply reliability. Two scenarios were evaluated—a baseline and reduced flow scenario—to assess projected impacts including financial, social, and environmental considerations.

2.1 Defining the Boundaries

The following boundaries were established for the case study:

- **Regional:** While the City services the entire San Diego area, this analysis focuses on the North City sewershed, which encompasses Phase 1 of the Pure Water Program. As such, modeling, designs, and demonstration testing within the area have been established. Any impacts experienced in the North City sewershed would therefore be extrapolated to the City's entire service area.
- **Time Frame:** To complete a comprehensive analysis, historical data was requested for the past 10 years. A smaller dataset was analyzed in some circumstances, such as the North City Advanced Purification Demonstration Facility, which was only brought online in 2010.

2.2 Defining Two Comparative Scenarios

The Baseline scenario represents existing conditions including implementation of the Pure Water Program as designed. The Reduced Flows scenario represents a theoretical situation where flows are dramatically reduced through a combination of WUE strategies and other consumer behavior adjustments such as greywater or decentralized reuse.

Baseline Scenario

The Baseline scenario consists of the design criteria established for Phase I of the Pure Water program. To support both non-potable reuse (NPR) and potable reuse customers, the City intends to use Phase I to produce 12 mgd of recycled water for NPR uses and 30 mgd of purified water for potable reuse. This scenario would require expansion of the North City Water Reclamation Plant (NCWRP), a new North City Pure Water Facility (NCPWF), a North City Pump Station and Pipeline to convey the purified water to Miramar Reservoir, and a new Morena Pump Station (MPS) and Pipeline to bring supplemental wastewater flows to the NCWRP (Figure 2-1).

Baseline

The Baseline scenario will be the design criteria established for the Pure Water Program, which includes an R-gpcd starting at 55 and reducing to 52 gpcd by 2035.

Reduced Flows

The Reduced Flows scenario assumes an R-gpcd of 35 which considers intensified WUE strategies and other consumer behavior adjustments that will reduce the amount of flows into the wastewater system.

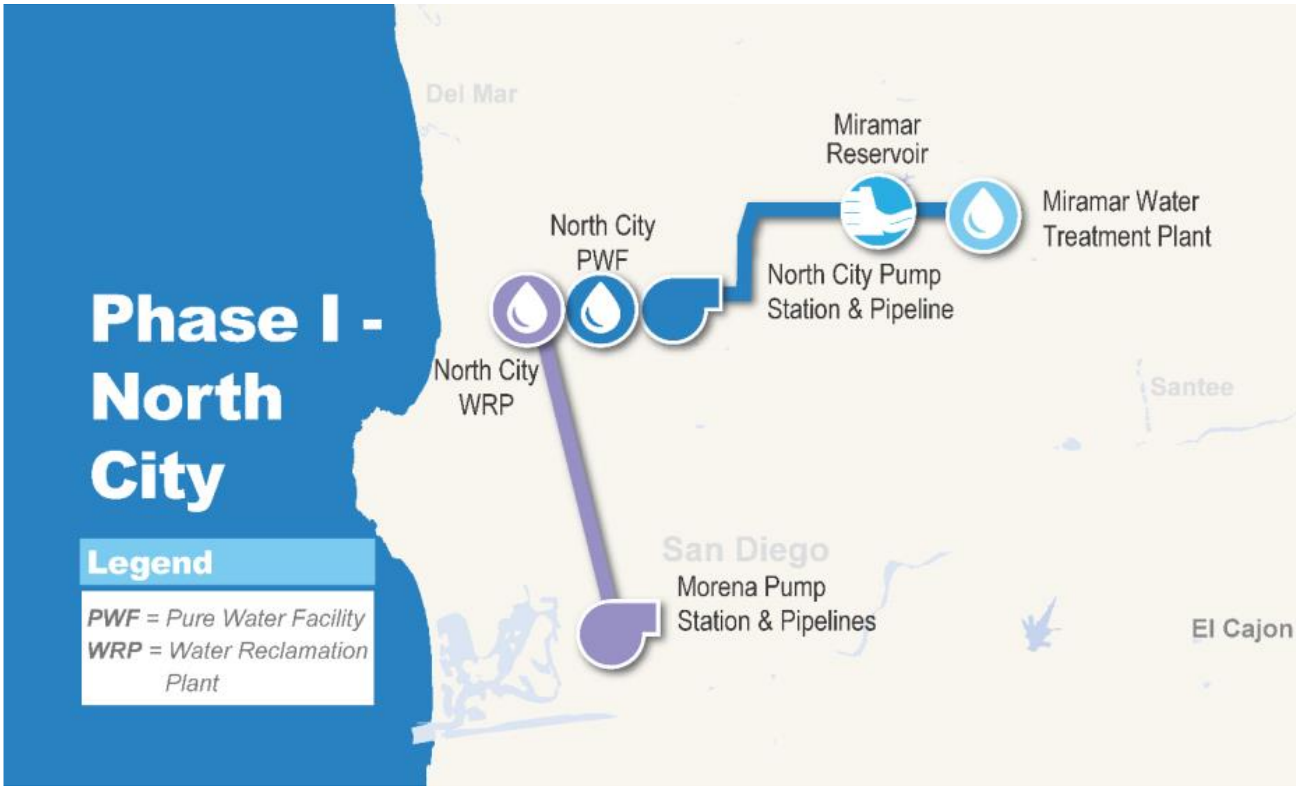


Figure 2-1. Phase I of the Pure Water Program consists of the NCWRP, NCPWF and MPS.

Source: City of San Diego, 2017b

The 42 mgd of effluent would require an influent of 52 mgd, as a portion of the water is returned from the wastewater and advanced water treatment process to the wastewater system. To appropriately size and locate Phase I facilities, design criteria were defined, which includes an expected R-gpcd value of 55 gpcd at 2015, declining to 52 gpcd by 2035. These values were calculated through modeling, outside of the scope of this case study, that considered historical wastewater volumes and population.

Reduced Flows Scenario

To understand the impacts of reduced flows, the comparative Reduced Flows scenario is defined with a significantly lower R-gpcd of 35, representing a combination of increasingly stringent WUE targets, greater adoption of grey water reuse, and potential implementation of decentralized or business-scale reuse systems.

These two scenarios represent bookends along a broad spectrum of potential realities. Evaluation of the two scenarios is intended to provide valuable, high-level insight into the potential impacts of reduced flows.

2.3 Evaluating Impacts through a Triple Bottom Line Context

To provide a holistic perspective, this case study examines each potential impact identified as part of the comparative analysis through a triple bottom line lens. This means that each impact is reviewed from an economic, environmental, and social perspective (Figure 2-2).

Figure 2-2. Each impact was reviewed through a triple bottom line context, which considers economic, environmental, and social perspectives.

Technical Approach

The analysis reviewed the City's wastewater collection system, wastewater treatment system, and advanced water treatment systems, and consisted of three key elements:

- **Potential Impacts:** As a companion piece to the CUWA white paper, potential impacts identified through that effort were leveraged as the starting point for this case study. Section 3 summarizes those potential impacts on wastewater conveyance, wastewater treatment, and recycled water systems.
- **City Analysis:** Data provided by City were analyzed to determine which impacts have been or could potentially be observed at baseline and reduced flow conditions. Section 4 of this report summarizes City-specific issues.
- **Triple Bottom Line Assessment:** Impacts identified for the City are categorized in Section 5 as quantifiable impacts (economic) and qualitative impacts (environmental and social).

2.4 Limitations of the Analysis

This high-level assessment consists of reviewing pertinent datasets that might demonstrate the potential impacts identified through CUWA's research (Section 3) on wastewater conveyance, wastewater treatment, and recycled water systems. It's important to highlight the limitations of this assessment, as it draws upon correlation to identify impacts caused by declining flows. Correlation does not equal causation. However, for the sake of this high-level assessment, the correlations that appear will be leveraged and quantified (as appropriate) to provide an order of magnitude perspective on the potential social, environmental, and economic impacts of declining flows.

SECTION 3

Impacts of Declining Flows on the Urban Water Cycle

CUWA's white paper on *Adapting to Change: Declining Flows and Utility Systems* (CUWA, 2017) researched the potential impacts of declining flows on the interconnected water systems, including drinking water distribution, wastewater conveyance, wastewater treatment, and recycled water projects.

3.1 Declining Flows Impact all Areas of the Urban Water Cycle

The CUWA white paper reviewed the impacts of declining flows on the water, wastewater, and recycled water systems (Figure 3-1). While impacts to the drinking water distribution system in San Diego due to declining flows have been observed, this analysis focuses on the wastewater conveyance, treatment, and recycled water systems within the North City sewershed.

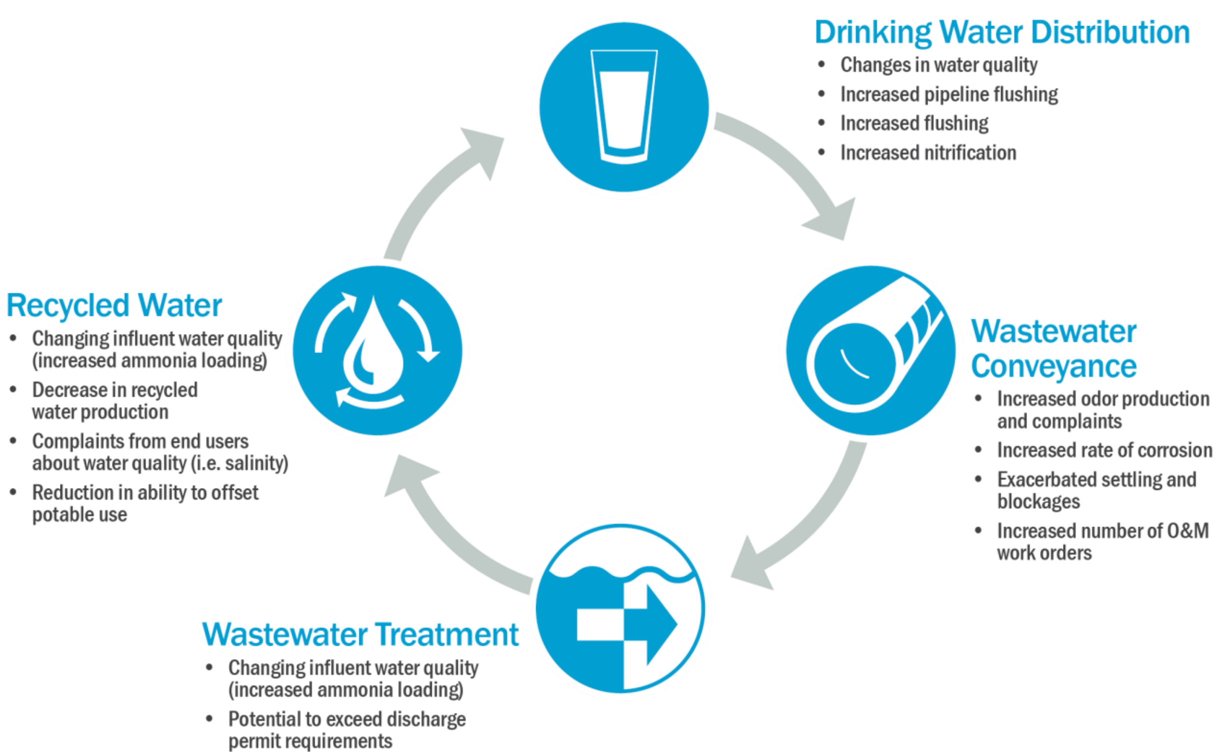


Figure 3-1. Declining flows in the urban water cycle can potentially impact all areas of the cycle.

Source: CUWA 2017

3.2 Impacts on Wastewater Conveyance Systems

The changing characteristics of wastewater from declining flows can impact odor production and corrosion through two methods:

- **Increased concentration of solids and organic material.** As wastewater flows decrease and organic and solids concentrations increase because of conservation, sulfide generation in sewage increase. This increase in sulfides, like hydrogen sulfide (H_2S), results in increased foul air emissions and sewer blockages.
- **Increased residence time.** Low flow in pipes also means a longer residence time, giving more time for the microbes in wastewater to consume oxygen, leading to anaerobic conditions. Increased residence time allows more sulfides to be produced, increasing the likelihood of foul air emissions and nuisance complaints.

These increases in H_2S exacerbates foul odor production and the rate of corrosion in unlined metal and reinforced concrete pipe.

What changes with lower R-GPCD?

Increased solids concentration in wastewater leads to increased generation of H_2S.

What are the potential impacts?

Higher solids and H_2S concentrations can increase foul odor production, accelerate the rate of corrosion, and exacerbate blockages.

Increased Odor Production

Odors in sewers are dominated by reduced sulfur species like H_2S, which is easily recognizable by its characteristic rotten egg odor. H_2S is a product of biochemical reduction of sulfate. As sulfide concentrations in the wastewater increase, bad sewer odors increase.

This impact would be particularly exacerbated in areas where there are long stretches of pipelines and manholes. Increased odor production would generate additional bad sewer odor work orders, which would require additional operations and maintenance (O&M) labor to address. Increase odors would also potentially require an increase in the purchase and use of odor mitigation chemicals, like Bioxide® (i.e., calcium nitrate) or iron chloride.

Accelerated Rate of Corrosion in Sewer Pipes

Corrosion in the conveyance system occurs when the free water surface releases H_2S to the atmosphere during anaerobic conditions and is adsorbed by moist sewer pipe. On the pipe surface, H_2S is converted to sulfuric acid, which corrodes unlined pipes. Accelerated corrosion in unlined pipes leads to a faster rate of structural failure. The primary failure mode for metal pipes is internal or external corrosion, which leads to holes in the pipe wall. Cast iron is particularly brittle, making it susceptible to cracking and subsequent collapse. Corrosion is also often the major factor in the failure of unlined reinforced concrete pipe (RCP), which typically fails after the interior surface of the pipe wall has deteriorated to a point where the reinforcing steel is exposed (Feeny et al., 2009).

This increase in the rate of structural failure because of accelerated corrosion corresponds with an increase in capital and O&M costs. There are strategies to mitigate the impacts of corrosion, such as lining RCP with a plastic liner. However, this lining also requires an economic investment.

Exacerbating Sanitary Sewer Overflows and Blockages

Standards used for hydraulic design include requirements of minimum slopes for various pipe diameters to achieve scouring velocities that minimize debris accumulation. However, conditions could exacerbate debris accumulation, including root intrusion; increase in fats, oils, and grease; and pipe sags (Feeney et al., 2009). This debris accumulation results in sanitary sewer blockages (SSBs), the number one cause of loss in sewer serviceability (Ashley, 2004).

Increased solids concentration in wastewater can potentially exacerbate sanitary sewer overflow (SSO) and blockages in the wastewater conveyance system. A study conducted by a water retailer in Australia correlated water consumption per household with the number of SSBs (Figure 3-2), indicating that lower water consumption gives rise to a higher rate of SSBs (Yarra Valley Water, 2011). This subsequently leads to clogged pipes, loss of sewer serviceability, and an increase in O&M.

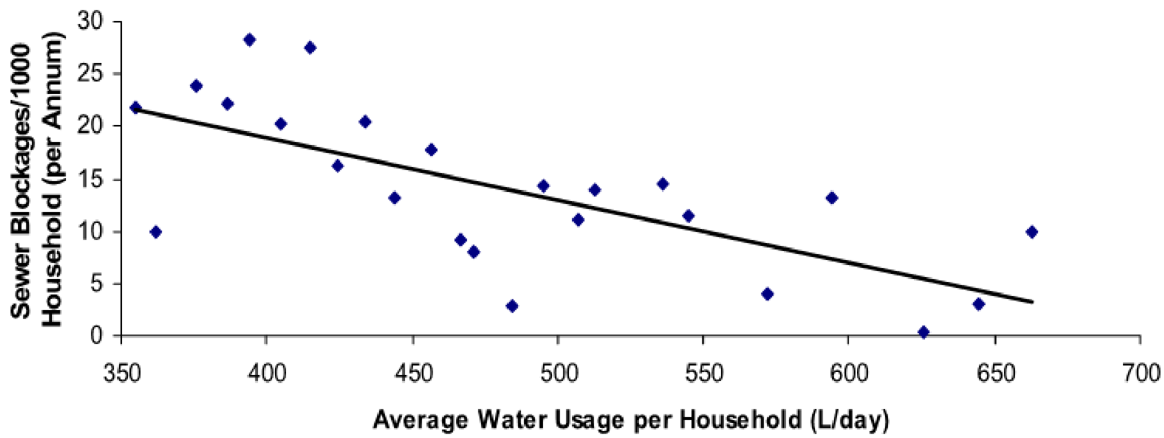


Figure 3-2. Lower water consumption gives rise to a higher rate of sewer blockages.

Source: Yarra Valley Water, 2011

3.3 Impacts of Reduced Flows on Wastewater Treatment

Declining flows in the wastewater system has two impacts on wastewater treatment plants. First, the amount of flow going into the plant is reduced. Second, the concentrations of contaminants increase in the influent wastewater at treatment plants.

Wastewater Influent Concentrations May Impact Effluent Quality

Increasing wastewater contaminant concentrations stress treatment processes as the amount of ammonia, total suspended solids (TSS), total dissolved solids (TDS), and organics (measured as biological oxygen demand [BOD]) increases beyond design specifications. This may potentially impact a plant's ability to meet discharge permit requirements and require wastewater treatment plants to invest in improvements or expansions earlier than planned. Higher loads may also require higher flows and greater volumes of chemicals for treatment.

Reduction of Source Wastewater Flows

Wastewater treatment plant effluent can also potentially be used to produce recycled water to meet project demands. For recycled water projects that have committed to a certain volume of recycled water effluent, a reduction in wastewater can impact those commitments.

What changes with declining flows?

As water decreases in the collection systems, but solids mass remains the same, the concentration of solids in wastewater increases. This leads to lower, more concentrated, flows of wastewater into the wastewater treatment plants.

What are the potential impacts?

- Increase of contaminant concentrations in influent wastewater, including BOD and TSS, which could strain treatment processes.
- Reduction of influent flows into wastewater treatment plants.

3.4 Impacts of Decreased Flows on Advanced Water Treatment

To expand water reuse statewide, utilities are designing and constructing new infrastructure to treat and distribute purified water. Declining flows can alter the treatment and cost-effectiveness of the recycled water infrastructure by altering factors considered in system design, like anticipated flow and water quality. Thus, declining flows could lead to underused community assets and limit the agencies' ability to meet state water reuse goals.

Changes in Wastewater Effluent can have Impacts on Recycled Water Quantity and Quality

Declining flows can result in the generation of a more concentrated wastewater stream, with elevated concentrations of TDS, nitrogen species, and carbon (Stevens, 2015). A recently published paper explores how drought and water conservation strategies combine to reduce influent quality and flow, and subsequently, effluent quality and flow. Assuming that no changes in operations occurs, the analysis showed that an increase in pollutants at the influent of a wastewater treatment facility led to increases in certain constituents in the effluent, including TDS, electrical conductivity, ions, chloride, calcium, and nutrients (Tran et al., 2017).

What changes with declining flows?

As concentration of contaminants increase in wastewater influent, degraded effluent quality can result, and consequently impact advanced water treatment projects.

What are the potential impacts?

Increase of certain contaminants could potentially impact the effectiveness of treatment processes in the advanced water treatment train.

SECTION 4

Leveraging Historical Data to Identify Impacts in San Diego

Historical data and research conducted within the North City sewershed were analyzed to identify any impacts the City may have experienced due to declining flows observed over the past decade. These data sets encompassed impacts on the wastewater conveyance, wastewater treatment, and recycled water systems.

4.1 Impacts on the Wastewater Conveyance System

The City's Public Utilities Department – Wastewater Collection Division is responsible for the collection and conveyance of wastewater from residences and businesses throughout the City, which encompasses a 330 square-mile area with a population of 1.3 million people. Wastewater is collected and conveyed through approximately 2,900 miles of sewer lines, more than 250,000 sewer latteral connections to sewer lines, 84 municipal pump stations, and 62,700 manholes.

Declines in flow within the wastewater conveyance system can be quantified by reviewing influent flows at the wastewater treatment plants. The City currently operates three wastewater treatment plants to treat its wastewater: the NCWRP, the South Bay Water Reclamation Plant (SBWRP), and the Point Loma Wastewater Treatment Plant. Given that the NCWRP and SBWRP currently operate as scalping plants, influent flows at the PLTWP would be the most accurate representation of how wastewater flows have been historically changing (Figure 4-1). Even with the variability in influent flows, caused by wet weather events and changes in operation at the upstream NCWRP and SBWRP, a steady decline of influent wastewater flows is evident. From 2006 to 2017, influent flow has decreased by 24 percent.

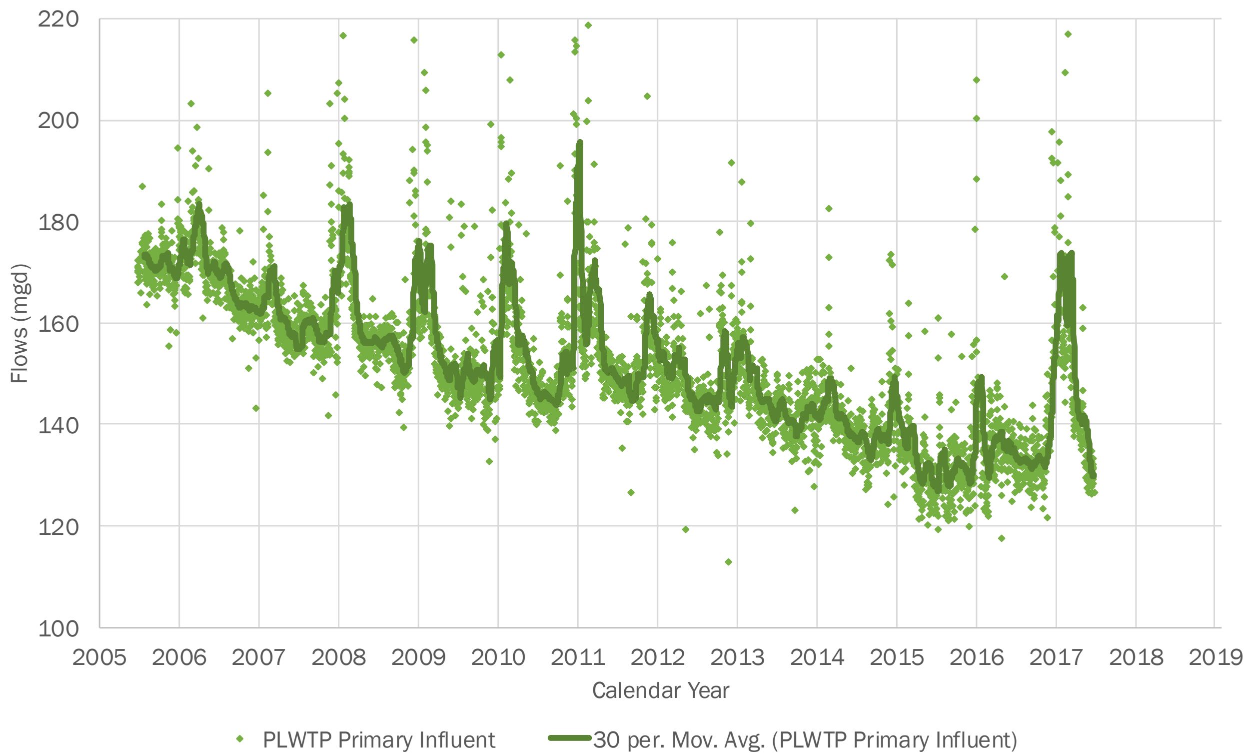


Figure 4-1. Influent flows at the Point Loma Wastewater Treatment Plant declined 24 percent from 2006 through 2017.

These correlate with the declining trends in gpcd, shown in Figure 4-2. Thus, understanding how reduced flows could impact the City's wastewater conveyance system is a critical consideration when developing a holistic water supply strategy.

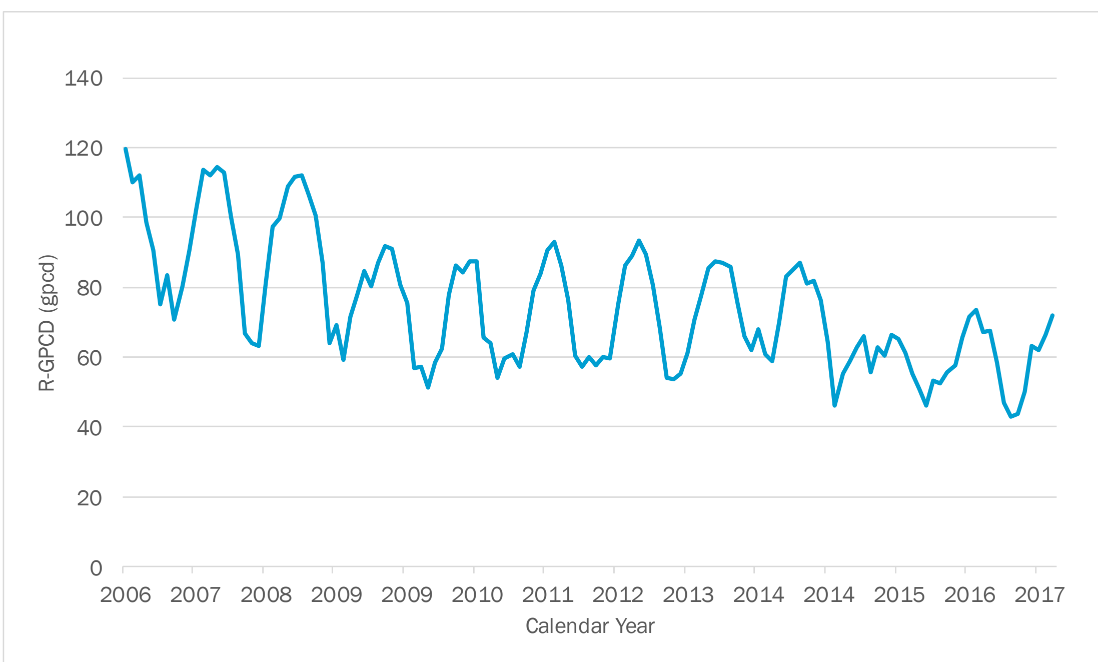


Figure 4-2. The City's R-gpcd has been steadily declining since 2006.

Report of Bad Sewer Odors Increase with Reduced Flows

Increased odor production may manifest as an increase in bad sewer odor (BSO) work orders. To determine whether reduced flows would increase BSO work orders, the number of BSO work orders from 2005 through 2018 were quantified and analyzed. As shown in Figure 4-3, the City's historical R-gpcd and quantity of BSO work orders received appears to have a slight inverse relationship.

Increased solids concentrations in pipes produce more H_2S, which generates more bad sewer odors.

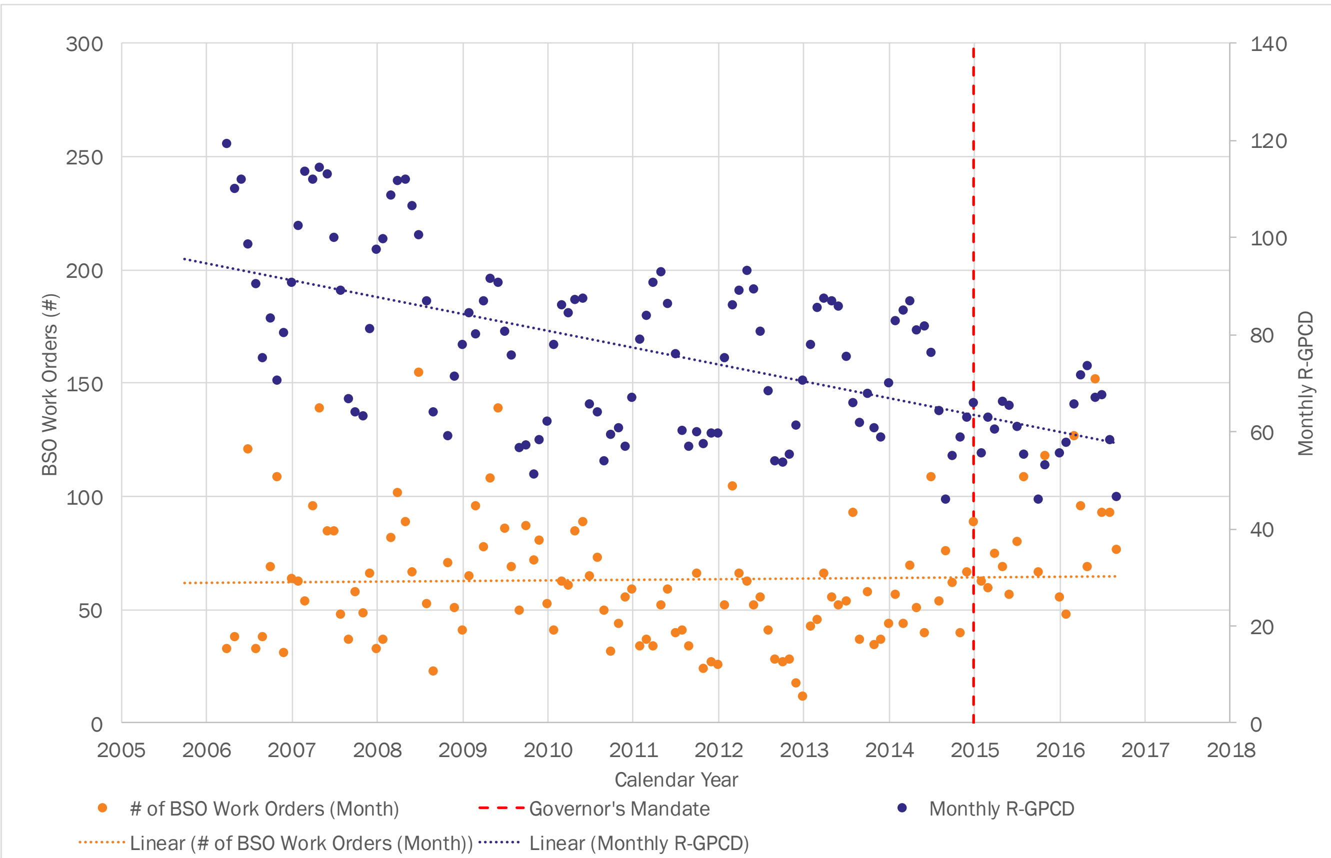


Figure 4-3. R-gpcd significantly reduced after the Governor's mandate, which was accompanied by an increase in BSO work orders.

However, after digging deeper into the R-gpcd values and the number of BSO work orders, there was not a sufficient correlation. This may be because the BSO work orders are a product of odor complaints filed by the community, and other factors were likely mitigating any increases in odor. This could include operational strategies (sealing manhole covers) or increased use of odor managing-controlling chemicals like Bioxide® (which is discussed in the next section).

The data set reviewed indicates that there is no significant difference in BSO work orders between the Baseline and Reduced Flows scenarios, meaning no economic, environmental or social impacts.

Gallons of Bioxide® Purchased Increase with Declining R-gpcd

Increased odor production may also impact the purchase and use of odor mitigation products, such as sodium hypochlorite *and* Bioxide®. These chemicals are trucked from a central supplier and injected directly into the wastewater conveyance system.

The purchase of various odor mitigation products during a fiscal year was assessed, including Bioxide®, impregnated carbon, and hypochlorite. The spike in Bioxide® purchase in fiscal years 2016 and 2017, shown in Figure 4-4, triggered a deeper evaluation of the details of Bioxide® use to determine whether this was a result of reduced system flow.

Additional information was requested from the City's Bioxide® vendor, Evoqua. They provided data listing each Bioxide® delivery and its volume from fiscal years 2008 to 2017 (Figure 4-5).

To ensure that Bioxide® trends were being evaluated due to increased odor production, and not the City choosing to change odor mitigation methods for that injection point, only injection points that have consistently been using Bioxide® from fiscal years 2010 to 2017 were evaluated.

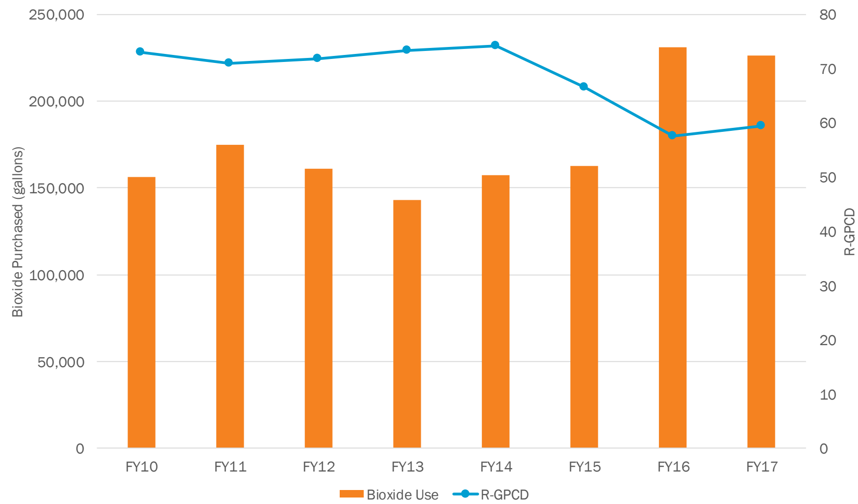


Figure 4-4. Increased Bioxide® purchases in fiscal years 2016 and 2017 triggered a more detailed analysis of Bioxide® purchase and use.

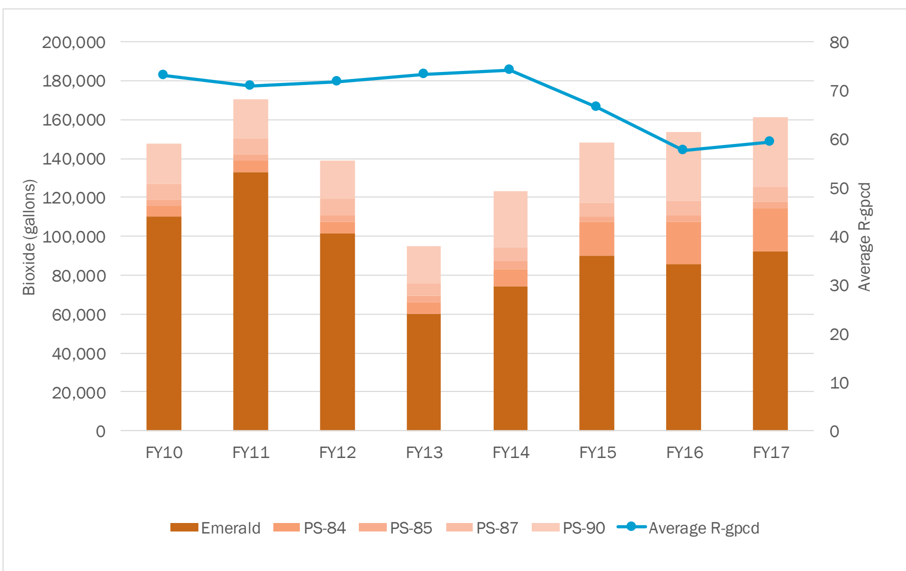


Figure 4-5. Increases in Bioxide® purchases (gallons) coincided with declines in R-gpcd.

Source: Data provided by Evoqua

From the trends in R-gpcd and Bioxide® purchases, a correlation was developed that allowed for additional Bioxide® needed to be calculated. The resulting economic increase for the Reduced Flows scenario is presented in Section 5.

Increased Greenhouse Gas Emissions from Increased Trucking

Increased Bioxide® use also leads to an increase in transport and delivery of the Bioxide®. The supplier, Evoqua, is in Temecula and the Bioxide® injection points are spread throughout the City (Figure 4-6). The average distance between Evoqua and the sampling sites is 30 miles.

To deliver Bioxide®, Evoqua used diesel trucks sized from 2,000 to 4,100 gallons. While there was an increase in Bioxide® use, there was the possibility that Evoqua merely compensated by increasing the size of their delivery truck. Thus, the frequency of deliveries per each fiscal year was reviewed to accurately gauge the greenhouse gas impacts (Figure 4-7).

Increased Bioxide® use coincides with an increase in the frequency of deliveries. An increase in the frequency of deliveries results in environmental and social impacts, which are discussed in Section 5.

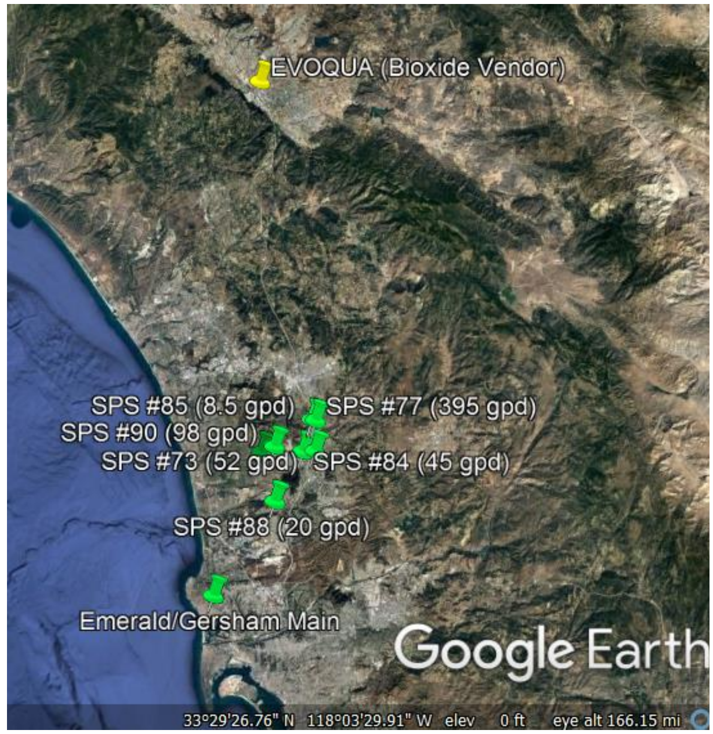


Figure 4-6. The average distance between the Bioxide® supplier (Evoqua) and injection sites is 30 miles.

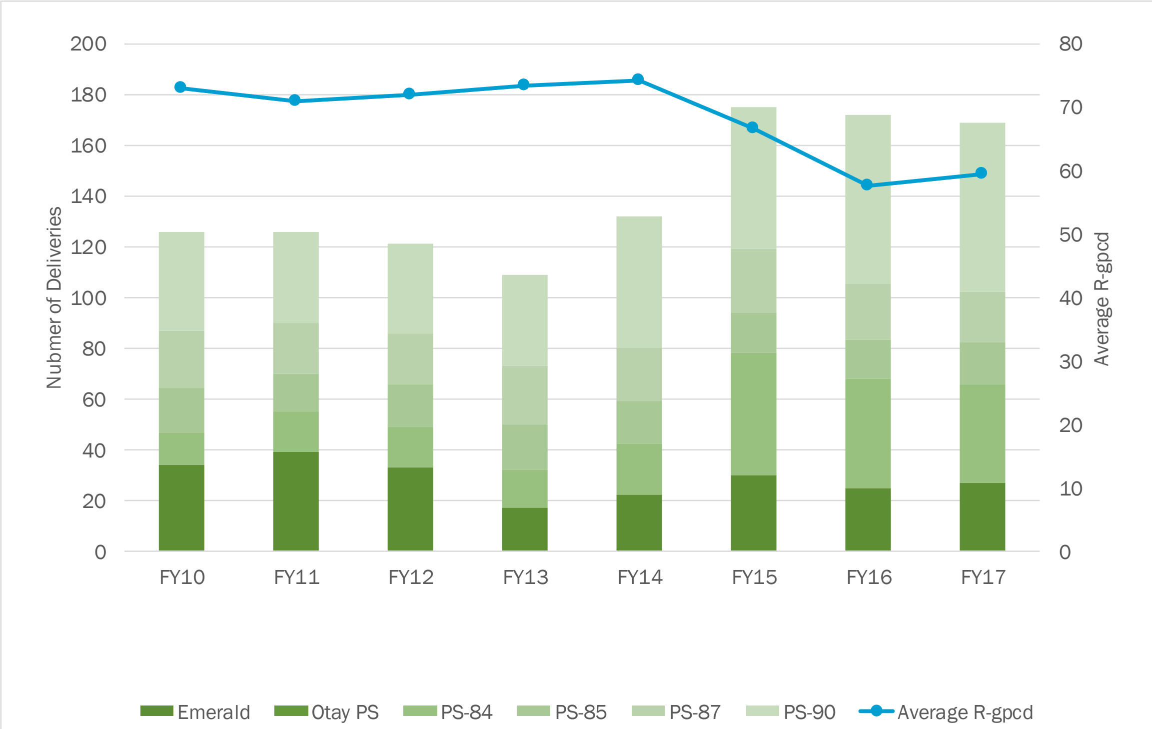


Figure 4-7. The frequency of Bioxide® deliveries increased with increased Bioxide® use at specified locations.

Source: Data provided by Evoqua

Corrosion Implications of Reduced Flows

Accelerated corrosion in pipes leads to a faster rate of structural failure. To evaluate whether the City's wastewater conveyance has been impacted by reduced flows, data for the replacement and rehabilitation of sewer lines were requested and analyzed (Figure 4-8).

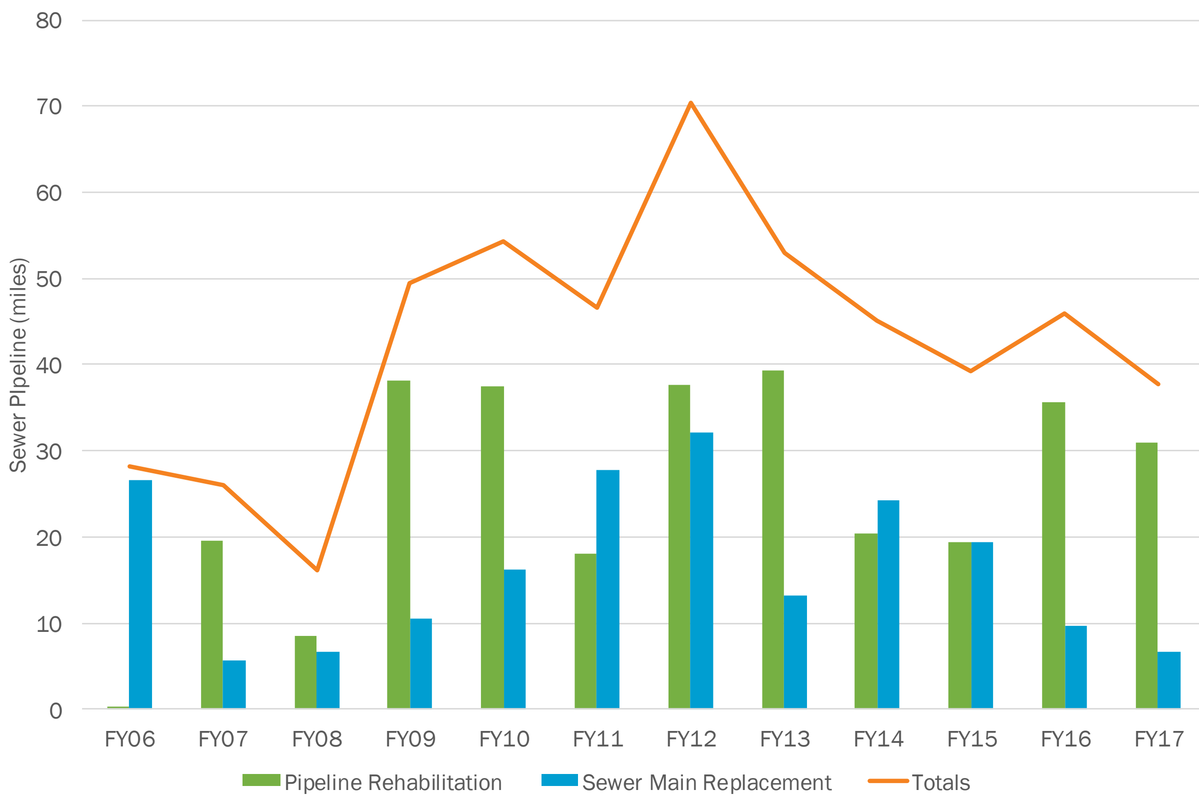


Figure 4-8. The pipeline rehabilitation and sewer main replacement rate appear to fluctuate per fiscal year.

Pipeline rehabilitation and sewer main replacement rates do not have a clear correlation to a reduction in flows. This is because these rates are more driven by the availability of funding and rehabilitation master plans. This is also expected as the impacts from an accelerated rate of corrosion are realized over longer time frames.

However, given the significant impact that accelerated corrosion can have, it is valuable to consider a theoretical impact through corrosion equations and modeling. The next section details a theoretical analysis of the potential impacts of accelerated corrosion.

Increases in H_2S Concentrations Accelerate the Rate of Corrosion

While the exact value of H_2S concentrations throughout the system is unknown, a range of potential economic impacts can be calculated. Per United States Environmental Protection Agency equations outlined in the *"Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants,"* the rate of corrosion specifically for RCP can be calculated as a function of H_2S concentrations, physical characteristics of the pipe, and flow:

$$C_{AVG} = \frac{11.5k\varphi_{aw}}{A}$$

Where;
C_{AVG} = average rate of corrosion (mm/yr)
k = coefficient of efficiency (dimensionless)
A = alkalinity of cement (dimensionless)
φ_{aw} = flux of H_2S to the pipe wall (gm^2-hr)

$$\text{Where, } \varphi_{aw} = 0.69(su)^{\frac{3}{8}}j[DS]\left({}^{b}/_{P'}\right)$$

Where;
s = energy gradient (m/m)
u = stream velocity (m/s)
j = fraction of H_2S as a function of pH
[DS] = H_2S concentration (milligrams per liter [mg/L]))
b/p' = ratio of stream at surface to exposed perimeter of pipe water (dimensionless)

When the same length of pipe is examined at a given pH, the rate of corrosion is linearly related to the rate of H_2S generation. **Thus, as H_2S increases, the rate of corrosion increases at the same rate.** This can be used to roughly estimate how the lifetime of a pipe could be reduced as a function of H_2S generation. As an example, if H_2S concentration in a pipe is increased by 10 percent due to reduced flows, the rate of corrosion is expected to accelerate by 10 percent and reduce the overall lifetime of the pipe by 10 percent. It should be noted that specific conditions, such as humidity and exposure to potential erosive forces, will impact the corrosion of pipes, i.e., not all pipes will corrode or experience material loss with the mere presence of H_2S.

Acceleration in the rate of corrosion would mostly impact unlined RCP pipe. However, the City has been proactively mitigating the impacts of corrosion and has no unlined RCP pipe left in its system. **Thus, most of this impact is going to be felt at concrete manhole structures. Manhole structures that are currently susceptible to corrosion would experience accelerated corrosion due to increasing H_2S concentrations in the Reduced Flows scenario. A reduction in the lifetime of the manhole would translate to a need for capital investment to rehabilitate the manhole earlier than estimated. The resulting economic, environmental, and social impacts are calculated and presented in Section 5.**

Impact on Sanitary Sewer Blockages

Declining flows in the wastewater conveyance system could exacerbate SSBs and SSOs. To determine whether the City had experienced increases in SSOs and SSBs, the number of SSOs and SSBs were analyzed. Research indicated that the City had already conducted a comprehensive analysis of sanitary sewer fills from 2000 through 2015. The research showed a drastic decrease in sanitary sewer spills, especially from 2001 to 2005 (Figure 4-9).

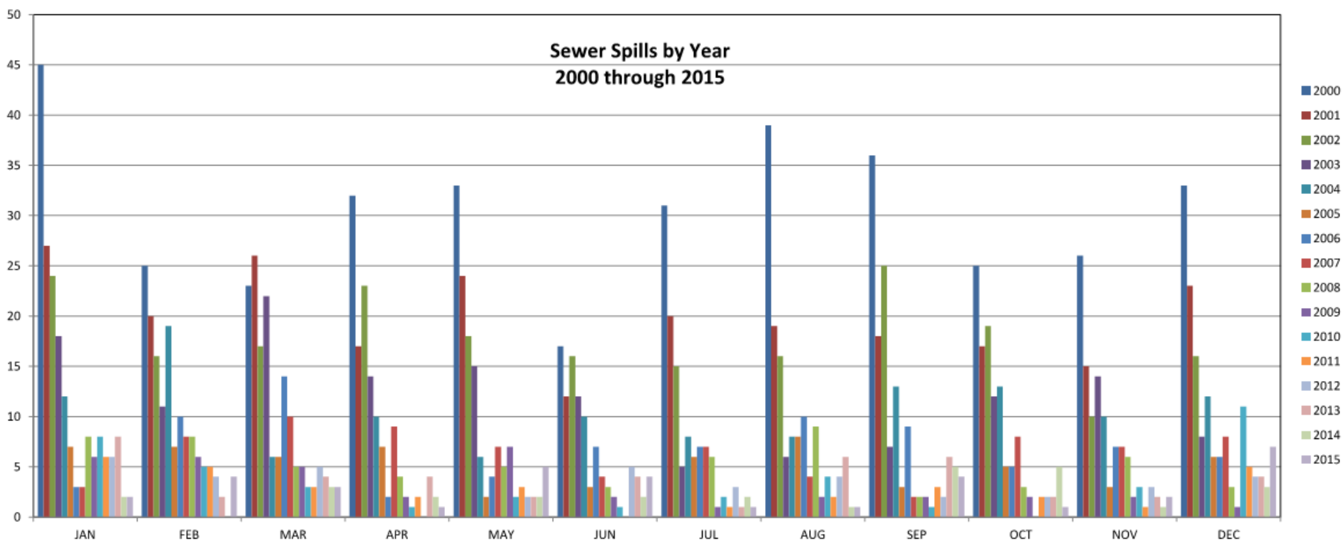


Figure 4-9. Sewer spills dropped drastically from 2000 to 2005 due to the City's aggressive Sewer Spill Reduction Program.

Source: City of San Diego, 2016

This decrease was due to the implementation of the City's aggressive Sewer Spill Reduction Program, initiated in 2001. This program consisted of cleaning all 3,000 miles of the conveyance system by 2004 and developing a systemwide cleaning schedule; televising and assessing the condition of more than 1,200 miles of the oldest and most problematic sewers; and increasing the number of miles of sewer lines replaced or rehabilitated from 15 miles per year to 45 miles per year. The program also has an educational component related to proper grease disposal, which mitigates potential blockages due to fats, oils, and grease.

Thus, the theoretical increase in the rate of SSB and SSOs experienced by the City is buffered by their comprehensive and continued maintenance. **Given the economic investment in the Sewer Spill Reduction Program would be the same in both the Baseline and Reduced Flows scenarios, there are no corresponding economic, environmental or social impacts.**

4.2 Impacts on the Wastewater Treatment System

The cornerstone of the North City sewershed is the NCWRP, which is designed to treat up to 30 mgd (on average) of wastewater. Portions of the wastewater processed through NCWRP are currently treated to Title 22 (California Code of Regulations [CCR]) Standards and distributed to reclaimed water customers through 79 miles of distribution pipelines. The customers then use the water for irrigation, landscaping, or industrial uses.

Phase I intends to expand the NCWRP and use its effluent as influent for the new NCPWF, which would treat the Title 22 water to purified recycled water quality, meeting if not exceeding drinking water standards. Changes to the wastewater influent flows or quantity can impact both the NCWRP expansion design and the MPS, the pump station built to bring supplemental flows to the NCWRP.

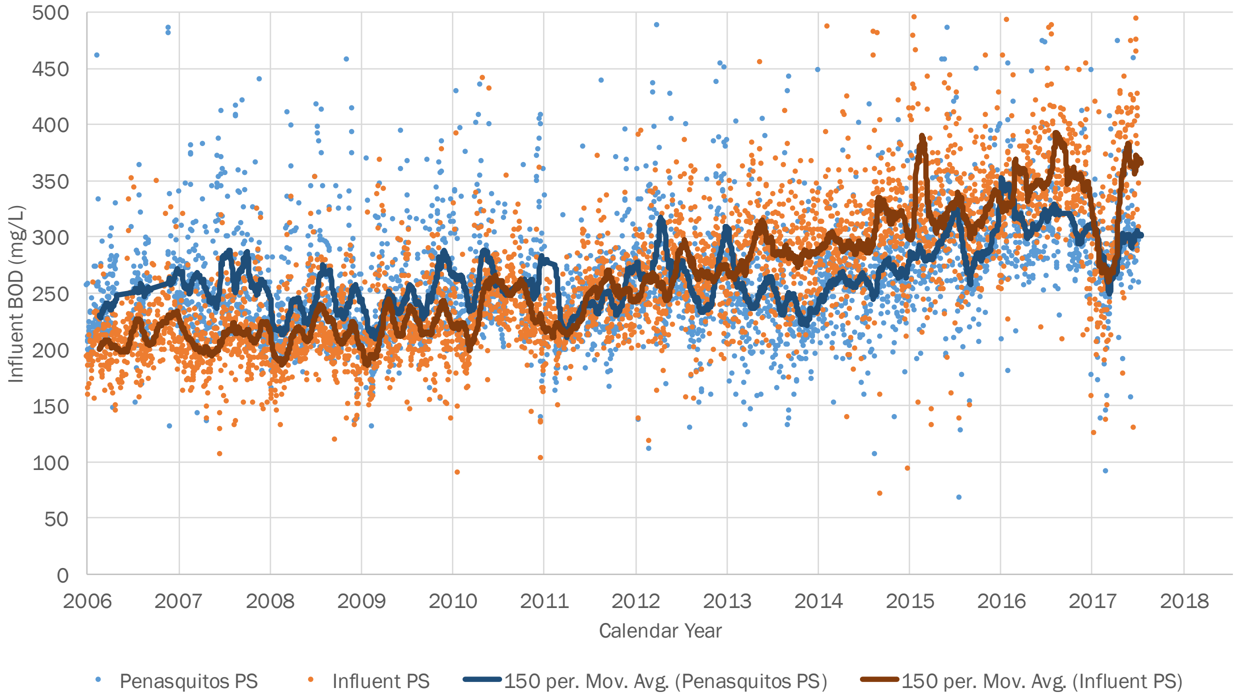
Given the City's current investment in the Pure Water San Diego Program, understanding the potential impacts of reduced flows on wastewater treatment is a critical consideration in developing a holistic water supply strategy.

Changing Wastewater Influent Quality at the NCWRP

As part of Phase I of the Pure Water San Diego Program, the City is currently designing an expansion of the NCWRP, which required establishing design criteria to properly size the treatment processes. However, declining flows can increase contaminant concentrations like BOD and TSS in the wastewater influent, and consequently increase mass loading of these parameters beyond the original design.

Increased pollutant concentrations have the potential to push influent wastewater quality beyond specified design criteria.

To understand how BOD and TSS may be increasing due to reduced flows, historical BOD and TSS concentrations were analyzed. BOD and TSS concentrations in the wastewater influent to the NCWRP have been steadily increasing over the last 10 years (Figure 4-10). From 2006 to 2017, BOD has increased from 200 mg/L to 300 mg/L, which represents a 50 percent increase. TSS has increased from an average of 230 mg/L to 350 mg/L, also representing a 50 percent increase.



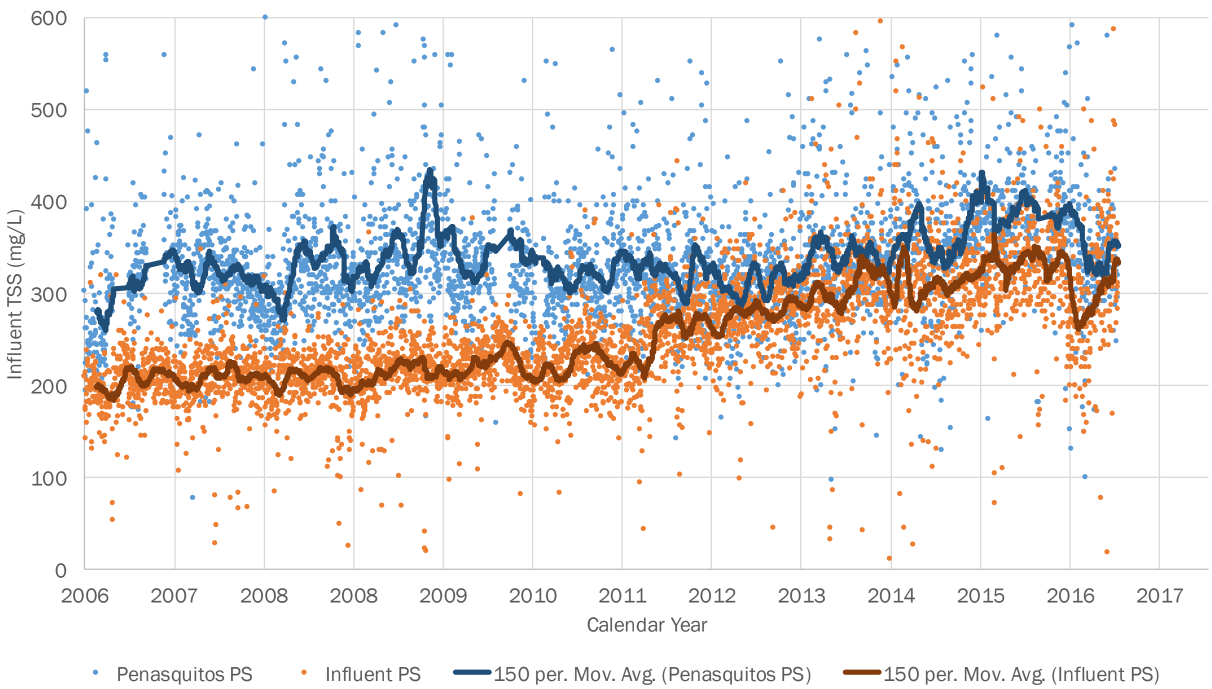


Figure 4-10. BOD (top) and TSS (bottom) concentrations have been increasing steadily in the primary influent at NCWRP since 2006.

The increase in TSS and BOD concentrations can be modeled by using R-gpcd assumptions for the Baseline and Reduced Flows scenarios and an assumed unit generation rate for TSS and BOD. The model considered the increase in TSS and BOD concentrations as flows declined. Given that the NCWRP would still need an influent flow of 52 mgd in both scenarios to produce the amount of recycled water needed, the mass loading in the Reduced Flows scenario is higher. The model concluded that by 2035, there would be a 17 percent increase in TSS and BOD loading (Table 4-1).

Table 4-1. Impact of Reduced R-gpcd on TSS and BOD Concentrations

Item	Baseline	Reduced Flows	Ratio Base: Reduced Flows
Flow (mgd)	52	52	1:1
TSS			
Concentration (mg/L)	300	350	1:17
Load (lb/day)	131,300	154,200	1:17
BOD			
Concentration (mg/L)	270	320	1:19
Load (lb/day)	118,800	139,500	1:17

The increased TSS and BOD concentrations would potentially require changes in the NCWRP expansion design, especially for treatment processes like aeration basins and secondary clarifiers. The resulting economic, environmental, and social impacts are presented in Section 5.

Reductions in Flows Impacting the NCWRP

The NCWRP currently receives flows from Pump Station 64 and the Penasquitos Pump Station. As part of Phase I of the Pure Water San Diego Program, the NCWRP is being expanded to supply 12 mgd of NPR and 30 mgd of purified water. This requires an influent flow of 52 mgd, which is more than the flows currently provided by its two existing pump stations. Thus, supplemental supply is intended to be pumped to the NCWRP by the new MPS, which was strategically located to access enough wastewater for the supplemental supply.

When considering water recycling, wastewater is reframed as a valuable source water.

If flows in the wastewater conveyance system are reduced, the source wastewater that would be redirected to the MPS would also decline. Given that Phase I is committed to producing a total of 42 mgd of product water, the supplemental supply role that MPS plays is critical. If the MPS' source water is reduced, the NCWRP's ability to produce the 42 mgd would be impacted.

Flow projections for the Reduced Flows scenario, which assume a wastewater generation rate of 35-gpcd, indicate there would be a reduction of 6 mgd for the sewers that would feed the currently proposed MPS. This loss could be recovered through relocation of the MPS. **Projected flows for other sewers in the area that could possibly be accessed to generate adequate wastewater supply indicate that the MPS would have to be relocated 2 miles south.**

However, given the progress that the City has made in the design of the Pure Water Program, it is highly unlikely that the City would relocate the MPS. **Thus, the 6 mgd of water lost has value,** which can be quantified based on the cost of importing the same volume of water and an underutilized advanced water purification facility designed to produce more flow than would be available. **Both the relocation and the loss of the water result in economic, environmental, and social impacts, which are calculated and presented in Section 5.**

4.3 Analysis of the Data from the Pilot Advanced Water Purification Facility

As part of Phase I of the Pure Water San Diego Program, the City is investing in a new full-scale advanced water purification facility called the NCPWF, which would mimic the 1 mgd demonstration advanced water purification facility (AWPF) currently operating on the NCWRP site. The NCPWF will be using the same five-step water purification process including ozonation, biological activated carbon, membrane filtration, reverse osmosis (RO), and ultraviolet disinfection with advanced oxidation.

To evaluate whether reduced flows impacted the AWPF demonstration facility, various constituents in the RO system were analyzed. The constituents in question were TDS, TOC, total nitrogen (Total N), and conductivity. These constituents were chosen because they have the potential to increase with declining R-gpcd, and would have the most significant impact on capital and O&M investments. An increase in TDS, TOC, and Total N could lead to accelerated fouling on the RO membranes and a corresponding increase in pressure to push more concentrated influent through the RO membranes.

However, the data from the City's AWPF demonstration facility (Figure 4-11) illustrated that these constituents remained stable in the RO feed despite declining R-gpcd values.

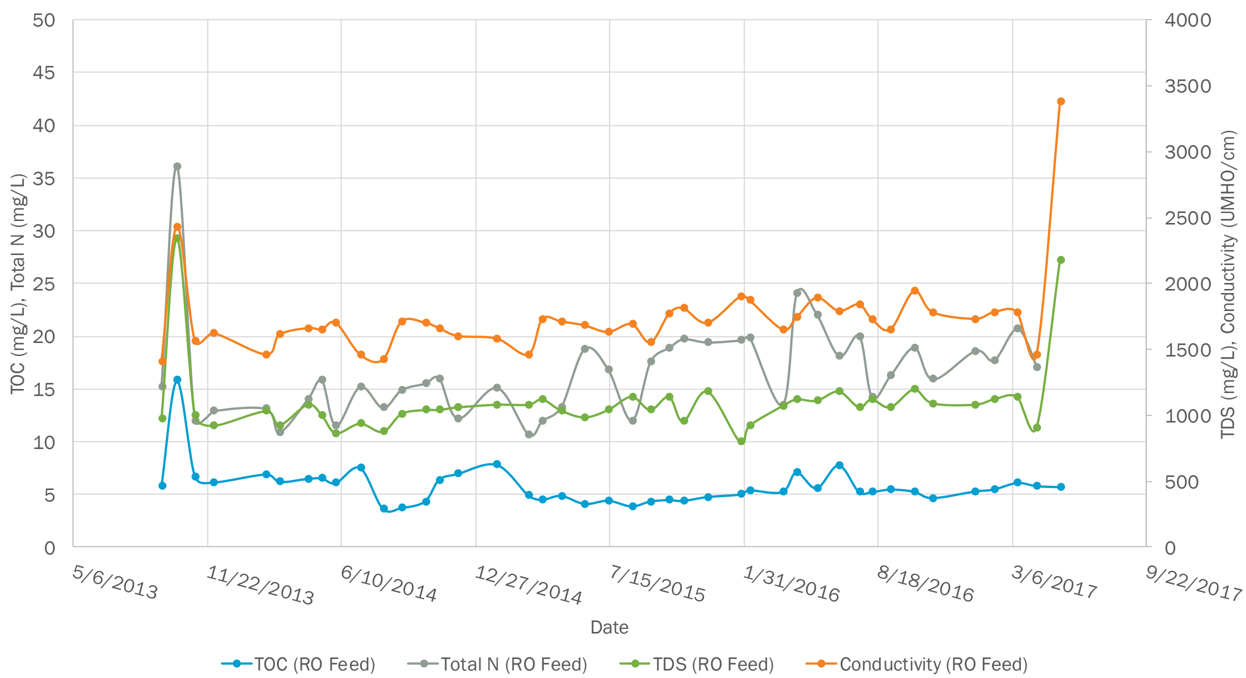


Figure 4-11. TDS, TOC, and Total N in the RO feed did not change despite declining R-gpcd values.

This speaks to the resiliency of the advanced water treatment train, and the upstream wastewater treatment process, as it can handle changes in influent quality. Thus, no impacts were identified for the City's advanced water treatment system.

While increased TDS concentrations were not observed in the RO feed water, research recently conducted by the Southern California Salinity Coalition (SCSC) and the National Water Research Institute reviewed the influence of source TDS and R-gpcd on influent wastewater TDS and presented conclusions that were pertinent to this study.

Influent TDS influenced by Source Water TDS and R-gpcd

The SCSC was founded in 2002 to "address the critical need to remove salt from water supplies and to preserve water resources in California". Given the complexities of factors that could influence the salinity of source waters and wastewater influent and effluent, the SCSC, in collaboration with National Water Research Institute, commissioned a study to analyze the effects that drought and conservation practices could have on the quality of recycled water (Stephens & Associates, 2017).

Using data provided by Eastern Municipal Water District, they conducted an analysis for influent wastewater TDS as a function of source TDS and R-gpcd. They calculated that the majority of influent wastewater TDS is influenced by source TDS, and some of it by R-gpcd (88 and 12 percent, respectively).

To quantify the influence of R-gpcd specifically, the researchers ran two statistical models from 2007 to 2016, one with the observed conservation (70 to 55 gpcd), and the other assuming no conservation (constant 70 gpcd). The statistical model with conservation showed a higher TDS concentration (blue) than the constant flow model (orange) (Figure 4-12), which translated into an increase of 1.7 mg/L of TDS for every 1.0 gpcd decrease in R-gpcd (assuming a constant source TDS).

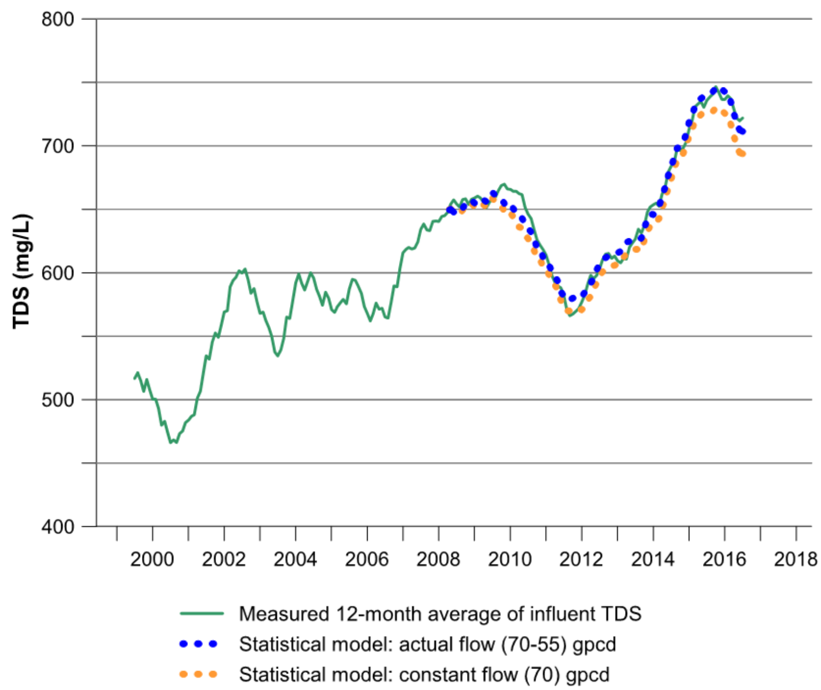


Figure 4-12. The statistical model assuming conservation (blue) predicted higher TDS concentrations.

Source: Stephens & Associates, 2017

It's important to note that this 1.7 mg/L increase is specific to Eastern Municipal Water District, and not directly transferrable to other utilities. For example, the researchers also conducted statistical models for Inland Empire Utilities Agency and their TDS to R-gpcd ratio was 1.2 mg/L of TDS increase to every 1 gpcd decrease in R-gpcd (Stephens & Associates, 2017).

There were still two major conclusions from this research that are pertinent to our study:

- **First, source TDS is a significant determiner of influent TDS**, and source TDS is more variable for agencies that import water, rather than using a local source. This is significant for utilities, like the City, who import from the Colorado River Aqueduct, as it tends to have higher concentrations of TDS.
  - This is relevant to the City, as the Pure Water Program is developing a local water source, which reduces their reliance on imported water. **This subsequently reduces their sensitivity to source water changes and its associated TDS changes, which has environmental benefits (discussed further in Section 5.2).**
- **Next, R-gpcd does have an impact on influent TDS concentrations.**
  - While the 1.7 mg/L is not directly transferrable to the City, it's critical to be aware that declining R-gpcd will have some impact on influent TDS which ultimately impacts recycled water quality and its use for irrigation or industrial reuse practices.

SECTION 5

Economic, Environmental, and Social Impacts of Reduced Flows

The economic impacts associated with the Baseline and Reduced Flow scenarios are calculated as a net present value (NPV). Environmental and social impacts were also considered as part of a holistic analysis of the interconnected water system.

5.1 Economic Impacts

The economic impact of reduced flows is quantified by the comparative difference between the Baseline scenario and the Reduced Flows scenario. For this economic analysis, costs for the Baseline scenario serve as the baseline; therefore, there are **no** economic impacts beyond current capital improvement plan and O&M budgets. The economic impacts of the Reduced Flows scenario are only the costs **in excess of** the baseline costs.

Limitations of the Economic Analysis

This section presents the assumptions and calculations used to quantify an annual cost and NPV for items that had economic implications as identified in Section 4. It should be noted that the calculations herein are based on correlation and theoretical assumptions. The goal of quantifying these economic impacts is to provide an order of magnitude perspective on the potential impacts that declining flows can have on the City's infrastructure.

Impacts on Wastewater Conveyance

The economic impacts of the Reduced Flows scenario identified for wastewater conveyance include an increase in the purchase of odor mitigation products and accelerated spending to address an increase in the rate of corrosion.

Increase in Odor Mitigation Products

While the City uses various odor mitigation products, Bioxide® was selected as the surrogate product for this case study. Using the data presented in Section 4, a correlation was developed between R-gpcd and Bioxide® purchase. This correlation was calculated to be:

$$bioxide\ use\ (gallons) = -2800 * (Rgpcd) + 404{,}000$$

Using this correlation, the gallons of Bioxide® needed to be purchased was calculated for the Baseline and Reduced Flows scenarios. Using the City's unit cost of $2.15 per gallon, the difference resulted in an annual increase of **$125,000 per year of additional Bioxide® purchases** for the Reduced Flows scenario.

Accelerated Rate of Corrosion Requiring an Accelerated Rate of O&M

As introduced in Section 4, the economic impacts of an accelerated rate of corrosion could be theoretically quantified by using equations that relate increasing levels of BOD to H_2S, and using increasing H_2S levels to calculate the acceleration in the rate of corrosion. This acceleration would then be applied to concrete manhole structures experiencing corrosion that the City currently owns and maintains.

To calculate this economic impact, the percent increase of H_2S must first be calculated for the Reduced Flows scenario. By using Pomeroy's equation (EPA 1985), an increase in H_2S can be correlated to an increased BOD:

$$S_2 = S_1 + (M)(t)[EBOD * \frac{D}{4} + 1.57]$$

Where;
S_2 = predicted sulfide concentration at time t_2 (mg/L)
S_1 = sulfide concentration at time t_1 (mg/L)
$t = t_2 - t_1$ = flow time in a given sewer reach with constant slope, diameter, and flow (hour)
M = specific sulfide flux coefficient (m/hr)
EBOD = concentration of BOD (mg/L)
D = pipe diameter (feet)

Assuming S_1 is zero, S_2 becomes a function of detention time and BOD concentrations. By using projected flows and BOD values provided by the City, the increase in H_2S concentrations can be calculated for the Reduced Flows scenario. Based on the relationship provided by Pomeroy's equation, **a 160 percent increase in H_2S concentrations would be observed by 2035 in the Reduced Flows scenario**. Using the linear relationship developed in Section 4, this would translate to a **160 percent increase in the rate of corrosion.**

This 160 percent increase would have an economic impact on the City by theoretically reducing the lifetime of manhole structures by 160 percent. However, it's important to note that only manholes with specific characteristics would be impacted by an accelerated rate of corrosion. These are manholes that are downstream of pump stations, have a decline in upstream and downstream slope, or contain converging flows. Specific conditions, such as humidity, could also impact corrosion. To appropriately estimate the economic impact, the accelerated rate of corrosion was only applied to manholes with these characteristics, referred herein as "impacted manholes".

To quantify the impacted manholes, the City provided a dataset of manhole condition assessments. Given that the City has not yet conducted a condition assessment on all the manholes in their system, this data set was leveraged as a sampling size to be extrapolated to the entire system. The percentage of "impacted manholes" would be developed from the sampling size, and then applied to the entire system to calculate the total number of impacted manholes.

Determining the percentage of impacted manholes from the sampling size data set. To determine how many manholes would be subject to an accelerated rate of corrosion, the condition assessment data was filtered to only include manholes that are currently experiencing corrosion. (This excluded "corroding steps", as they corrode regardless of the manhole characteristics described above.) From the provided data set, **2.1 percent** of the City's manholes were experiencing corrosion from their latest condition assessment. It's important to highlight this 2.1 percent represents the minimum number of impacted manholes, and that there may be manholes that would experience accelerated corrosion that aren't captured in the 2.1 percent. Thus, the cost estimate developed around the 2.1 percent is the minimum economic impact on the City.

Extrapolating the 2.1 percent to the entire City's entire system. Using GIS data from February 2015, there is an estimated 62,700 total manholes in the system. Per the City, roughly 1,900 manholes have already been rehabbed, replaced, or repaired. If these manholes have been rehabbed, replaced, or repaired with a method that mitigates corrosion, that reduces the total manhole count to 60,800. 2.1 percent of 60,800 means roughly 1,300 manholes would be subject to an accelerated rate of corrosion. Once again, these 1,300 manholes represent the minimum number of manholes in the system that would be impacted by accelerated corrosion.

Calculating the total cost to rehabilitate the 1,300 manholes. To address the 1,300 manholes that would experience accelerated corrosion, the City would need to invest money to rehabilitate these manholes earlier than anticipated. Assuming an average riser depth of 9 feet, a unit cost of $3,400 was developed, covering rehabilitation of the riser, bench, and trough. 1,300 manholes at $3,400 per manhole would mean the City would need to spend roughly $4,420,000 to rehabilitate all the "impacted manholes". A 20 percent contingency was then added to the $4,420,000 to cover frame and cover replacements (not included in the unit cost), as well as any operational procedures that could exacerbate the rate of corrosion. For example, the City sometimes uses a silicone sealant on manhole covers to mitigate odors, but that exacerbates the rate of the corrosion. Thus, the total cost to mitigate the accelerated corrosion is $5,300,000.

It's important to note that this total cost assumes that the method of rehabilitation would prevent any future impacts of accelerated corrosion for that manhole.

Calculating a cost per year to rehabilitate the impacted manholes for the Baseline scenario. The total cost of manhole rehabilitation would not differ between the Baseline and Reduced Flows scenarios, because manhole rehabilitation is an investment the City is already planning to make in the next 10-15 years. However, the accelerated rate of corrosion would require the City to address the impacts of corrosion much earlier than anticipated. Per the City, the average number of manholes/year that the City has rehabbed, replaced, or repaired is roughly 120 manholes/year. Assuming the same rate, the City would need 11 years to rehabilitate the remaining 1,300 manholes. Thus, the $5,300,000 over 11 years would equate to $482,000 per year through 2028 for the Baseline scenario.

Calculating a cost per year to rehabilitate the "impacted manholes" for the Reduced Flows scenario. In the reduced flows scenario, the 160 percent increase in the rate of corrosion would require the City to reduce the lifetime of manholes by 160 percent. That would require the City to address the "impacted manholes" in 4 years (through 2021), as opposed to 11 causing the annual cost to increase to $1,330,000 per year through 2021 for the Reduced Flows scenario.

The economic impact of accelerated corrosion is the required increase in investment per year (minimum $850,000 per year) to address corroding manholes over 4 years rather than 11.

What is the economic impact? The other economic impacts discussed within this report have been included in an NPV analysis through 2035. However, given that the total $5,300,000 for both the Baseline and Reduced Flows scenario is required before 2035, the economic impact for accelerated corrosion isn't best demonstrated in NPV. (The NPV difference between the two scenarios, specifically for corrosion, is ~$270,000 through 2035.) **The significance of the economic impact is the increased investment required (at least $850,000 per year) by the City in the first 4 years to address accelerated corrosion.** Given that the budget for the Public Utilities Department is determined per fiscal year, the City would have to increase their budget for manhole rehabilitation to address accelerated corrosion.

Impacts on Wastewater Treatment

The economic impacts of the Reduced Flows scenario identified for wastewater treatment, namely the NCWRP, include increased NCWRP expansion costs, a reduction of 6 mgd at the MPS location, and a theoretical location of the MPS to capture adequate supplemental flows.

Increase in Capital Costs for the NCWRP Expansion

The analysis in Section 4 resulted in an increase in TSS and BOD concentrations of 17 percent for the Reduced Flows scenario. This would impact treatment processes sized accordingly to mass loading, such as secondary clarifiers and aeration basins. The economic impact was thus quantified by increasing the capital costs of the secondary clarifiers and aeration basins of the existing NCWRP design by 17 percent. Using the 10 percent cost estimate developed for the NCWRP expansion, a 17 percent increase results in a one-time capital cost increase of **$8.6 million** for the Reduced Flows scenario.

Theoretical Costs to Relocate the MPS

Reduced flows in the system could potentially require relocation of the MPS to ensure access to enough wastewater to provide the necessary supplemental flows at the NCWRP. Projected flows for other sewers in the area that could possibly be accessed to generate adequate wastewater supply indicate that the MPS would have to be relocated 2 miles south. This relocation would present a significant capital cost investment as it would require crossing of the San Diego River. The San Diego River is 100 feet deep at the location of the identified crossing; thus, the tunneling would require deep launching and receiving pits.

Unit costs for tunneling were derived from the MPS—10 percent Cost Estimate (MWH 2016), which translated into a tunneling cost of $3 million. An additional 2 miles of pipeline would also be required, which—using the same MPS 10 percent Cost Estimate—would cost $12.7 million. The additional 2 miles would also generate more head loss, increasing the cost to run the mechanical and electrical components of the pump station. Beyond the physical infrastructure, redesign of the pump station, with additional permitting costs, would also be required. Table 5-1 provides a high-level estimate of these potential costs.

Table 5-1. Cost to Relocate the Morena Pump Station

Component	Cost
Pipeline	$13,000,000
Tunneling	$3,000,000
Mechanical & Electrical	$300,000
Soft Costs (28%)	$4,500,000
Total Capital Costs	**$20,500,000**
Annual Increase in Electrical Costs	**$50,000**

Value of the Lost 6 MGD

Given that the MPS is already being designed, it is unlikely that the MPS would be relocated. Thus, the reduction of 6 mgd of wastewater source water is also considered as an economic impact. This impact is quantified by calculating the annual cost of importing the same volume of untreated water. Some water is lost through the recycled water treatment process, and 70 percent of the wastewater influent becomes recycled water effluent. Thus, a reduction of 6 mgd of wastewater source water would result in a reduction of 4.2 mgd of purified water.

A constant 4.8 mgd would equate to a loss of 4,700 acre-feet of raw water per year. Using the San Diego County Water Authority's 2017 rates for untreated delivered water, that would equate to a value of **$4,500,000 per year.** This reduced production would also have social and environmental implications, as it would undermine the City's commitments to purified water production.

NPV Analysis of All Economic Impacts

Each of the economic impacts was imported into an NPV calculation to quantify cumulative impacts from 2017 through 2035. An escalation rate of 2.5 percent and a discount rate of 4 percent was assumed, which are consistent with the values used for the Pure Water Program. Table 5-2 summarizes these impacts.

Table 5-2. Economic Impacts of the Reduced Flow Scenario		
Economic Impact	**Value**	**One-Time Cost or Annual for NPV**
Wastewater Conveyance		
Increase in Bioxide® Purchases	$125,000	Annual
Accelerated Investment due to Corrosion	An increase of $850,000 per year for four years. (See discussion above.)	Not Included in NPV
Wastewater Treatment		
Increase in NCWRP Expansion	$8,600,000	One-Time
Relocation of the MPS (Capital)	$20,500,000	One-Time
Relocation of the MPS (Operations)	$50,000	Annual
Value of the lost 6 mgd	$4,500,000	Annual
NPV Total	**($102,00,000)**	

It's important to note that while there are these economic impacts due to declining flows, there are also economic benefits. For example, there could be reduced pumping costs due to the reduction in wastewater flows. There could be O&M benefits from fewer sewer overflows, and the wastewater treatment plants would be treating less influent. However, the economic impact presented here emphasizes the need to have a holistic perspective and consideration of all potential impacts during planning.

5.2 Environmental and Social Impacts

The City is focused on establishing a resilient, drought-proof, and reliable water system for the benefit of the community and the environment. The social and environmental implications of the Baseline and Reduced Flow scenarios are therefore important elements of the evaluation of these two scenarios.

Ensuring water supply reliability and resiliency is paramount to every water utility, and a water shortage can be a detriment to public health. With climate change expected to exacerbate droughts, water utilities like the City are developing strategies to buffer water supply shortages and ensure water supply reliability.

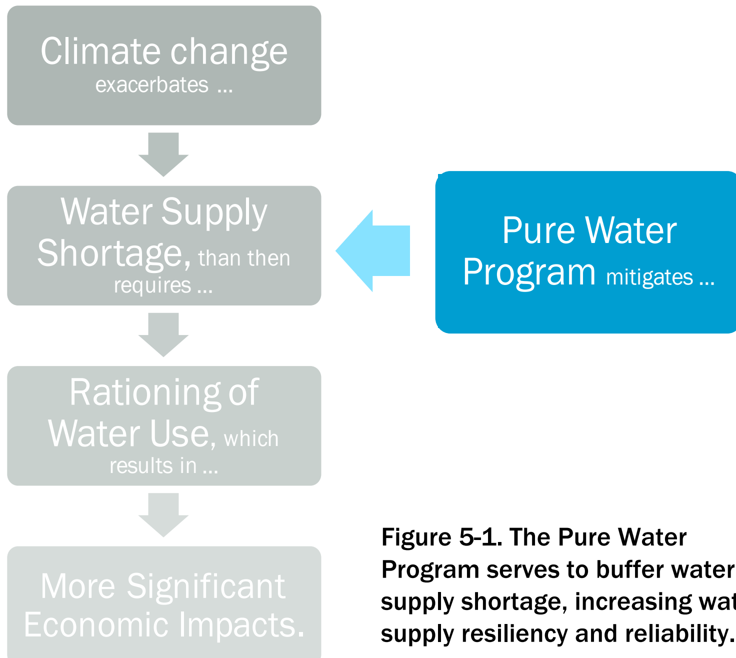


Figure 5-1. The Pure Water Program serves to buffer water supply shortage, increasing water supply resiliency and reliability.

A report published by CUWA in 2009 considers the economic dimensions of urban water shortage and estimates the economic losses resulting from requiring consumers to reduce their indoor residential water use (i.e., in a rationing state). The report focused on CUWA member agencies, which includes the City.

The study reviewed the City's water and sewer rates and calculated the prices per acre-feet in pre- and post-rationing scenarios. **The cost per acre-feet water prices in post-rationing scenarios were higher as the City was making less revenue, but the costs for O&M of the distribution systems remained static. Thus, investing in programs that can mitigate the impacts of water supply shortage provides economic and social benefits.**

Environmental and Social Benefits of the Pure Water Program

The Pure Water Program provides significant environmental and social benefits (Figure 5-2). While both scenarios include the Pure Water Program, the severely reduced wastewater flows defined in the Reduced Flows scenario decreases the volumes of purified water effluent produced. Thus, the Reduced Flows scenario potentially **undermines** the benefits of the Pure Water Program, which include:

- **Development of a locally sources, drought-proof water supply.** The Pure Water Program leverages the local wastewater produced as its source supply. This local supply lessens the City's dependence on imported water, which is susceptible to drought.
- **Reduction in sensitivity to changing source TDS.** Currently, the City imports approximately 85 percent of its water supply from other water areas, including the Bay-Delta and the Colorado River. As discussed in Section 4.3, influent wastewater TDS is heavily dependent on source TDS, and the Colorado River water historically has higher TDS concentrations (Daniel & Associates 2017). By reducing the percentage of imported water and supplementing it with a high-quality local supply, the City buffers and lowers their sensitivity to source TDS fluctuations.
- **Providing a source of emergency supply water.** The Pure Water Program provides a source of reliable water during emergency situations, like earthquakes or wildfires. One of the limitations faced by firefighters is the availability of nearby water. As the Pure Water Programs lessens the City's dependence on their stored water reserves, those remain as a source of emergency supply water. In addition, the pipelines for the City's imported water supplies run over earthquake fault lines, and a substantial earthquake has the potential to cut off those supplies. In that event, the Pure Water Program wastewater can serve as a supplemental supply.
- **Reduction of ocean discharge volume and improvement in quality.** Conservation plays an important role in the reduction of ocean discharge. However, as conservation only reduces the volumes of water entering the system (not solids), this reduction is limited by the minimum flow velocities required to keep wastewater moving in the system. In contrast, the Pure Water Program pulls both liquids and solids out of the wastewater system for water reuse, which can more significantly reduce ocean discharge. In addition, as solids are also removed from the system, TSS volume in the ocean discharge is also decreased. In 2016, there was a 23 percent reduction in ocean discharge due to a combined effort of water conservation and recycled water. By 2035, ocean discharge can be reduced by 65 percent due to a combination of conservation, recycled water, and the Pure Water Program.

Figure 5-2. The Pure Water Program provides social and environmental benefits for the San Diego community.

Source: City of San Diego, 2018b

Other Environmental and Social Impacts of Reduced Flows

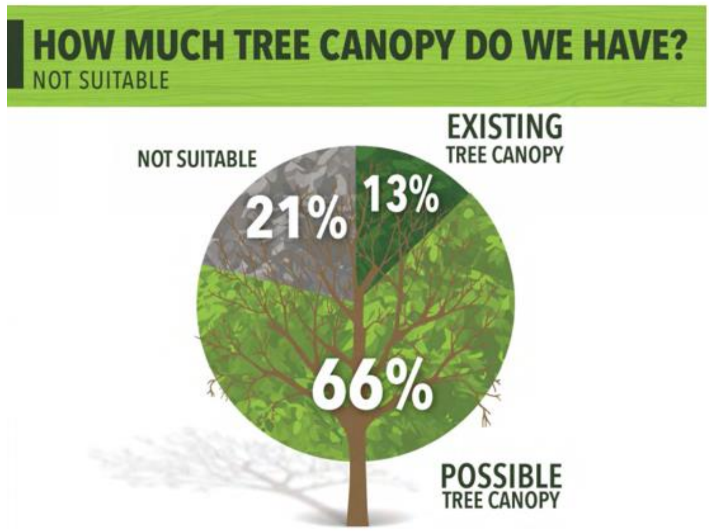
Other social and environmental impacts of the Reduced Flows scenario (as outlined in Section 4) are:

- **An increase in Bioxide® deliveries** has both environmental and social impacts. Increased trucking from reduced flows emits more greenhouse gas emissions into the atmosphere. Many of the injection points are also located within residential communities, and more deliveries means more truck traffic, inconveniencing the residential community.
- **An accelerated rate of corrosion** has both environmental and social impacts. Acceleration in manhole structures means more construction, requiring construction materials and operation of heavy equipment, producing more greenhouse gas emissions.

Commitment to Climate Action Plan

According to the conservation standards currently being developed, the City's "water use budget" is the aggregate total of indoor use, outdoor use, and distribution system losses. There are situations where individuals will argue that meeting the water use budget would be accomplished by focusing on outdoor reductions, thus mitigating the potential impacts of reduced R-gpcd.

However, it is important to consider that the City has also committed to improvements that require outdoor irrigation. For example, the City has committed to a certain tree canopy percentage in their Climate Action Plan (Figure 5-3). This constrains the City to certain volumes of outdoor irrigation to meet these environmentally beneficial goals. Investing in water recycling programs like Pure Water should afford the City more flexibility in their supplier water use target, as regulations intend to incentivize utilities to continue their investment in water reuse.



Year	% Tree Cover
2003	7%
2010	4.2%
2014	13%
Climate Action Plan Targets	
2020	15%
2035	35%

Figure 5-3. The City has committed to 35 percent of tree canopy by 2035 in its Climate Action Plan.

Source: City of San Diego, 2017c

100 Percent Renewable Energy

The Pure Water Program includes a commitment to running on 100 percent renewable energy. This means that greenhouse gas emissions caused by importing water are instead transformed into renewable energy sources. Thus, even though Pure Water may require more energy, the fact that is renewable energy provides an environmental benefit.

SECTION 6

Conclusions and Next Steps

With water use regulations under development per the California Water Action Plan, it is critical to consider the impacts of reduced flows holistically. This case study analyzed the economic, environmental, and social impacts of reduced flows on the City's interconnected water systems.

As supplier water use targets and water use standards are currently in development, it is vital to understand the interconnectedness of the urban water cycle. Changes in one area of the cycle, such as a reduction of flows into the system, is likely to impact other areas. Every action associated with water supply reliability has an important role to play; however, a localized strategy will inherently differ from utility to utility depending on site-specific considerations. As utilities continue to invest in programs and infrastructure that support water supply reliability, it is important to consider how different water supply reliability strategies, like WUE and water supply diversification, can impact each other. The City, as a leader in both strategies, can serve as a valuable case study to provide insight into what those impacts may be. In addition, impacts need to be analyzed through a triple bottom line lens to develop a cost-effective strategy for improved supply reliability while also benefiting the environment and community.

This case study reveals that significantly reduced flows could cost the City on the order of $102,000,000 through 2035 in addition to environmental and social impacts within the region. **These impacts underscore the importance of a holistic analysis of the urban water cycle to ensure development of the best water management plan, as each utility's experience is unique to its water supply situation. This uniqueness also highlights the importance of flexibility in statewide water use standards, as different regions may experience different impacts.** The City is a great example of how a variance could help agencies account for local impacts and investments in water supply reliability measures, including increased use of recycled and purified water as recommended by the California Water Action Plan.

As prefaced above, it's important to note that there are some benefits and impacts of reduced flows that were not quantified in this case study, but are important and should be investigated further. The benefits include:

- Reduced use of water (including imported and desalinated), and the related financial savings and environmental benefits.
- Reduced energy and chemical use in drinking water and wastewater conveyance and treatment.

This report also focused on the impacts of reduced flows from indoor residential use as those flows remain within the interconnected urban water cycle. However, there may also be impacts from reduced outdoor irrigation use including:

- Loss of areas landscaped with irrigated plants, which provide benefits like improved aesthetics, mitigation against the heat-island effect, and increased property values.

Ultimately, increasing water use efficiency has both benefits and potential impacts on water, wastewater, and recycled water systems, which can be balanced through informed policy. A holistic, one-water approach can benefit smart policy and provide the best solutions in managing California's water resources.

SECTION 7

References

Ashley, Richard & Bertrand-Krajewski, Jean-Luc, *Solids in Sewers: Characteristics, Effects, and Control of Sewer Solids and Associated Pollutants,* IWA Publishing, 2004.

Brown and Caldwell, *Blueprint for One Water,* Water Research Foundation, Project #4660, 2017.

California Department of Water Resources (DWR), State Water Resources Control Board, California Public Utilities Commission, California Department of Food and Agriculture, and California Energy Commission, *Making Conservation a California Way of Life,* State of California, 2017.

California Urban Water Agencies, *Adapting to Change: Utility Systems and Declining Flows,* CUWA, 2017.

United States Environmental Protection Agency (EPA), *Design Manual – Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants*, Cincinnati, OH, 1985.

City of San Diego, "Public Utilities Sewer Spills from 2000-2015*", Sewer Spill Reduction Program,* 2016, https://www.sandiego.gov/sites/default/files/sewer_spills_by_year_2000-2015.pdf (February 13, 2018).

City of San Diego, "Pure Water San Diego Fact Sheet", *Informational Materials,* 2017a. https://www.sandiego.gov/sites/default/files/pure_water_san_diego_fact_sheet_9-15-16_1.pdf (February 13, 2018)

City of San Diego, "Pure Water San Diego Phase 1 Fact Sheet"*, Informational Materials*, 2017b. https://www.sandiego.gov/sites/default/files/pure_water_san_diego_phase_1_fact_sheet_-_4-20-17_1.pdf (February 13, 2018)

City of San Diego, *Urban Forestry Program Five Year Plan,* 2017c. https://www.sandiego.gov/sites/default/files/final_adopted_urban_forestry_program_five_year_plan.pdf (February 13, 2018)

City of San Diego, "Service Area Map", 2018a. https://www.sandiego.gov/mwwd/general/servicearea, (February 1, 2018)

City of San Diego, "Pure Water San Diego", 2018b. https://www.sandiego.gov/water/purewater/purewatersd

Daniel B. Stephens & Associates, *DRAFT - Evaluation of Long-Term Trends and Variations in the Average Total Dissolved Solids Concentration in Wastewater and Recycled Water,* Southern California Salinity Coalition and National Water Research Institute, 2017.

EPA, *Design Manual: Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plans*, 1985.

Feeney, C. S., Thayer, S., Bonomo, M., & Martel, K., *White Paper on Assessment of Wastewater Collection Systems,* EPA, 2009.

Stevens, M., *Unintended Consequences of Conserving Water: Leaky Pipes, Less Revenue, Bad Odors,* Los Angeles Times, 2015.

Tran, Q. K., Jassby, D., Schwabe, K.A., *The implications of drought and water conservation on the reuse of municipal wastewater: Recognizing impacts and identifying mitigation possibilities,* Water Research, 2017.

USGCRP, *Climate Science Special Report: Fourth National Climate Assessment, Volume I.* Washington, DC, USA: U.S. Global Change Research Program, 2017.

Yarra Valley Water, *Data Sewer Blockages vs Average Water Usage per Household,* Melbourne, 2011.