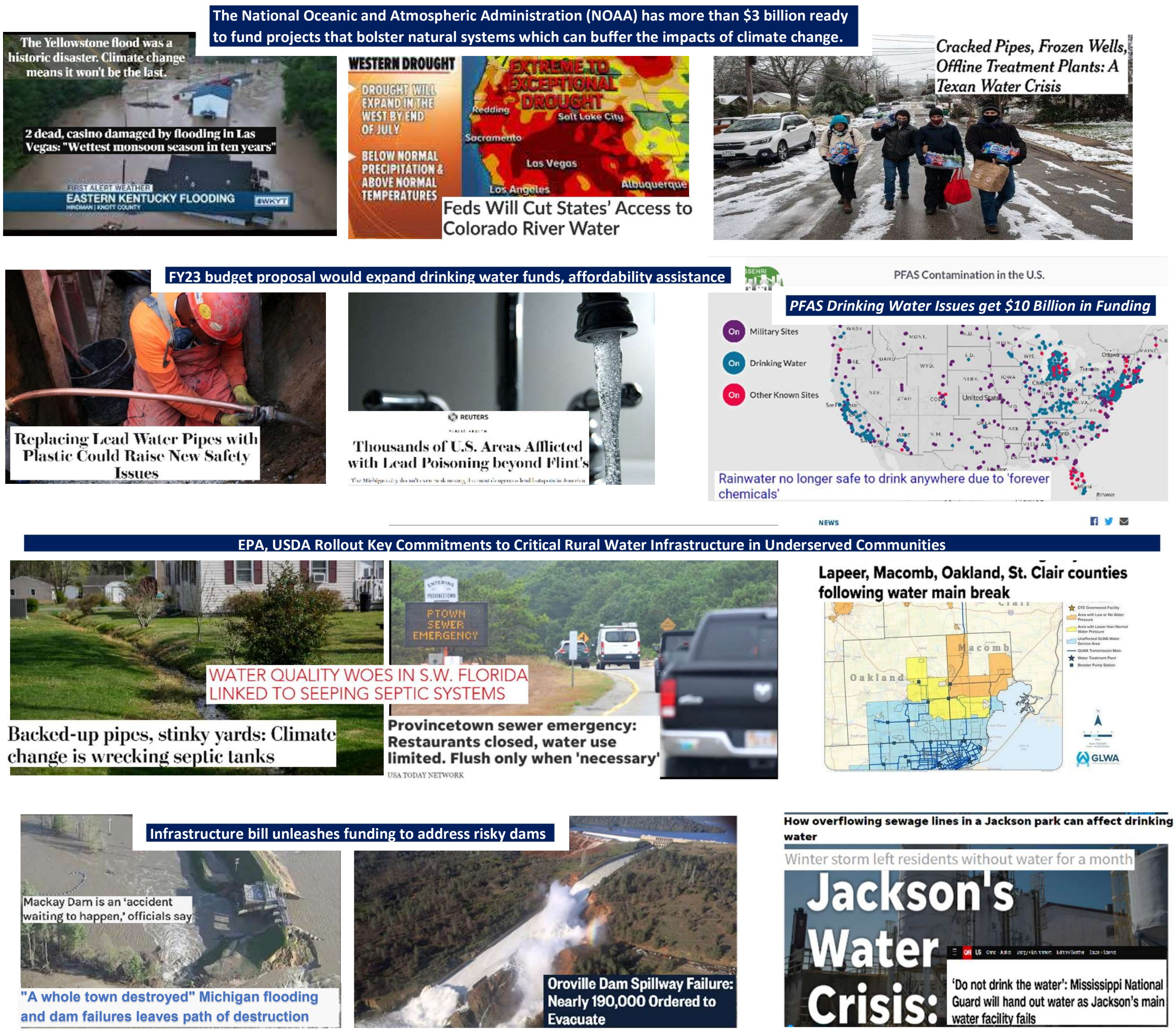
America’s Water 2022

– A Snapshot of the Challenge and Steps Towards Solutions



Background for the 7th Annual America’s Water Event, September 20, 2022

Re-Thinking Water: Ensuring America's Water Security: Designing, Financing & Managing Infrastructure for Climate Adaptation

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sciensWATER
Making sense of water

Context

It is time. For over two decades, community and industry groups have decried the state of the aging US water infrastructure and the lack of federal action to address the necessary trillion-dollar investment. The impacts on our daily life are now pervasive:

- Flint, MI is now a poster child for lead in drinking water, a national problem.
- The Alabama Black Belt highlights environmental and human impacts of failing septic tanks and the spread of disease, a growing concern.
- Defense and industrial installations are a source of PFAS contamination hotspots, introducing these "forever" chemicals into groundwater and rainwater.
- Jackson MS and Galveston, TX citizens receive recurrent boil water notices.
- Oroville CA and Midland MI are now known for dam failures.
- Empty reservoirs and Colorado River water restrictions cripple agriculture, energy production and fisheries in the West.
- Large scale groundwater depletion leads to concerns of perpetual water scarcity, land subsidence (30ft in CA), and flooding.
- Floods plague much of the East Coast, Southwest, Midwest and Pacific Northwest, killing people, destroying property, disrupting supply chains, transportation, energy networks and recreation.
- Chronic water main and sewer failures are a national scourge.
- The perception that US drinking water is no longer safe drives a surge in bottled water and filtration device sales.
- Rising water and wastewater rates have fueled affordability concerns in many cities.

Climate extremes and climate change have amplified the rate, type and severity of water system failures with impacts on food, energy, ecology, health, manufacturing and distribution supply chains and the entire economy. ***Solving water*** is, consequently, a ***core goal for addressing climate risks***. Infrastructure investments are critical for future economic growth and sustainability, but they need to complement appropriate policy and financial instruments. While most water infrastructure and policy issues are "local", the current situation warrants a strategic ***National Water Action Plan*** for **"re-thinking"** our approach to *how*, *where, what and when to invest*, and the complementary policies.

The Biden Administration proposed $45 billion for lead pipe removal; $10 billion for monitoring and remediating newly identified chemicals such as PFAS found in drinking water, especially for rural systems; $56 billion in loans and grants to address aging water systems; $16 billion to plug old oil and gas wells that may contaminate water sources; $500 million for Low Income Water Assistance Programs; and a miscellany of unspecified water relevant investments for climate resilience to droughts, reforms of the National Flood Insurance Program, dam safety and watershed restoration/natural system enhancements. State and federal agencies and the private sector are also planning investments. Major federal funding initiatives are being complemented by state initiatives. For instance, Texas has allocated $80 billion and South Dakota has allocated $1.6 billion for their water systems. Likewise, there is significant private sector interest. The ***what, where, and how*** are open questions, as the needs are potentially much larger and more urgent than can be met in the near term.

Water infrastructure addresses a range of challenges that are managed by different public and private entities, with different regulatory and jurisdictional domains. It is argued that a unified approach, such as One Water, may provide more effective outcomes for society. This entails integrated local, regional and national strategies that address surface and groundwater availability and quality, flood hazards, wastewater and storm water collection, reuse and nutrient energy recovery, and an integration of nature based and engineering solutions with financial risk mitigation instruments. Integrated or holistic water management will require rethinking the regulatory, technical, financial and governance structures that currently exist. How these can be developed and implemented in different climatic, social and environmental settings motivates ***"Re-thinking water"***.

The America's Water Event brings together some of the major federal agencies, the private sector/NGOs, community representatives and academics to discuss the challenges and opportunities that will shape the plans for a 21st century infrastructure to deliver affordable, reliable and high quality water services in the face of an uncertain climate to rebuild the nation's economy and environment.

Additional background information is available here. A discussion of solution and implementation strategies that synthesizes the discussion as to the emerging solutions will be added after the September 20, 2022 event.

Background

Climate

Climate hazards affect society primarily through water. Storms, floods and droughts collectively account for the vast majority of impacts from natural hazards. This year, 2022, has seen exceptional drought, perhaps the worst in 1200 years, persist across nearly half the country, affecting 130 million people and 230 million acres of crops. Major reservoirs such as Lake Mead, Lake Powell and the Great Salt Lake are at or near their lowest levels. Communities and farmers in the West are staring at a bleak future, despite investments in improving water use efficiency. A second round of Federal Water Restrictions was recently placed on the Colorado amid warnings that the West faces increasing and perpetual aridity. The Colorado River Basin, California, Utah and Texas face significant water supply challenges. Agricultural output is likewise significantly impacted, contributing to price increases and inflation. Cities are accelerating plans for water conservation and developing alternate sources. Industry is responding with goals for "net water positivity" with investments in efficiency, wastewater reuse and in offsets through agricultural conservation.

Even during the severe drought, "Once in 1000 year" floods occurred this year in the Yellowstone National Park, Death Valley, Las Vegas, St. Louis, S. E. Illinois, Eastern Kentucky, Dallas and Mississippi. This is consistent with the expectation that the hydrologic cycle intensifies as the earth warms, but is not unexpected even without climate change. At the same time sea level rise is leading to recurrent flooding in coastal areas, affecting transportation, electrical utilities, water/wastewater services and ecosystems. Hurricanes amplify these threats through storm surge, and disruption of electricity and water services.

Dire projections are being made for the impacts of future climate changes.[1] The 4th National Climate Assessment Report places Water directly after the climate chapter, recognizing that ***climate impacts flow to society and ecology through water***. *The* UN World Water Development Report 2020 'Water and Climate Change' says: *Water is the 'climate connector' that allows for greater collaboration and*

[1] Examples of climate /water trends

coordination across the majority of targets for sustainable development (2030 Agenda and its SDGs), climate change (Paris Agreement) and disaster risk reduction (Sendai Framework)."

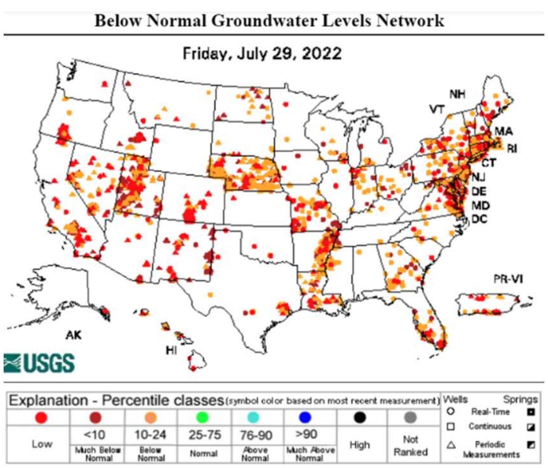
The development of reservoirs, levees, conveyance and drainage systems in the 20th century contributed significantly to the reduction of losses from these hazards. However, these are now aging, in need of repair and replacement, and many have had adverse ecological impacts. Flood insurance programs have come under scrutiny as subsidized insurance is now seen as a contributor to increased development in high risk areas; and, hence, have amplified exposure, as climate risks also increase. Removing these subsidies to price the real risk is proving challenging. A similar challenge exists with drought/crop insurance whose introduction in the 1970s led to a large shift of crops to high risk regions of the country, and subsequent increase in water stress and groundwater depletion.

Investments in improving near term (0 to 10 years) forecasts of extreme climate events, and their consequences are an immediate first need to facilitate infrastructure sizing, risk pricing and mitigation strategies for utility operators, farmers, manufacturers, supply chains and communities. What will these forecasts lead to and risks be managed? What are the prospects and opportunities?

What physical infrastructure is needed over the next 10 years to address climate and demographic challenges and where, as population moves into coastal and sunbelt areas subject to drought, flooding and mobilization of pollution, and for communities with declining and poorer populations that face higher climate risks? What are the corresponding investment needs and where could those come from to ensure affordability and equity?

Groundwater

Groundwater supplies 50% of drinking water (99% for rural users) in the USA, and nearly 70% of agricultural water use. It is the primary buffer to drought. Groundwater ages range from 10 to 10,000 years, and natural recharge rates are slow. Consequently, it's a stock, and overuse increases contamination and depletion. These have become recurrent concerns– from California to the Midwest (Ogalalla Aquifer) to the Northeast (e.g., Rockland County & Long Island, NY), the Mississippi Valley, the Southwest (Texas, New Mexico and Oklahoma) and the Southeast (Florida).



Regulation of groundwater is increasing in several states, such as Florida, California, Nebraska, Arizona, and Texas. **A critical question is whether and how groundwater aquifers can be used as managed reservoirs with potential recharge from treated storm water and wastewater. How would such a system be managed and by whom, how would it be monetized, water quality assured, and water rights protected? How would decentralized urban systems be designed to safely use underground aquifers for storage and transmission of water to support water goals for industry and communities?**

Infrastructure

Water is central to the production of food and energy, and the preservation of ecosystems in addition to its primary role in human sustenance, industrial production, navigation. Its quality and quantity determine its suitability for use and these vary by place, due to climatic factors and due to human activity in the area. Infrastructure to provide these services includes dams for water storage, canals and pipelines for water conveyance, water and wastewater treatment to assure the quality of water, wells and pumps for groundwater extraction and recharge, and levees and drainage systems for flood control.

Despite its critical role, water infrastructure has seen the least federal investment since the 1980s, and the USA lacks coordinated national water planning and execution. A result is an ***aging and failing infrastructure*** whose resilience to the changing climate is questionable. The financial burden of investment has shifted to communities, states and the private sector. Smaller and poorer communities have found it hard to get the finances they need to maintain, operate and upgrade their systems. Questions of ***affordability*** and ***equity*** of water related services consequently emerge.

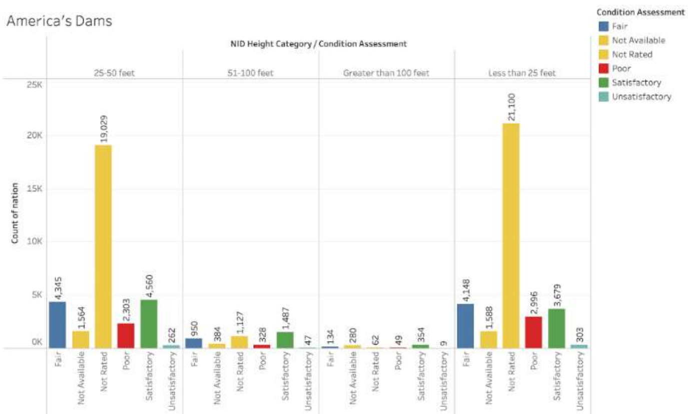
While climate is an ***amplifier*** of water risk, the aging water conveyance and treatment infrastructure poses health risks as lead, PFAS, and other ***drinking water quality*** violations increase. Many communities have failing septic tanks and sewers for wastewater disposal. The Black Belt of Alabama now iconifies the ***human health challenge*** that results. Long Island exemplifies the ***ecological impact***. Rising sea levels, extreme temperatures and rainfall aggravate these impacts.

The empty reservoirs, floods, aging dams that pose a hazard, lead and PFAS in drinking water, breaking main pipes, and failing septic tanks and contamination of rivers and aquifers come across as ***disconnected problems*** expressed in different places. This contributes to piecemeal, fragmented and inefficient approaches and low investment in meeting our water challenges.

Designing the future architecture of water systems in the country has to be the priority of any national approach to climate adaptation and resilience. "*Climate impacts on water ecology and economy are entering a new phase of severity that demands both new investment and new policy to adapt. Investment is there through the Jobs Act and the Inflation Reduction Act, but significant policy gaps remain and are the near-term frontier for water management throughout North America."* Most communities are looking for help with water, wastewater and flood control renewal. It is a singular opportunity to ***re-think*** which services are provided how, when and where, ***so that the substantial investments do not translate into sunk costs or stranded assets*** and ***reflect the promise of emerging technologies and systems thinking*** on financing, regulation, and management while engaging the populations to be served.

Dams/Storage

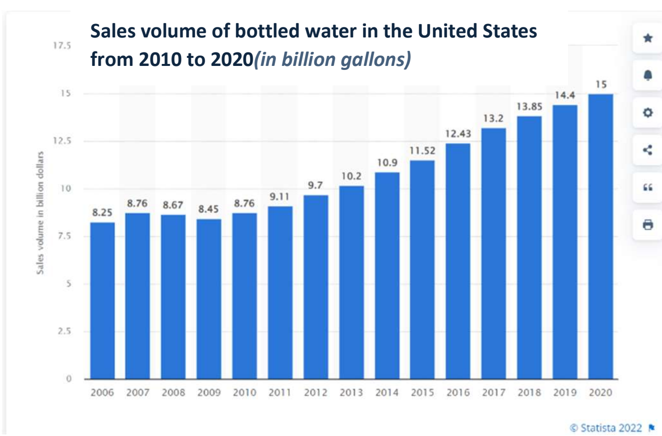
The USA has over 90,000 dams with a median age of 60 years, which is close to the original design life. Of these over 50,000 are owned by municipalities and private operators. The state of repair of a large number of these dams is unknown, while many are rated as unsatisfactory or poor, even though they are considered “high hazard”. Consequently, with an increasing frequency of extreme precipitation, even in arid regions, there is growing concern with their potential failure leading to catastrophic impacts on downstream populations and critical infrastructure. In addition to the direct impacts of failure, the resulting **loss of services** for water storage, recreation, hydropower and flood control is a **water security concern**. The surge in renewable energy from wind and solar is creating a secondary interest in the installation of hydropower and pumped storage on existing dams, since this may provide an effective solution to long duration energy storage. This may provide capital for dam restoration. Interactive analytics for US dams are provided here.



Where should dams be removed to reduce the risk of catastrophic failure and to improve ecosystem function? Where are new dams/repairs needed to provide storage to meet needs in a changing climate? Who is likely to invest, and what regulatory changes are needed? What are innovations in design and operation for "greener" outcomes? How can climate forecasts be leveraged for system planning and operation to reduce risks?

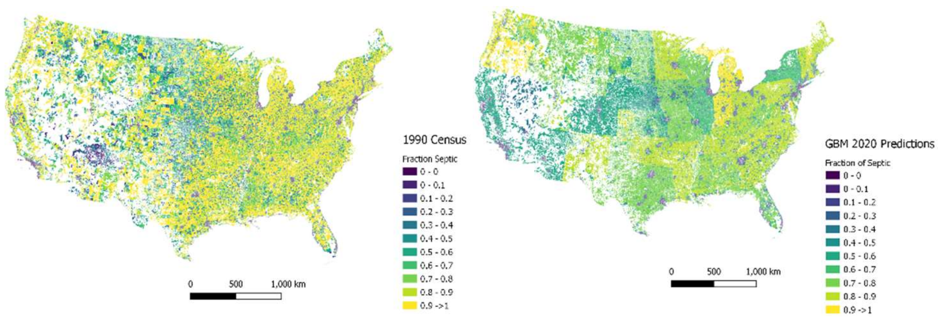
Urban Drinking Water, Wastewater and Stormwater Infrastructure

Reservoirs, wells, pumps, pipes, sewers and treatment plants are the components of water infrastructure. The dominant design that evolved in the 20th century was a **centralized architecture** with one or more major drinking water and wastewater treatment plants and extensive pipe, sewer and pump systems to collect and convey the water to/from these plants. Wastewater is treated to a regulatory standard and then released to the environment, and source water from wells and rivers is treated to a drinking standard and supplied. Stormwater capture aims at reducing urban flooding, and its treatment in wastewater treatment plants addresses its contamination. Questions about the appropriate treatment standard and the residual human and ecosystem exposure to health risks are endemic.



These questions are being asked more often, as systems have aged, the frequency of failure and exposure (e.g., lead, PFAS) increased, and concerns with the quality of drinking water led to an acceleration in bottled water sales. Pipes are the **dominant cost** (~70%) of centralized systems, while economies of scale are realized by making larger treatment plants. Main pipes and sewers replacement can cost between $500K to $1500K/mile. The **failure rate of pipes and sewers** is determined by their age, ambient conditions and material. The USA averages **850 main pipe failures per day, as compared to 850 per year in the 1950s!** The high cost of lead pipe removal and the growing arguments to significantly upgrade treatment systems to regulate and treat "forever chemicals" to reduce drinking water exposure pose additional financial challenges for utilities and communities. The increasing aridity in some regions, and the increasing urban flooding in others is stimulating the need for **wastewater treatment and reuse**, and **nature based solutions**. There is also pressure to decarbonize water systems through lower energy use.

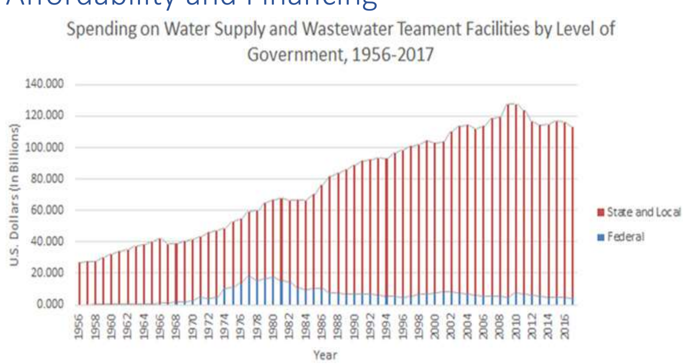
On the other end of the spectrum, many communities (including nearly 30% of new residential construction since 1990) has installed on-site septic systems for wastewater disposal. While such systems can be effective, they are failing many areas where they are prevalent creating pollution and health hazards.



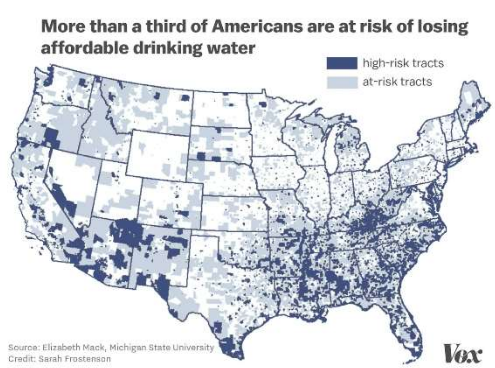
% of population with septic systems in 1990 (census) vs 2020 (predicted by CWC)

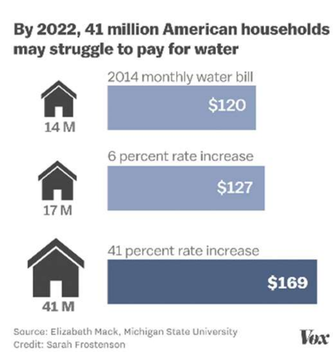
Collectively, these factors point to the need for a significant disruption in the traditional architecture of the urban water systems - a **future implementation of highly distributed or decentralized, yet networked systems** that are more energy efficient. **Given the projected trillion dollar investments in conveyance and treatment what are the optimal system scales and technologies for different size cities, climate conditions and population densities? When is wastewater treatment and reuse an effective solution not just in arid but also in very wet locations? To assure safety should drinking water be purified to a much higher standard at the point of use as compared to the mandated treatment at the utility ? What are the types of sensors and testing needed to assure the performance of our drinking and wastewater/reuse systems? Can sensors, IOT and AI allow insights into the reliability and quality of service at the points of use, and transparently improve utility performance? Can cities, industries or communities be designed to have net zero energy and water goals?**

Affordability and Financing



Federal spending on water and wastewater infrastructure has declined since 1980[2]. State and local governments have had to fund a larger share of the costs, but even these investments have declined since 2008. A recognition of the need has driven recent finances towards this sector, e.g., $3 billion allocated by Congress in 2020 to repair aging dams. However, this is over 30 years, and looks insignificant compared to the $1.1 billion spent just on the repair of the Oroville dam spillway that failed in 2017, leading to the evacuation of 200,000 people. The estimated cost of repairing and maintaining the spillway before failure was





[2] Greer, Robert A. "A review of public water infrastructure financing in the United States." *Wiley Interdisciplinary Reviews: Water* 7.5 (2020): e1472.

$100 million, and was deferred. Similarly, the lead in water crisis that affected 20,000 children in Flint, MI would have cost $80/day to avert, but will end up costing over $600 million in compensation and remediation efforts, based on recent spending and pending claims. The inability of local and state agencies to find funds has led to deferred maintenance, higher costs in the long run, and hazards for communities. The Federal government has a State Revolving Fund for community water projects. However, it is significantly underfunded relative to the demand, and the technical burden of preparing the request often puts these funds out of the reach of many of the smaller communities it targets. These communities are also unable to access private capital given their financial health and the cost of capital. Most water utilities are independent, public sector entities owned by a community. There are over 50,000 such utilities in the country. There is also an argument that the current public funding models promote the creation of systems that are too large and too expensive for the communities, and increase the debt burden and service cost, factors that contribute to deferred maintenance and a lack of affordability.

Water and wastewater rates have been rising rapidly in many parts of the USA, reflecting the increasing costs faced, leading to affordability and equity concerns. In combination with increasing water reliability and quality problems, this creates the concern that consumers unwillingness to pay for poor service will translate into resistance to further rate increases and further strain the financial health of utilities. This could create a self-reinforcing spiral of financial failure and physical system failure. On average, private water companies have charged higher rates, but claim to provide higher quality of service. However, they account for a very small share of total consumers served, and also face challenges with raising funds for capital improvements. A recent trend has been the introduction of private capital into regional water companies that are aggregating equipment manufacturing and deployment as well as utility operation and financial services. There are also emerging private companies that are meeting industrial, energy and mining sector water supply, treatment and wastewater services. While this is still a very small segment of the water sector, **the question is whether this emergence can be sustained and if through centralization/aggregation of support services a new model for more reliable and affordable provision of services can emerge?**

Water and wastewater infrastructure projects are inherently local, but the challenges faced by communities are common across a region or the nation. There is currently a very large funding backlog, and cooperation across communities and service providers could help leverage the technical capacity needed to design the right scale and types of projects and compete effectively for public and private funds, and provide affordable services. How can this be achieved in practice?