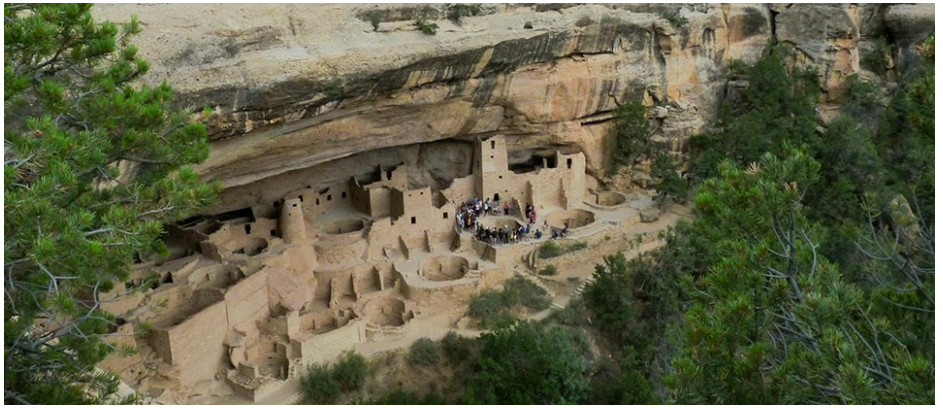
QUANTUM DYNAMICS
presents

First *fundamental* and *rigorous* steps
towards improving urban water infrastructure
and minimizing water main leakage losses,
potentially improving water supply by 15% - 25%,
in the face of a looming megadrought

Throughout history great civilizations have risen and fallen...



...with the availability of water...

Water Is
– And Always Will Be –
The Nexus Of …

Agriculture...

Industry...

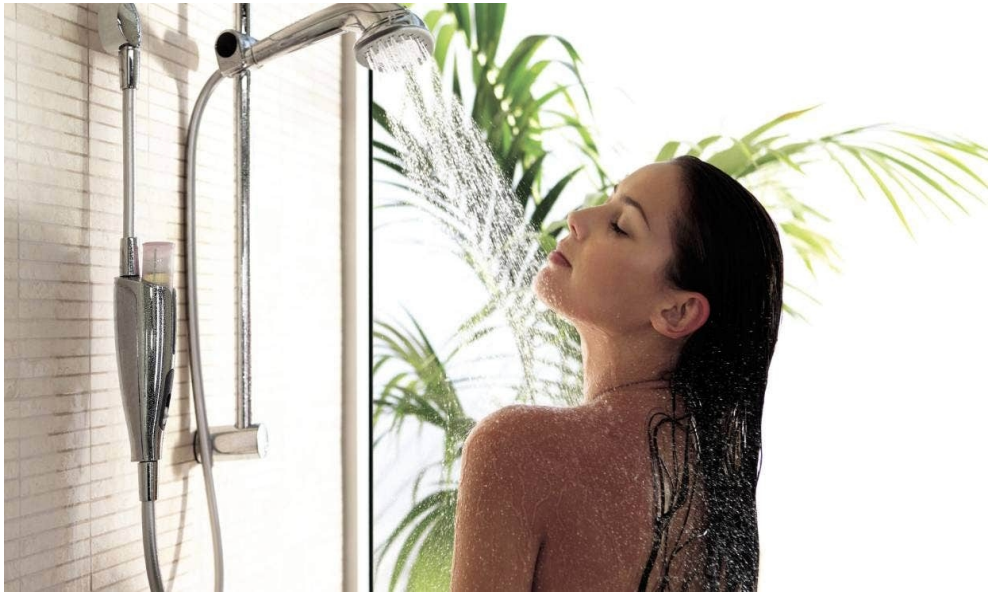
Energy...

Note the “bathtub ring” behind Hoover Dam. Water in Lake Mead is currently at its lowest level since the construction of the dam over 9 decades ago. When water level behind the dam is at its maximum the dam generates 2080 megawatts. Due to the current low water level, it is currently capable of producing only 1360 megawatts – and there are fears that it may be unable to generate electricity within several years.

On 2021-Aug-04 lack of water forced the power plant at Lake Oroville, one of California's major lakes, to cease generation in the midst of a prolonged heat wave.

This situation is already significantly reducing the supply of electricity and water throughout the entire Southwest United States.

Life Sustaining
Human Consumption...



And widespread drought displacement and human – and business – migration...

…and conflicts over water rights...

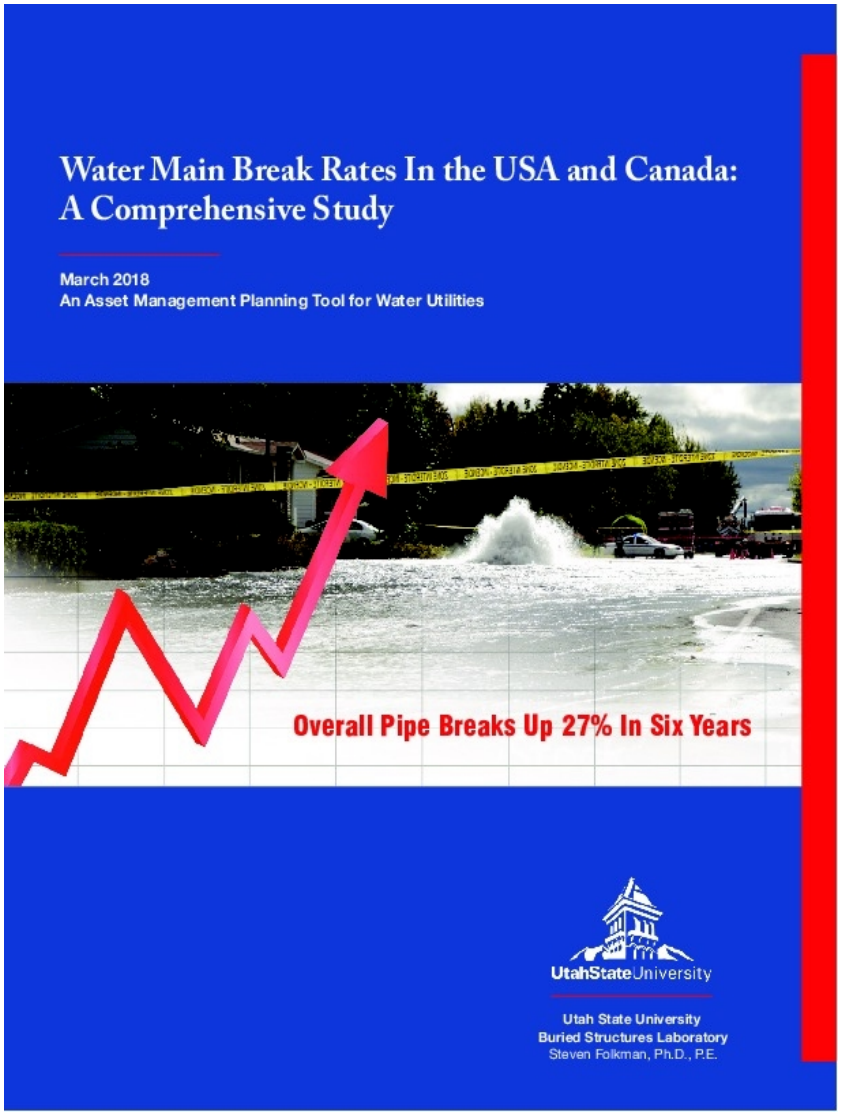
Water mains define a city...

Water mains are the oldest municipal infrastructures, some of which are approaching 200 years of age. Even many newer water mains crack and/or develop pinhole leaks, frequently seeping for decades before leakage is detected as surface water or sinkhole.

“The vast majority of water utilities in California do not manage leakage, but instead react to it, usually after it has caused disruption like water outages or damage to property. Effective leakage management requires the water utility to be proactive in seeking and abating hidden leaks and optimizing the operation of the distribution infrastructure.”

-- NRDC, *Secondary Research for Water Leak Detection Program and Water Loss Control Study.* 12/2009

...and water mains are failing with ever increasing frequency



Water Main Leakage Entails Significant Loss Of Water

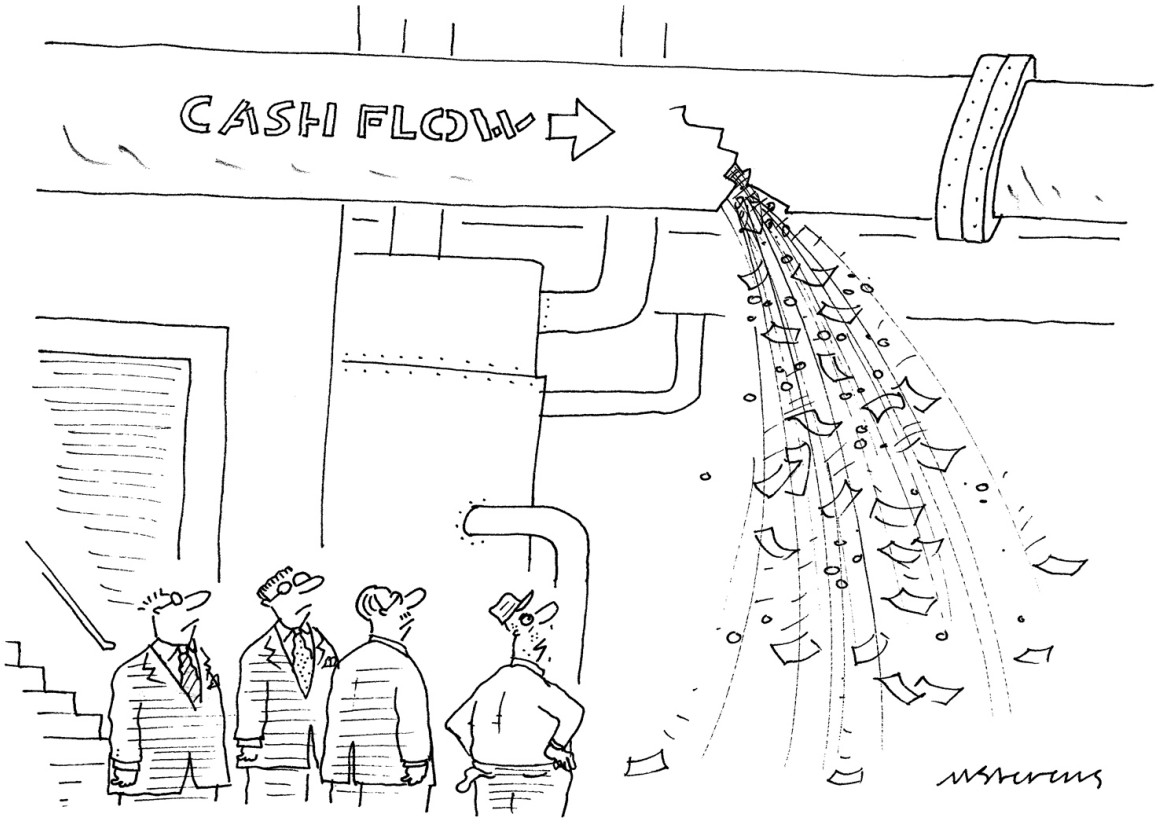
"44% of all U.S. water infrastructure is near the end of life or failing and within the next ten years will be out of life. *Over 20% that we have treated, we put in pipes and it just leaks."*

– Susan Story, President of American Water, the Nation's largest investor owned water utility

"The range of water losses for the 21 utilities answering the survey was 6.8 – 45.5%, with *an average loss of 22.6%*. The real losses given in gallons / mile of main / day are 645.42 – 3,496.21, with an average of 1,821.15 gallons / mile of main / day."

– American Water Works Association (AWWA)

Distribution-Side Leakage from Water Mains is a Major Source of Water Shortage and Utility Inefficiency



"Well, gentlemen, there's your problem."

The American Society of Civil Engineers Gives the United States' Water Infrastructure a Grade of D

This report details the cost to the nation's economy if current investment trends in the nation's water infrastructure continue, and it explores the massive economic benefits people would realize from fully funding the nation's water infrastructure needs. The report is organized in the following manner:

- **The US Water Infrastructure Investment Gap** section summarizes the mismatch between the current spending levels and funding needs.
- **The Costs of Inaction** section analyzes the impact on gross domestic product (GDP), businesses, households, and public health if current investment trends in water infrastructure continue for the next 20 years.
- **The Economic Benefits** section describes the economic gains that could be realized over the next 20 years if the water infrastructure investment gap were closed and spending needs fully funded.

The United States is entering what may be the deepest economic contraction since the Great Depression.[3] As such, the policy and investment decisions that public officials make will have enormous consequences on the pace of economic recovery. This analysis presents two very different futures. If **current underinvestment in water continues**, businesses will become less competitive, household costs will increase, GDP will shrink, and public health may be at greater risk. If **the United States acts boldly and closes the water infrastructure investment gap**, we will boost economic recovery, create jobs, fuel business activity across a wide range of sectors, improve public health, and protect the environment.

ASCE created the Infrastructure Report Card to assign grades for the nation's infrastructure based on condition, safety, capacity, and other factors. The most recent report card assigned drinking water and wastewater infrastructure a D and D+, respectively. Closing the investment gap would be equivalent to the nation's water infrastructure achieving at least a "B" letter grade, reaching a state of good repair and posing a minimal risk, or an "A" letter grade, a standard of resilience and capacity that is fit for the future.

D

Drinking water infrastructure grade according to ASCE's most recent Infrastructure Report Card

D+

Wastewater infrastructure grade according to ASCE's most recent Infrastructure Report Card

– *Economic Benefits of Investing in Water Infrastructure: How a Failure to Act Would Affect the US Economy,* American Society of Civil Engineers (2020)

We are only at the beginning of the worst “megadrought” since 800 CE

RESEARCH

DROUGHT

Large contribution from anthropogenic warming to an emerging North American megadrought

A. Park Williams[1]*, Edward R. Cook[1], Jason E. Smerdon[1], Benjamin I. Cook[1,2], John T. Abatzoglou[3,4], Kasey Bolles[1], Seung H. Baek[1,5], Andrew M. Badger[6,7,8], Ben Livneh[6,9]

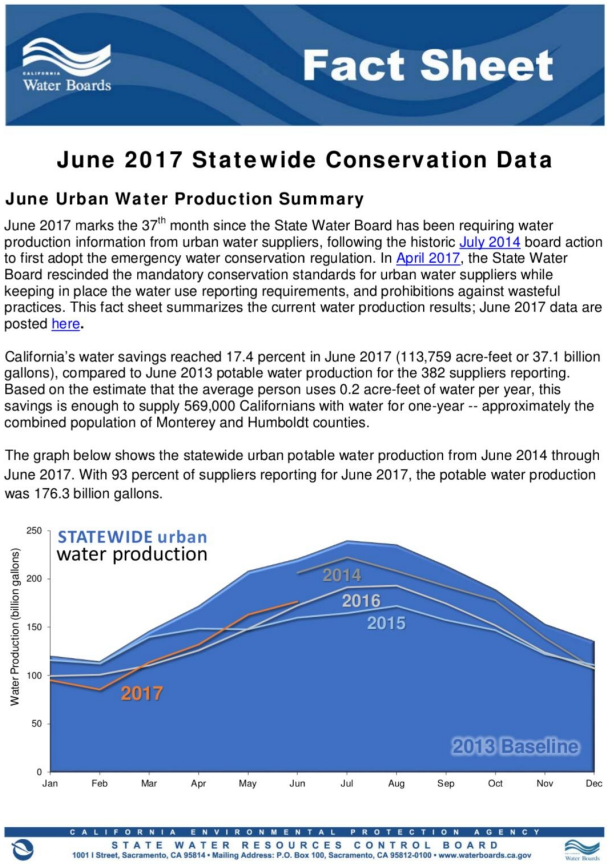
Severe and persistent 21st-century drought in southwestern North America (SWNA) motivates comparisons to medieval megadroughts and questions about the role of anthropogenic climate change. We use hydrological modeling and new 1200-year tree-ring reconstructions of summer soil moisture to demonstrate that the 2000–2018 SWNA drought was the second driest 19-year period since 800 CE, exceeded only by a late-1500s megadrought. The megadrought-like trajectory of 2000–2018 soil moisture was driven by natural variability superimposed on drying due to anthropogenic warming. Anthropogenic trends in temperature, relative humidity, and precipitation estimated from 31 climate models account for 47% (model interquartiles of 35 to 105%) of the 2000–2018 drought severity, pushing an otherwise moderate drought onto a trajectory comparable to the worst SWNA megadroughts since 800 CE.

– *Science* **368**, American Association for the Advancement of Science, pp 314-318 (17 April 2020)

We can't control lack of rain and snow due to climate change, nor population growth, nor can we continue pumping diminishing ground water...

...but we can – and must – take ***the first <u>fundamental</u> and <u>rigorous</u> steps*** towards controlling leakage in aging / failing water main systems...

Why? The average national ***distribution-side*** *water leakage loss* is **~22.6%** (AWWA), while the maximum California ***consumer-side*** *conservation* efforts in drought years yielded only **~17.4%** water savings (California Water Boards Fact Sheet)



Water Boards

Fact Sheet

June 2017 Statewide Conservation Data

June Urban Water Production Summary

June 2017 marks the 37th month since the State Water Board has been requiring water production information from urban water suppliers, following the historic July 2014 board action to first adopt the emergency water conservation regulation. In April 2017, the State Water Board rescinded the mandatory conservation standards for urban water suppliers while keeping in place the water use reporting requirements, and prohibitions against wasteful practices. This fact sheet summarizes the current water production results; June 2017 data are posted here.

California's water savings reached 17.4 percent in June 2017 (113,759 acre-feet or 37.1 billion gallons), compared to June 2013 potable water production for the 382 suppliers reporting. Based on the estimate that the average person uses 0.2 acre-feet of water per year, this savings is enough to supply 569,000 Californians with water for one-year -- approximately the combined population of Monterey and Humboldt counties.

The graph below shows the statewide urban potable water production from June 2014 through June 2017. With 93 percent of suppliers reporting for June 2017, the potable water production was 176.3 billion gallons.

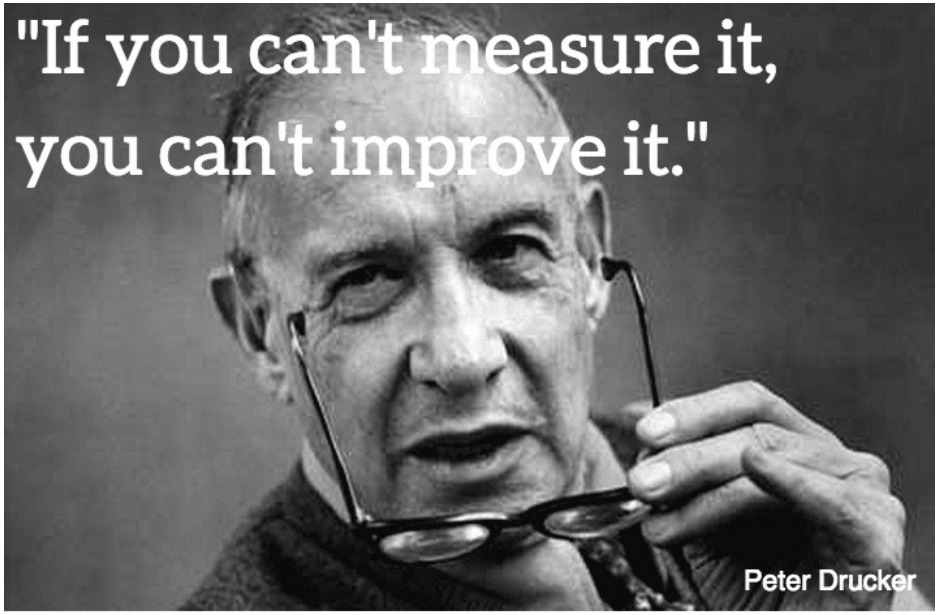
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
STATE WATER RESOURCES CONTROL BOARD
1001 I Street, Sacramento, CA 95814 • Mailing Address: P.O. Box 100, Sacramento, CA 95812-0100 • www.waterboards.ca.gov

I.e. the average water distribution utility loses more water to leakage than California's most stringent consumer-side conservation efforts can save during worst drought years!

If, in coming years, through the leak detection facilitated by improved measurement, we were to recapture ~15% of the ~20% average loss of water input into water mains, and also maintained consumer-side conservation of ~15%, then *an ~30% savings in urban water would result!*

Measurement of large distribution-side water flows must be improved

- To provide truly accurate and reliable water audits
- For the earlier detection of distribution-side leakage at significantly lower levels
- To determine / identify leakage locations
- To determine loss rates and prioritize repair / replacement where numerous leaks are systemic
- To optimize allocation of repair capital / resources



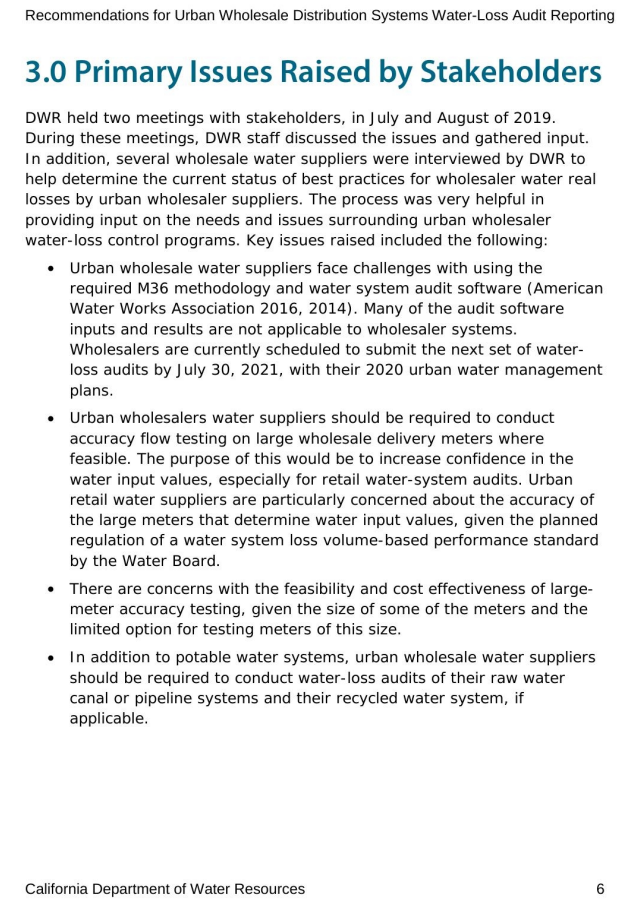
A water supply shortage is the difference in quantity between available water and that actually delivered to the consumer.

The accuracy / uncertainty of measurement directly affects how well we can manage that which is being "measured".

Calibration of measurement systems is the universally *required* basis of all quality management systems and is *absolutely required to improve measurement*

- Calibration of measurement systems is a basic requirement of ISO 9000, ANSI/ASME NQA-1, MIL-I-45208, etc. In all cases of consumer protection, it is also a firm ***legal*** requirement.
- Few/no water distribution organizations can currently calibrate large water main meters with low uncertainty
- "Urban retail water suppliers are particularly concerned about the accuracy of the large meters that determine water input values, given the planned regulation of a water system loss volume-based performance standard by the Water Board."

  – California Department of Water Resources, *Report to Legislature* (November 2019)



Recommendations for Urban Wholesale Distribution Systems Water-Loss Audit Reporting

3.0 Primary Issues Raised by Stakeholders

DWR held two meetings with stakeholders, in July and August of 2019. During these meetings, DWR staff discussed the issues and gathered input. In addition, several wholesale water suppliers were interviewed by DWR to help determine the current status of best practices for wholesaler water real losses by urban wholesaler suppliers. The process was very helpful in providing input on the needs and issues surrounding urban wholesaler water-loss control programs. Key issues raised included the following:

- Urban wholesale water suppliers face challenges with using the required M36 methodology and water system audit software (American Water Works Association 2016, 2014). Many of the audit software inputs and results are not applicable to wholesaler systems. Wholesalers are currently scheduled to submit the next set of water-loss audits by July 30, 2021, with their 2020 urban water management plans.
- Urban wholesalers water suppliers should be required to conduct accuracy flow testing on large wholesale delivery meters where feasible. The purpose of this would be to increase confidence in the water input values, especially for retail water-system audits. Urban retail water suppliers are particularly concerned about the accuracy of the large meters that determine water input values, given the planned regulation of a water system loss volume-based performance standard by the Water Board.
- There are concerns with the feasibility and cost effectiveness of large-meter accuracy testing, given the size of some of the meters and the limited option for testing meters of this size.
- In addition to potable water systems, urban wholesale water suppliers should be required to conduct water-loss audits of their raw water canal or pipeline systems and their recycled water system, if applicable.

Distribution side conservation through reduction and efficient management of water losses

- Is the *most effective and economic* way of reducing levels of losses
- Improves *public health protection* by minimizing water ingress during repairs
- Increases the level of service to customers through *improved reliability* of water supplies
- *Is the **best source for "new water"** resources for systems facing water supply shortages*
- ***Reduces pressure on water resources,*** yielding environmental improvement
- ***Defers capital expenditure*** on water resources and supply schemes
- *Improves public perception* of water companies
- *Reduces leakage liabilities* to water suppliers

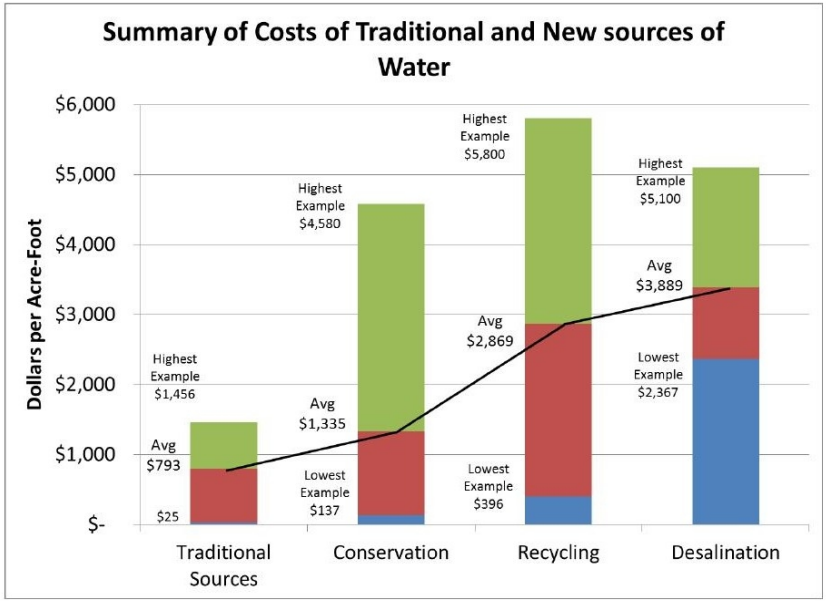
– Sturm & Thornton, *Water Loss Control in North America: More Effective Than Consumer Side Conservation*

The Water Saved by the Elimination of Leakage is ***The Least Expensive Source of "New Water"***

- The average cost of water from *existing / traditional* sources is $793/acre-foot
- The estimated average cost of water obtained through *recycling* is $2,869/acre-foot (3.6x traditional water)
- The estimated average cost of water obtained through *desalination* is $3,889/acre-foot (4.9x traditional water)

– *What Will Be The Cost of Future Sources of Water for California*, California Public Utilities Commission, 1/12/2016

New Sources Are More Costly

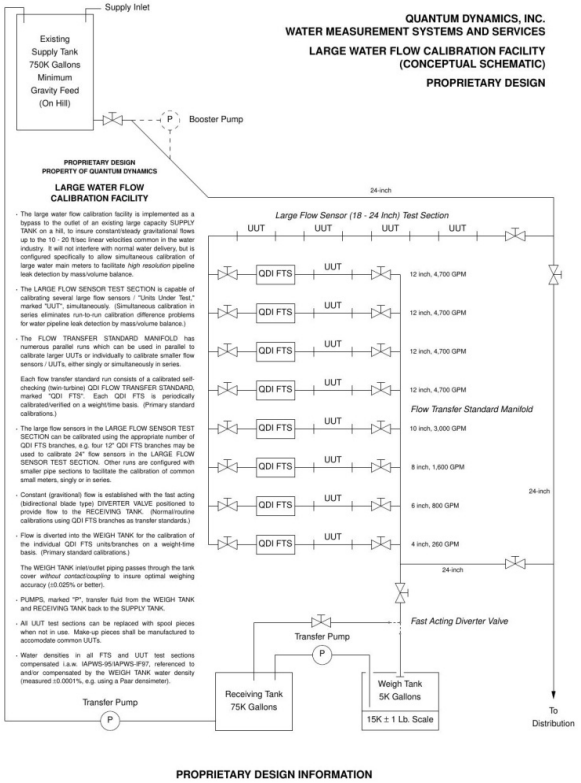


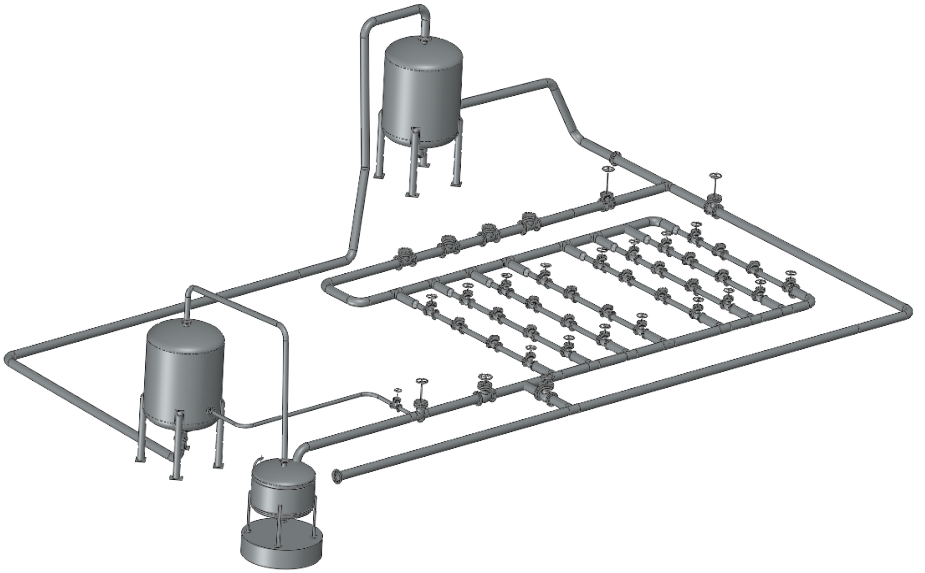
It Makes No Sense to Put Expensive Recycled or Desalinated Water Into Water Mains that Continue to Leak

So let's get started...

- In order to detect leakage at lower levels, we require significantly improved measurement
- We currently have no real, rigorously based and verifiable, information on how accurately water is measured in water mains
- But we do know that leakage losses from aging / failing water main infrastructures are significant, averaging ~20%
- Calibration determines the accuracy of measurement devices relative to a known standard
- Calibration of measurement systems is a basic *requirement* for all quality management systems, i.e. *water utilities do not currently have rigorously based quality management systems*
- Once measurement uncertainty is reduced through calibration, leakage can be determined at significantly lower levels – allowing earlier, less expensive, repairs, and avoiding catastrophic failures
- The cost of a large water flow calibration facility is typically less than several months of the average water utility's annual leakage loss
- A low uncertainly large water flow calibration facility has been designed specifically to facilitate water main leak detection by volume balance

QUANTUM DYNAMICS, the Nation's leading military-aerospace flow metrology organization, and an acknowledged leader in the field of pipeline leak detection by mass/volume balance, presents ***the low uncertainty large water flow calibration facility*** with design features to facilitate water infrastructure leak detection





Simplified Artist's Illustration

(See Adjacent Design for Details)

The low uncertainty large water flow calibration facility provides the fundamental and rigorous basis for

- Rigorously based truly accurate water audits
- Earlier detection and location of water leakage losses at significantly lower levels, potentially saving decades of leakage losses
- Prioritization of repair/replacement of leaking water main sections in systems where leakages are numerous
- Optimization of capital expenditure for pipeline repair/replacement

*It is undeniably **the first and most fundamental step** on the long road to effective management of urban water supplies.*

The large water flow calibration facility is implemented as a bypass to existing water supply infrastructure, and will not interfere with normal water supply operations.

*If improved measurement and the consequent leak detection reduces distribution-side leakage loss from ~20% to ~10% and consumer-side conservation achieves ~15%, this would result in **an overall ~25% saving in available urban water.***

SUMMARY

- Without accurate / low uncertainty flow measurement, the legally required water audits remain uncertain.
- Without accurate / low uncertainty flow measurement, early leak detection and minimization of leakage by system balance – the purpose of water audits – cannot be achieved. This clearly effects the efficiency of water delivery.
- CA-DWR states that urban water retailers are particularly concerned regarding the accuracy of their large meters. CA-DWR is now recommending that large water flowmeters be calibrated.
- Calibration of measurement instruments is *a* ***fundamental requirement*** *of ALL quality management systems*, and is a ***legal*** requirement of all consumer protection agencies, *viz* seals on gasoline pumps, grocery store checkout scales, etc.
- Calibration of large metering systems is ***the first and most fundamental step on the long path towards truly effective water management***.
- The water saved by the minimization of water leakage loss is **the least expensive source of "new water"** in water stressed regions
- Reduction of distribution-side leakage loss from 20% to, say, 10% plus consumer-side conservation of, say, 15% results in ***an ~25% of increase in available urban water, or ~25% of urban water saved***.
- SW United States is facing a "megadrought". It's time to take the first step. It's long overdue.

Southwest North America is facing the worst "megadrought" since 800 CE, and our water infrastructure is failing. We cannot afford to wait...

For further information or to request a copy of the full proposal for
The Low Uncertainty Large Water Flow Calibration Facility
Please Contact

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Woodland Hills, California 91367
(818) 719-0142
a.liu@qdflow.com

QUANTUM DYNAMICS, CAGE/FSCM 16951, has *continuously* maintained its status as a US Defense Logistics Agency "Certified Quality Vendor" and US Navy "Quality / Best Value Contractor" since the inception of these two US Government programs recognizing the intrinsic value of high quality, reliability, and system longevity.
It is the only flow metrology organization that has ever achieved said accolades.

In March 2021 the editors of The Water Network selected Arnold Liu as a water "thought leader".

HISTORICAL NOTES

QUANTUM DYNAMICS first became aware of the water main leakage problem nearly a decade ago, when New Mexico's Secretary of Energy mentioned the severity of Albuquerque's *water main leakage* problem during a presentation on leak detection in *natural gas* transmission pipelines. This awareness was again reinforced at an annual Pipeline Safety Conference, when an NRDC Vice President pointed out his organization's concern about the water loss problem. QUANTUM DYNAMICS then set about analyzing the problem. The result was a voluminous 100+ page technical proposal with cost-benefit analysis, etc., describing how low uncertainty calibration would lead to improvement of legally mandated water audits and the ability to perform leak detection by system balance. Said proposal has been distributed for over 5 years to various water authorities and water system managers – and even politicians – with several updates on the emerging water crisis, new water legislation, etc. Said proposal has largely been ignored, either due to lack of interest, unwillingness/inability to read a technical proposal, or failure to recognize the consequences of ignoring ever worsening water shortages.

It is hoped that this visual presentation – and the now increasingly recognized dire social consequences of prolonged drought and water shortages – will finally evoke action on the part of cognizant water authorities.

QUANTUM DYNAMICS is a leading military-aerospace flow metrology organization. Our website is www.qdflow.com .

Due to its flow metrology expertise, QUANTUM DYNAMICS was also sought out to implement the gaseous pipeline leak detection systems that were lauded in industry standard desk references *Pipeline Rules of Thumb Handbook* and the *ISA Instrument Engineer's Handbook* as "outstanding".

Several of Arnold Liu's academic publications and white papers are included at the www.researchgate.net, www.pipelinesafety.org, and International Water Network websites. In March 2021 the editors of The Water Network (Zurich, Switzerland) selected Arnold Liu as a water "thought leader" .