



CALIFORNIA DEPARTMENT OF
WATER RESOURCES



American Water Works Association
California-Nevada Section



REDUCING REAL WATER LOSSES

MARIE STEFFENSEN, DANISH WATER TECHNOLOGY ALLIANCE

MICHAEL ROSENBERG PEDERSEN, AARHUS VAND

LINDSEY STUVICK, MOULTON NIGUEL WATER DISTRICT

TRAVIS SMITH, KAMSTRUP

ANDREW MCCARTHY, CAVANAUGH





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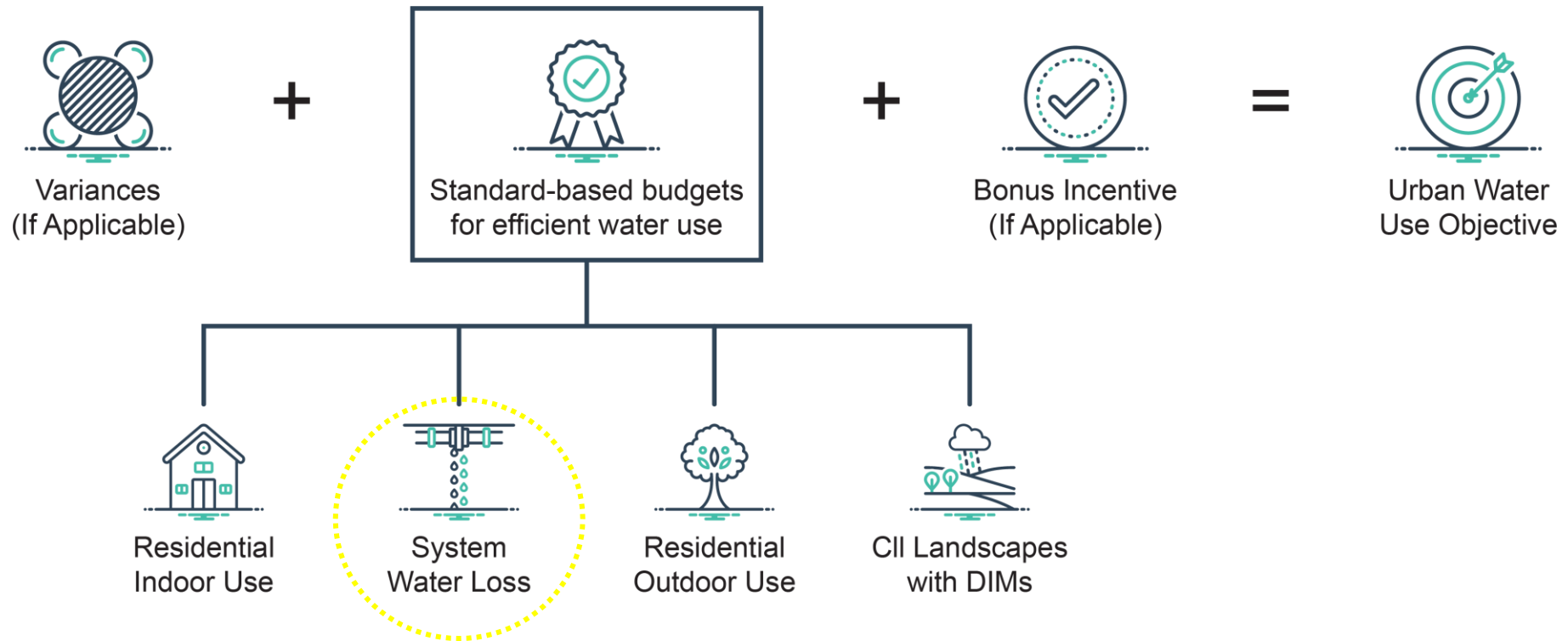
REDUCING REAL WATER LOSSES

- **Water Loss Budget**
- **The Danish Water Technology Alliance & Partnerships**
- **Speaker-time!**

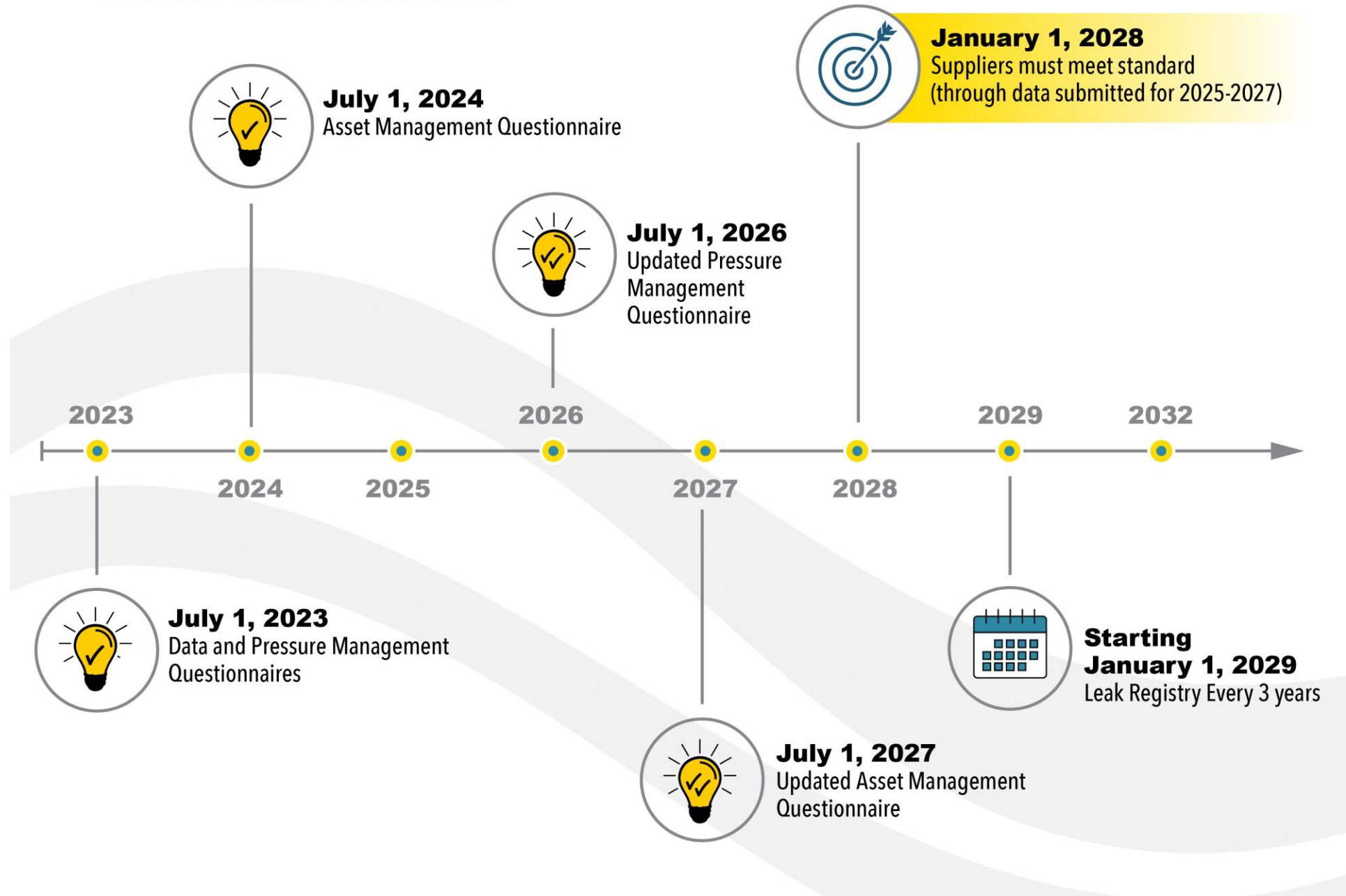


Calculating an Objective

Based on efficiency standards and customized, supplier-specific data



Water loss timeline



Efficient Water Loss Budget



Example budget for efficient water loss

41 Gallons Per Connection per Day * 365 days * 150 thousand connections =
~ 2 billion gallons (~ 7 thousand AF)

§970

Water Loss Budget

What is required and by when?

For the report submitted
by **January 1, 2028**:

A supplier must calculate the **real water loss budget** based on its system-specific standard/s.

- A supplier that owns and operates multiple systems must calculate a real water loss budget for each system it owns and operates; and then sum those budgets.

Until then, the real water loss budget may be based on reported real water losses.

The State Water Board adopted the Water Loss Performance Standards regulation in October 2022.

- The regulation established **system-specific real water loss standards** for Urban Retail Water Suppliers; it requires compliance with those standards by January 1, 2028.
- The regulation also requires suppliers to complete several questionnaires.

§970

Water Loss Budget

What do the data from the 2025 reports show?

Of the **342** suppliers that submitted reports....

- **37** suppliers have a water loss budget that is over 10% of their uncapped objective.
- **94** based their budgets on reported real loss.
- **14** lack real water loss budgets.
- **245** calculated budgets based on their real water loss standard/s.

The water loss budget represents, on average, 6% of a supplier's uncapped objective. The median is 5%.

Of the **245** suppliers that calculated budgets based on their real water loss standards...

- **120** have a real water loss budgets smaller than their cumulative reported real losses, **7** of which have real water loss budgets of zero due to missing data.
- **69** used data other than those on OpenData.

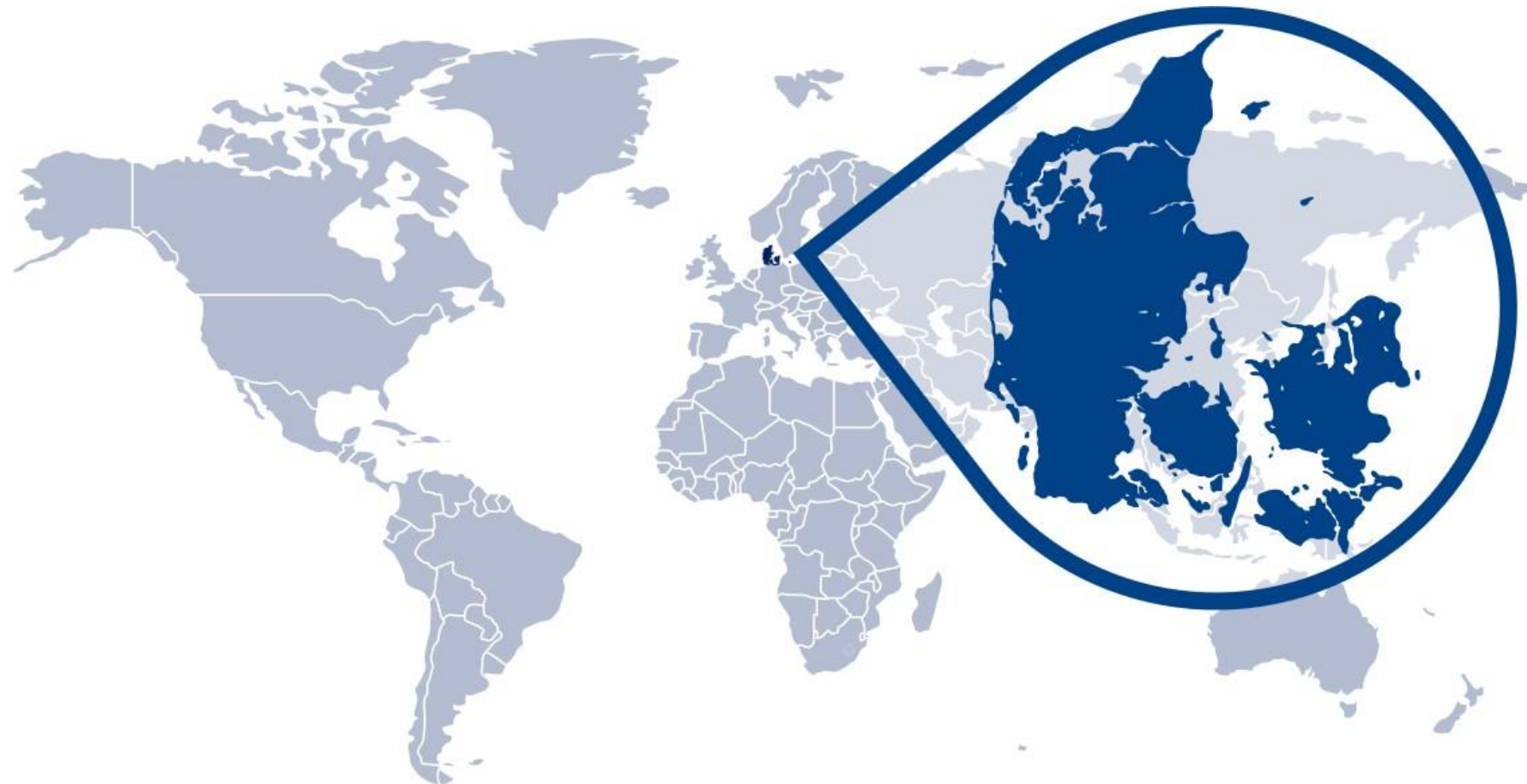


**MINISTRY OF FOREIGN AFFAIRS
OF DENMARK**
The Trade Council



THE WATER TECHNOLOGY ALLIANCE

California, April 2025
Marie Steffensen



DENMARK IN NUMBERS

Population: 5.88 million

Area: 16,580 square miles (California: 163,700 square miles)

Coastline: 4,536 miles (California: 840 miles)

Islands: 443 (76 habitable)

Distance from the ocean: max. 32 miles

Land use: 2/3 agriculture land (~28M pigs)

Precipitation: Avg. annual 31 in.

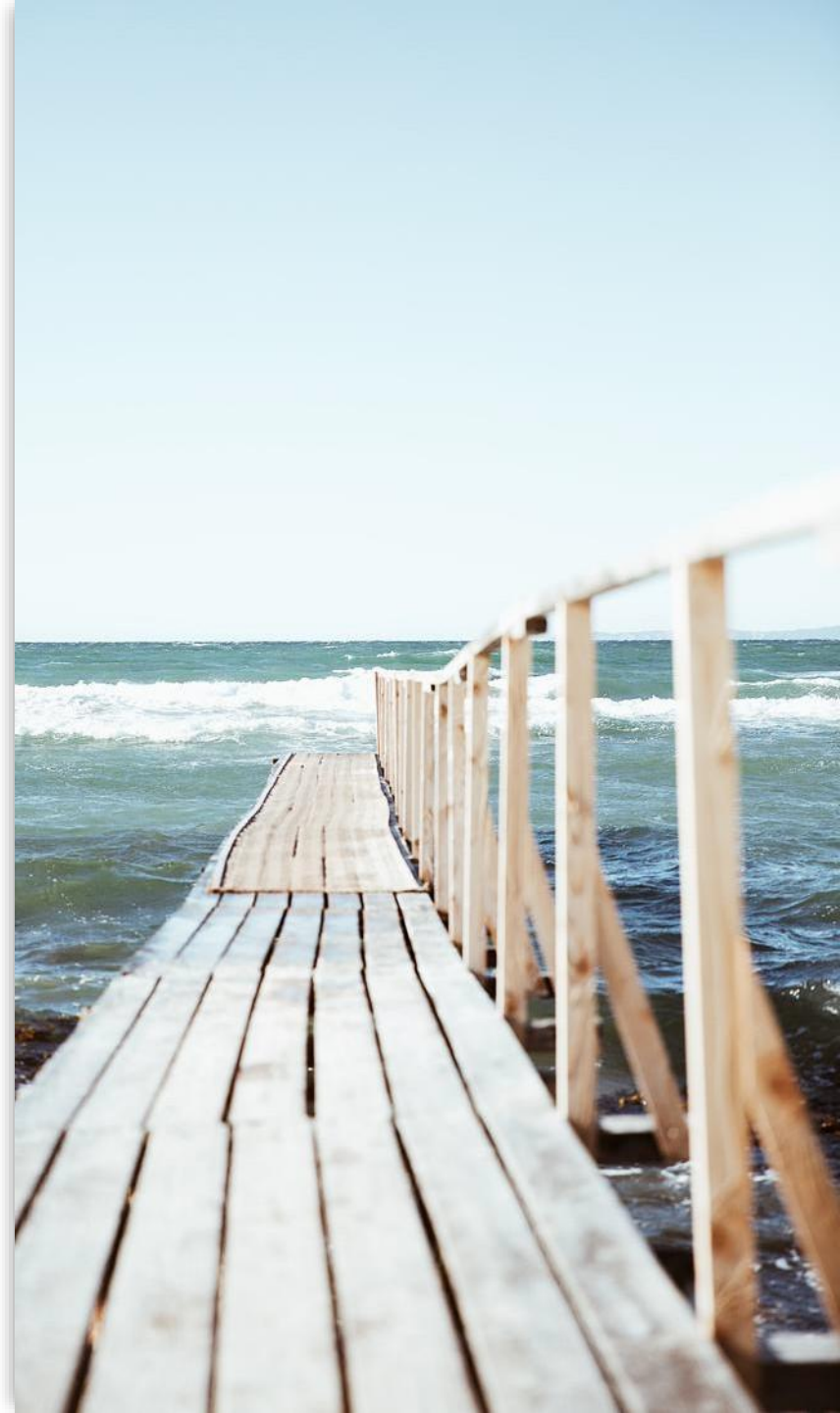
Water Source: 100% groundwater (no treatment, no disinfection)

Water Consumption: 26 gal./p./d.

Government: Constitutional monarchy. Democratic Government.

GDP per capita (2024): 71,829 USD

The world's **happiest** nation several times according to UN, OECD, etc



WATER DISTRIBUTION



SEWER SYSTEMS AND RESILIENCY



WASTEWATER



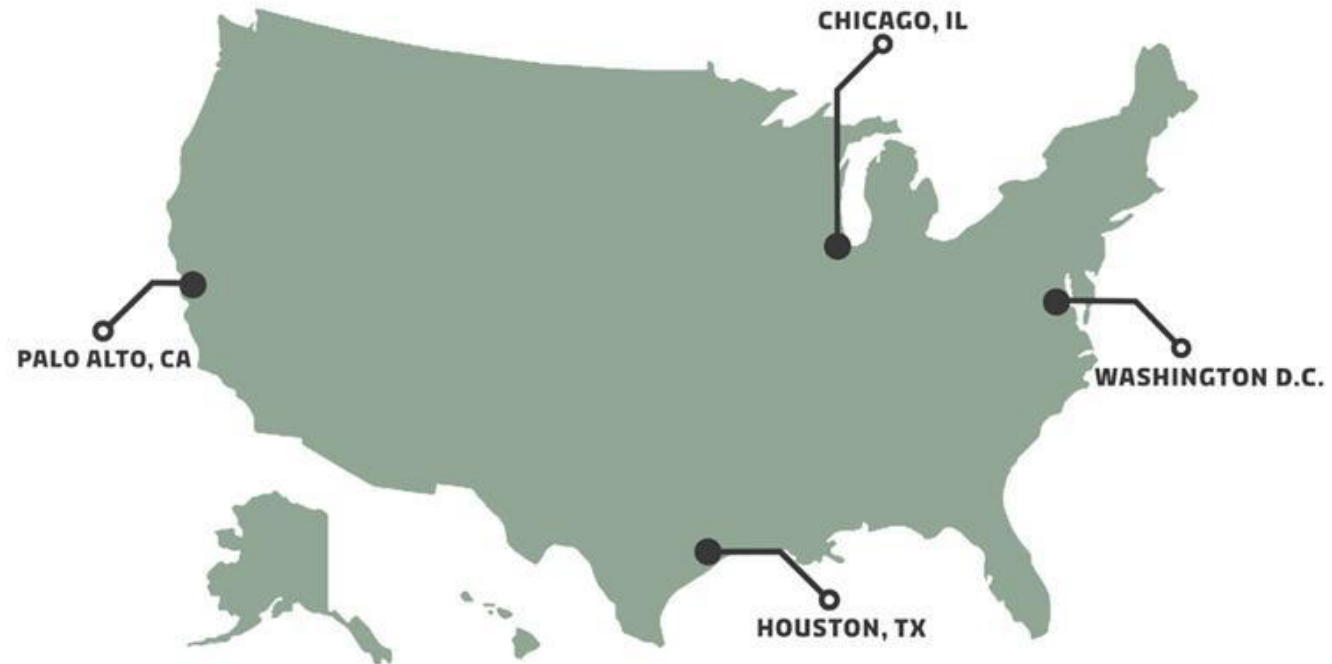
WATER TECHNOLOGY ALLIANCE

WHAT: National knowledge exchange program on water

WHY: Denmark's water vision:

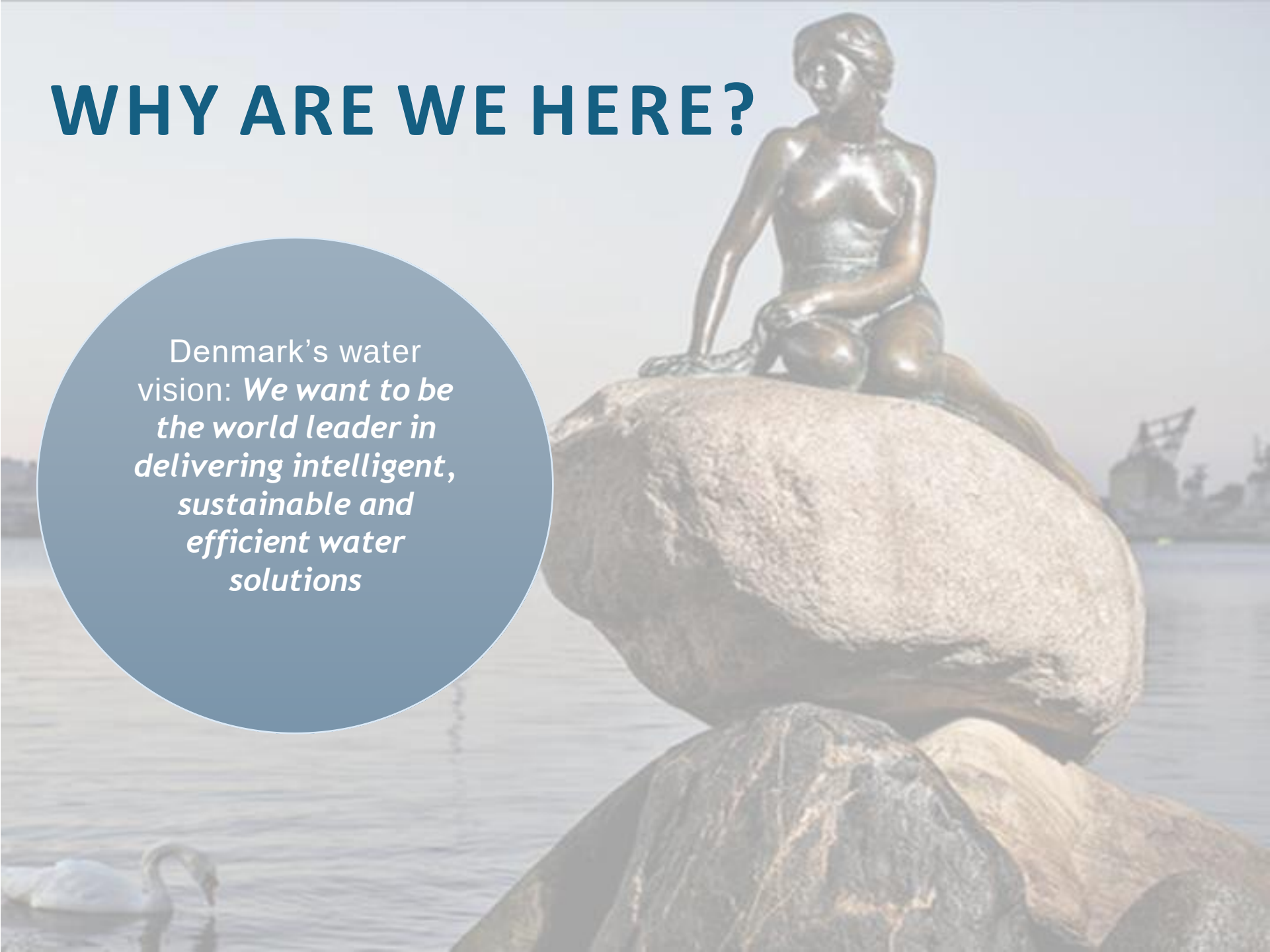
**"WE WANT TO BE THE WORLD LEADER IN
DELIVERING INTELLIGENT,
SUSTAINABLE, AND EFFICIENT WATER
SOLUTIONS"**

WTA USA



WHY ARE WE HERE?

Denmark's water
vision: *We want to be
the world leader in
delivering intelligent,
sustainable and
efficient water
solutions*



DIRECTION OF THE WATER SECTOR IN DENMARK

**THE DANISH WATER SECTOR
AIMS TO BE ENERGY AND
CLIMATE NEUTRAL BY 2030**

...BUT DENMARK IS A SMALL COUNTRY

We emit 0.1 % of the global greenhouse gases



PARTNERSHIPS AND COLLABORATION

MoU w. State of California (2017 – resigning in 2021)

- Water resources and water management - flagship project was the Geophysical Architecture Project (GAP)
- Government to government knowledge sharing
- Resigning w. Minister for Environment of Denmark and Secretary Crawford and Bluemenfelt

MoU w. Moulton Niguel and Aarhus Vand

- Digital innovation and technology, customer experience, and workforce development

MoU w. Sonoma Water

- Climate resilience, water management, and environmental policy

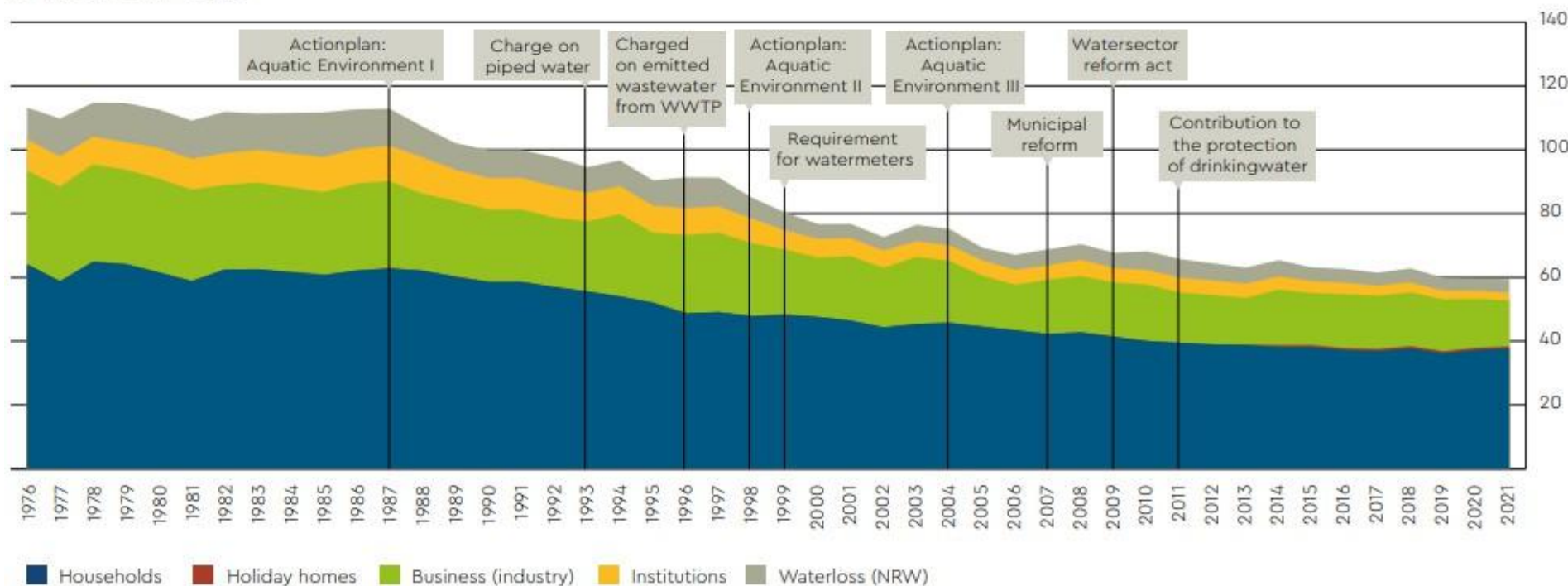


Benchmarking in the Danish water sector

- Focus on efficiency --> benchmarking introduced in 2010
- 2 % more efficient every year
- The benchmarking is published every year by the Danish water and wastewater association

CONSUMPTION OF DRINKING WATER, 1976 - 2021

M³/PERSON/YEAR



Since 2014, a new category of "holiday homes" has been introduced, which is factored into the household figures.

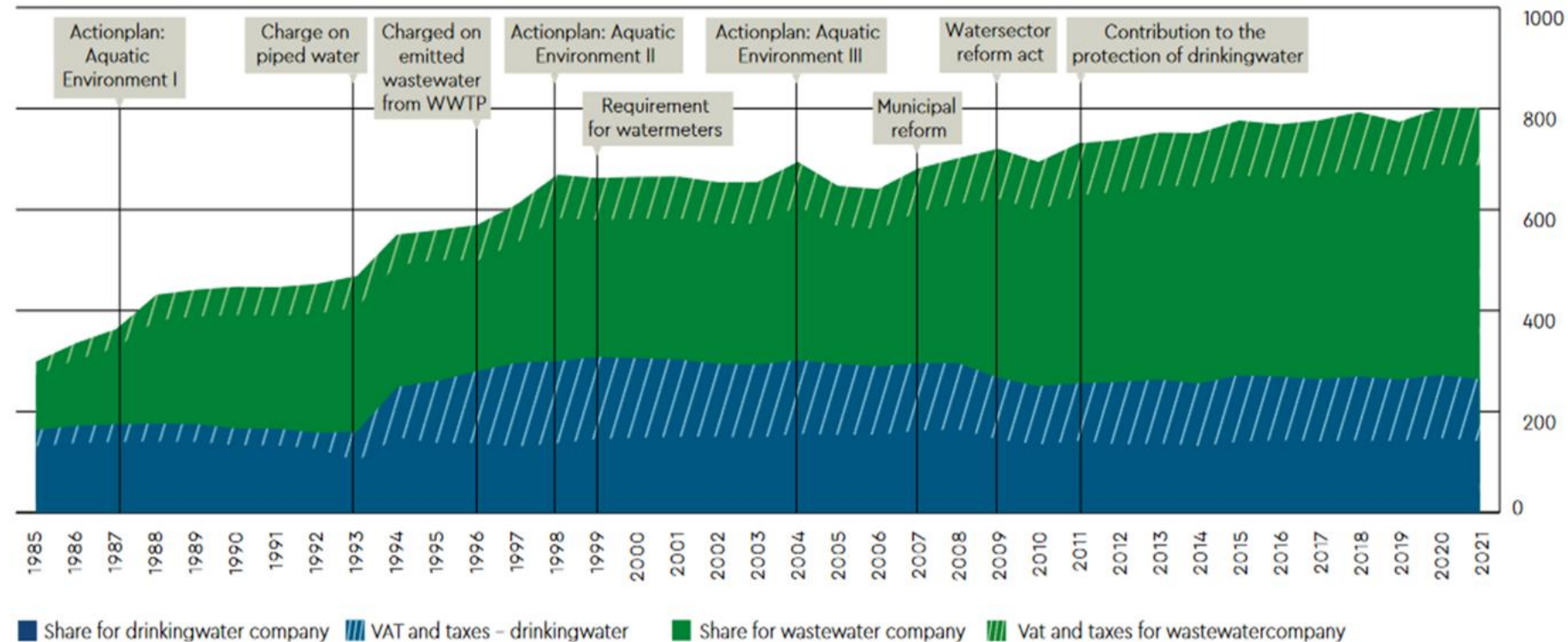
1976–1998: Master project: Modelling of water demand in Denmark by Nana Sofie Aarøe – data from 14–30 companies.

1999–2021: Data from DANVA's calculations for "Water in Figures" — data from 33–116 companies.

The statement for 2021 is based on statistics supplied by 72 drinking water companies, which together serve 3.636 million inhabitants.

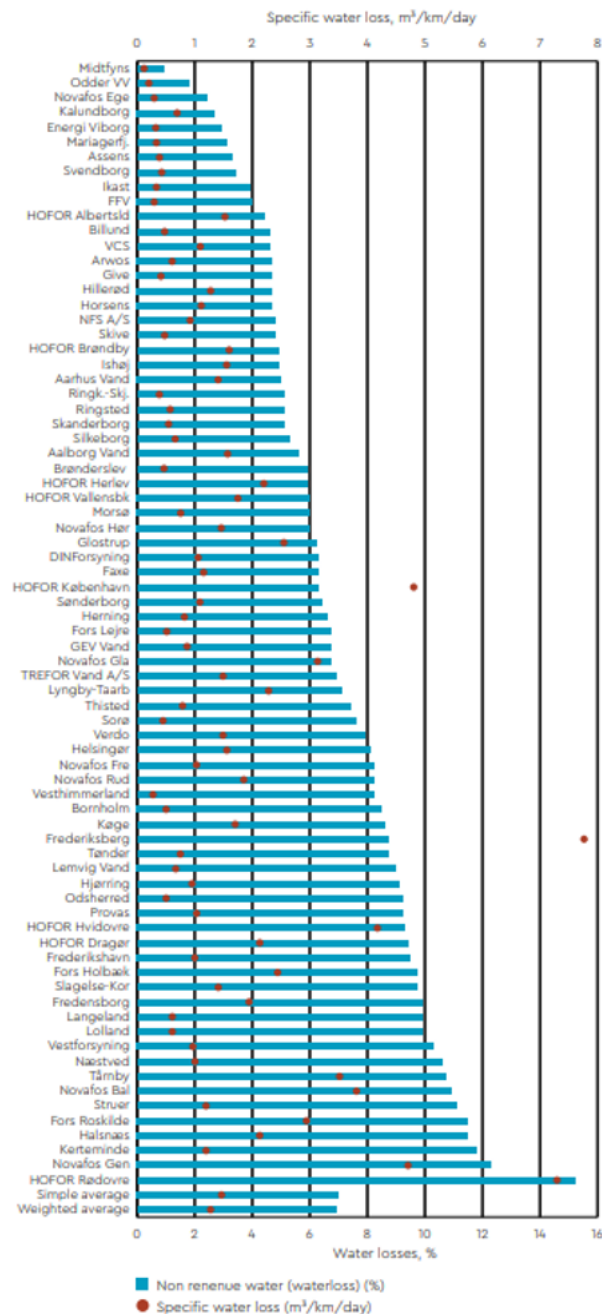
Benchmarking in the Danish water

AVERAGE HOUSEHOLD EXPENCES, 1985 - 2021
€/YEAR (2021 PRICES)



An average family's household water costs are based on 2.12 persons per household and the annual individual water price and consumption. Data for 1985 to 2008 is based on 32-50 suppliers and from 2009 onwards on 60-200 water suppliers and 60-97 wastewater companies. Changes are evident on the graph for 2008 to 2009.

NON-REVENUE WATER (WATER LOSS), 2021



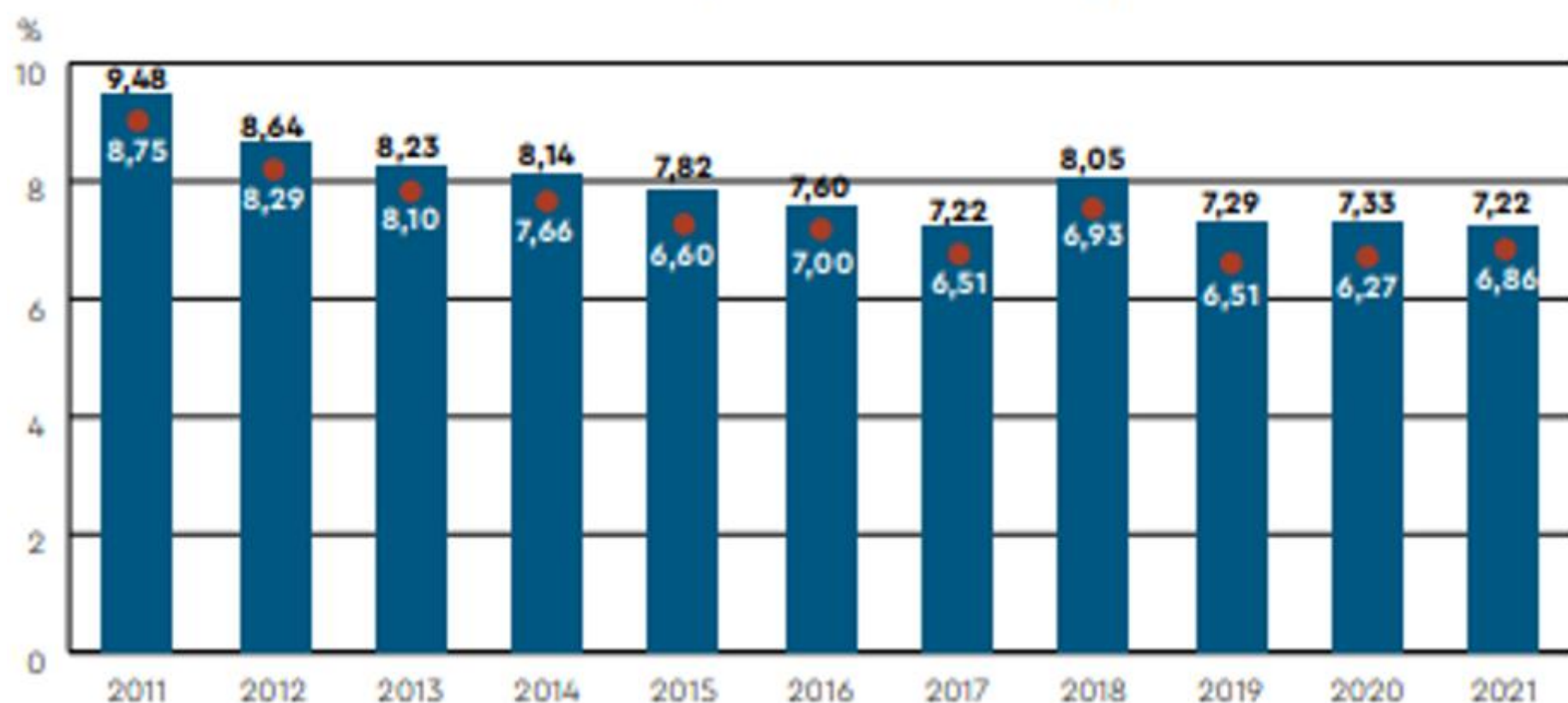
A HOUSEHOLD'S ANNUAL LIVING EXPENSES — SELECTED CATEGORIES

Share of a family's consumption:

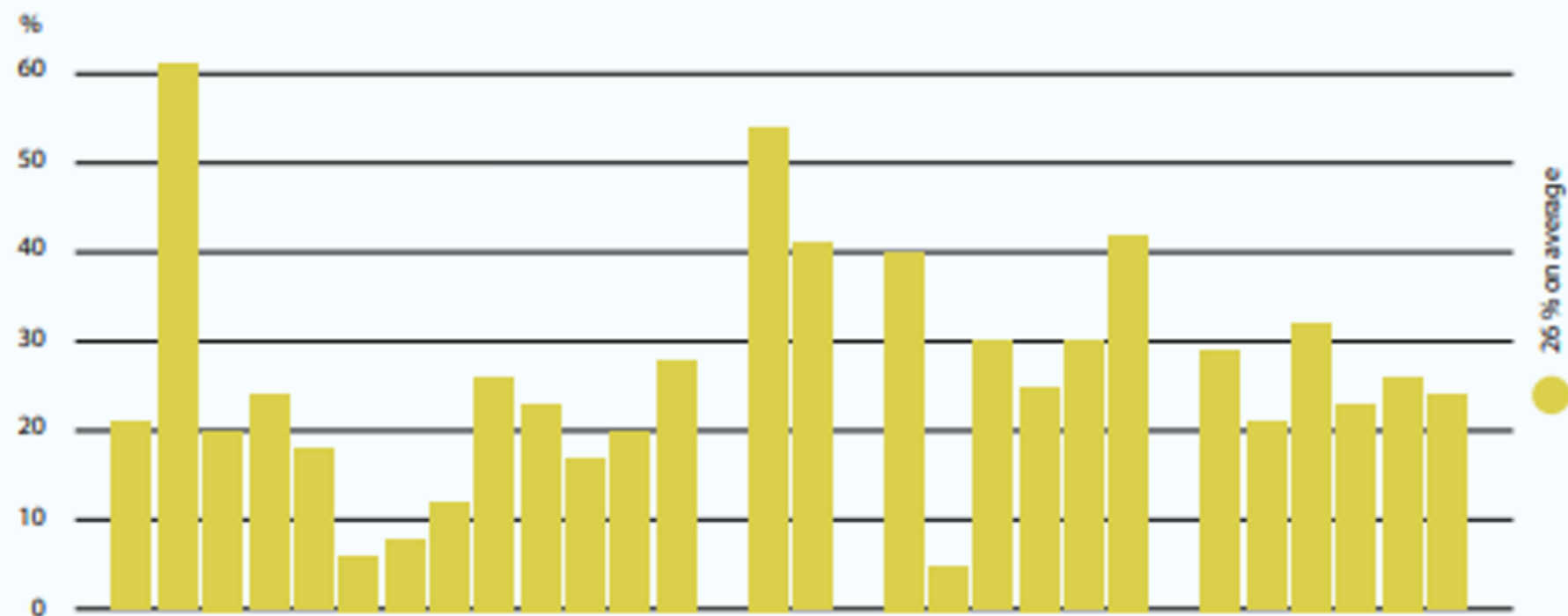
Dental services	0.82%
Waste disposal	0.88%
Fastfood/takeaway	1.37%
Drinking water and wastewater	1.41%
Telephony and Internet	1.78%
Petrol and diesel	1.85%
Electricity	2.06%
Clothing	3.58%
District heating	3.16%
Insurance	4.99%

Data from statistikbanken.dk/FU02 — data for 2020. The example covers an average family with a consumption of € 42,836.

NON-REVENUE WATER (WATER LOSS), 2011 - 2021



WATER LOSS IN EU MEMBER STATES



Individual countries are anonymised, as it is the variation in water loss that is in focus.

Source: EurEau Water in figures 2021



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MICHAEL ROSENBERG PEDERSEN,
AARHUS VAND



Aarhus Vand

Key figures



Operator of the entire water cycle

Tap water

- ① Ground water protection
- ② Pumping of groundwater
- ③ Waterwork
- ④ Pure water tank
- ⑤ Distribution well

Consumer



Wastewater

- ⑥ Wastewater basin
- ⑦ Pumping station
- ⑧ Wastewater facility
- ⑨ Energy production

Climate adaptation

WATER IN FIGURES 2022 DENMARK

EXTENDED EDITION
IWA WORLD WATER
CONGRESS &
EXHIBITION 2022

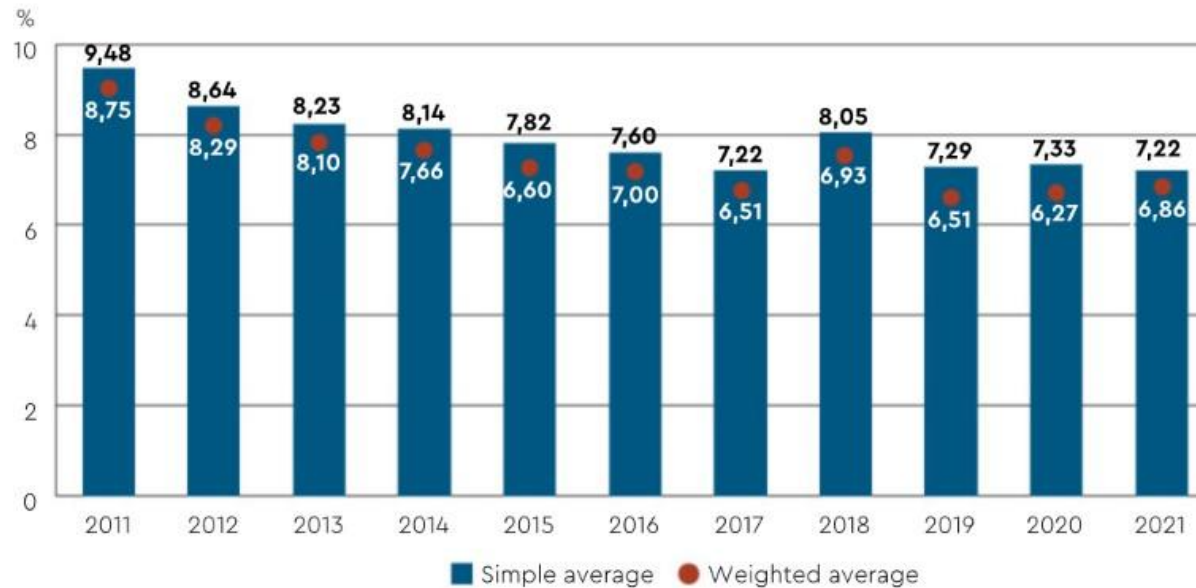


STATISTICS &
BENCHMARKING

Urban water loss – how low can we go?

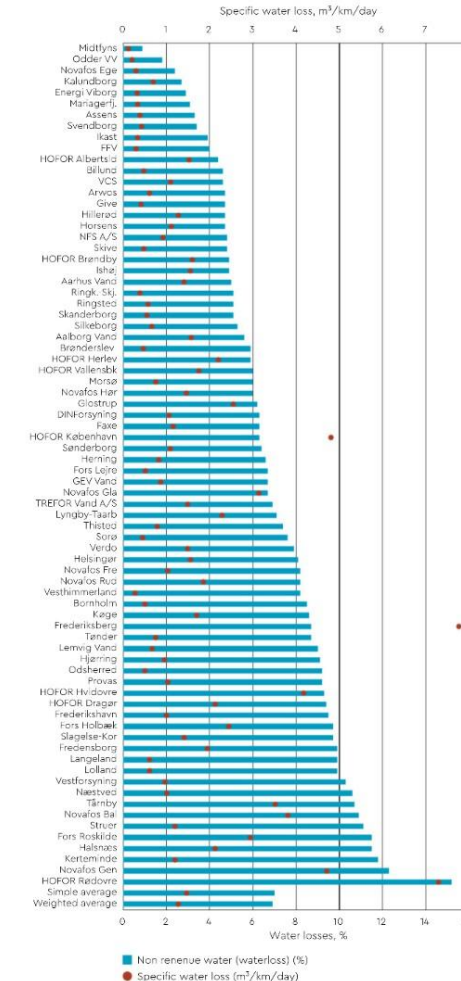
Non revenue water

NON-REVENUE WATER (WATER LOSS), 2011 - 2021



Average (%) based on 50–52 drinking water companies which have participated in DANVA benchmarking over the past 11 years.

NON-REVENUE WATER (WATER LOSS), 2021



Step by step - Active Leakage Control in Aarhus Vand

Digital platforms – non revenue water

1



Leakage monitoring
- Based on reliable data!

2



Prioritize and plan

3



Leakage detection
- 0-point measurements
- Acoustic leak



Step by step - Active Leakage Control in Aarhus Vand

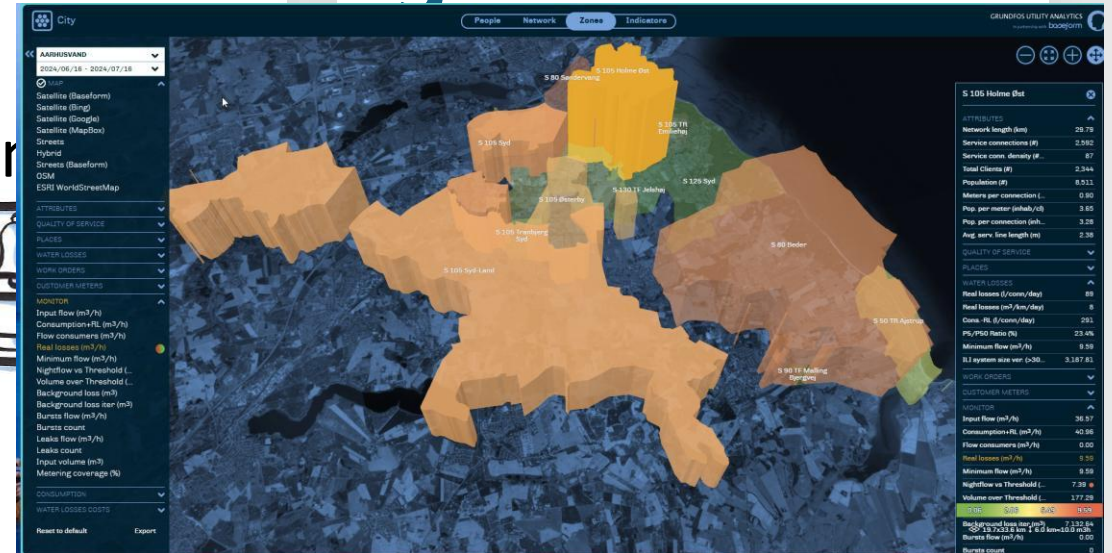
Digital platforms – non revenue water

1

Leakage monitoring
- Based on reliable data!



2



3

detection

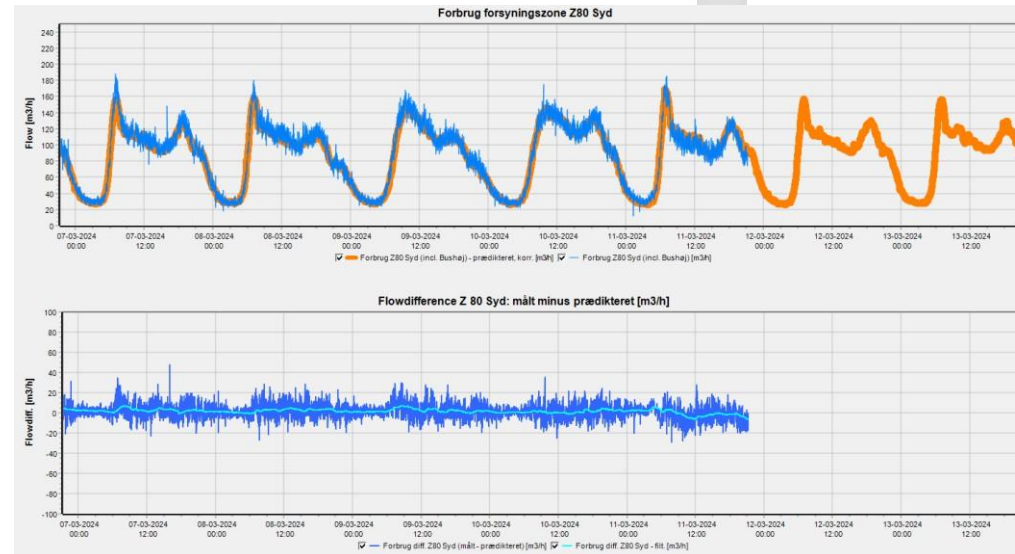
Step by step - Active Leakage Control in Aarhus Vand

Digital platforms – non revenue water

1

Leakage
monitoring
- Based on
reliable data!

2



3

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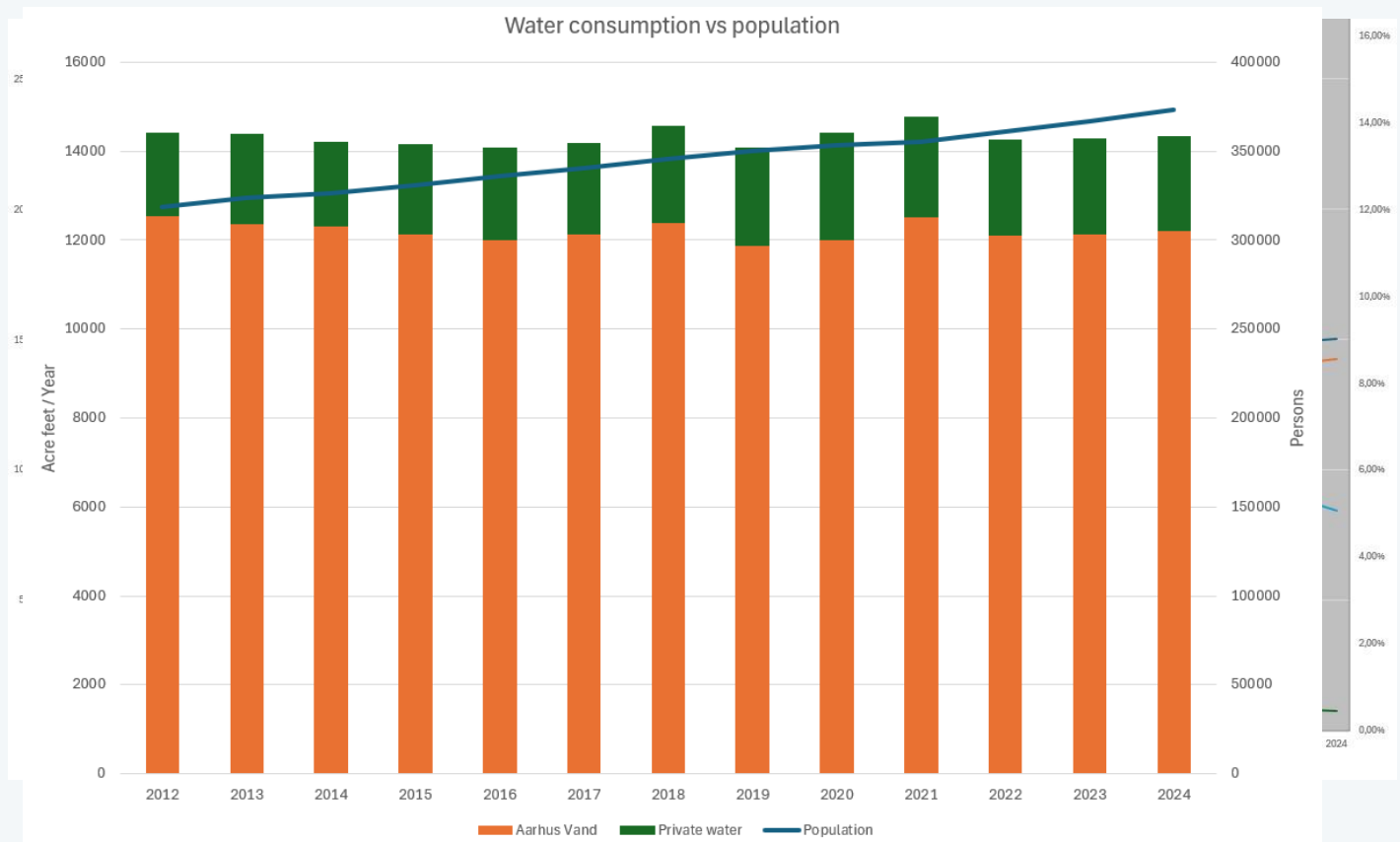
Step by step - Active Leakage Control in Aarhus Vand

Digital platforms – non revenue water



ents
eak
detection

Non-Revenue Water over time



IWA water balance

		m³/år		m³/år		m³/år			
Produced Water	15.043.199	Authorised Consumption	14.280.710	Billed authorised	14.264.501	Billed metered	14.264.501	Revenue Water	94,93%
				Unbilled authorised	16.209	Billed unmetered	0		
		Water Losses	762.489	Apparent losses	0	Unbilled metered	13.317	NRW	5,07%
						Unbilled unmetered	2.892		
				Real losses	746.280	Unorthorised consumption	0		
						Meter inaccuracies	0		
						Leakage - distribution pipes	679.939		
						Leakage ower flows	70		
						Leakage connections	66.271		

$B \text{ water loss} = S \text{ water loss} \times \text{Connections} \times 365 \text{ days}$
 $B \text{ water loss} = S \text{ water loss} \times \text{Miles} \times 365 \text{ days}$
 $S \text{ Water Loss} = B \text{ Water Loss} / (\text{Connections} \times 365 \text{ days})$

$Swl = 207,013,739 \text{ gal/}$
 $(68,800 \times 365)$
 $Swl = 8,2 \text{ gal/con/day}$

The "value" of NRW

NRW - Aarhus

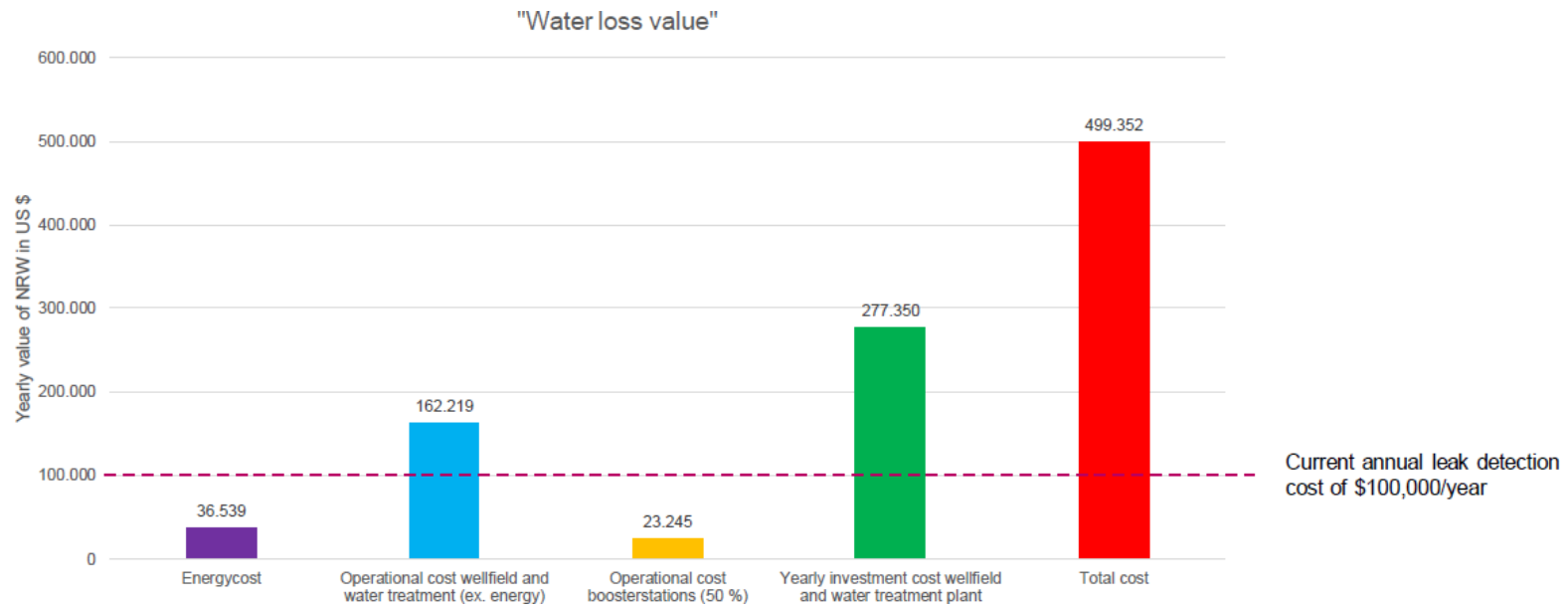
		m³/år		m³/år		m³/år		Revenue Water	94,93%
Produced Water	15.043.199	Authorised Consumption	14.280.710	Billed authorised	14.264.501	Billed metered	14.264.501		
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						Leakage - distribution pipes	679.939		
						Leakage over flows	70		
						Leakage connections	66.271		

The remaining water loss is equivalent to the yearly production from one small water treatment plant



Economic level of leaks

NRW - Aarhus



Innovation, test and partnering

What is next?

Smart meter Innovations project

- 2023 - Innovation tender
- 2024 - Scoping, inspiration and plan
- 2025 - Pilots
- 2026 - Implementing

Pressure changes and leaks

- Testing AI trained pressure monitoring

Partnering

- Mou with MNWD



Takings:

- Data flow
- Change management
- Customer engagement



Thank you for your time

Michael Rosenberg Pedersen

Head of Drinking Water, Aarhus Vand

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Mobile +45 40791376





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LINDSEY STUVICK,
MOULTON NIGUEL WATER DISTRICT



About Moulton Niguel



Drinking-Water, Recycled Water, and Wastewater Treatment



Serve 170,000+ Customers in 6 Cities in South Orange County



7-Member Board of Directors



200 Employees



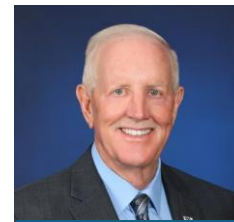
AAA Credit Rating from Fitch and S&P Global



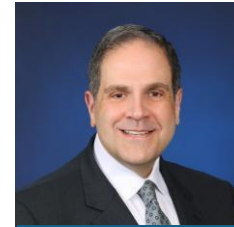
Top Workplace OC & USA



Recognized Statewide and Nationally for Innovation, Environmental Stewardship, and Customer Service



Duane D. Cave
President



Brian S. Probolsky
Vice President



Diane Rifkin
Vice President



Richard S. Fiore
Director



Sherry Wanninger
Director



Donald Froelich
Director



William Moorhead
Director

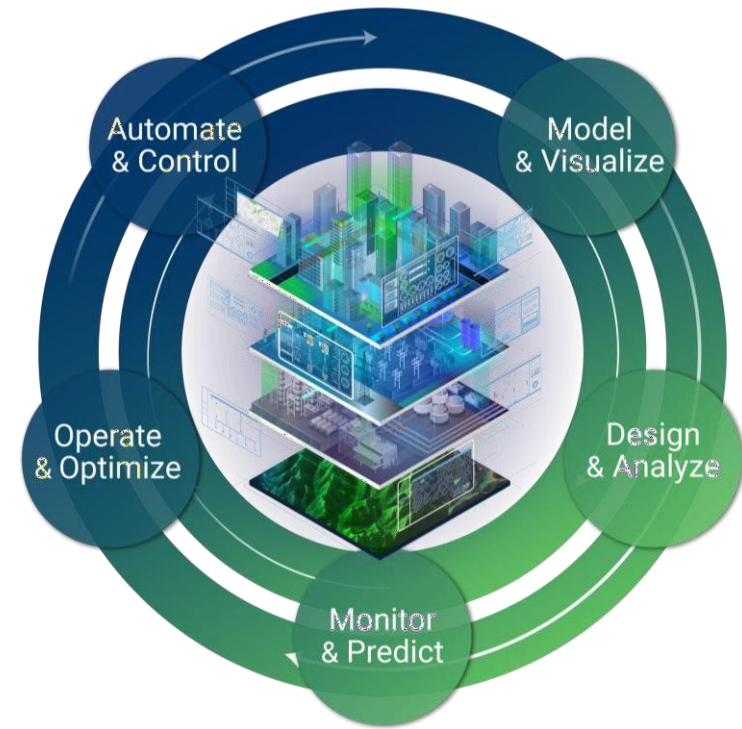
The Danish Connection

- Danish WTA Fact Finding Trips
- Danish delegation visits
- MOU with Aarhus Vand and Danish WTA
 - Digital innovation & data models
 - AMI & customer portals
 - Wastewater treatment technology
 - OASIS & ReWater
 - Change Management
 - Workforce development

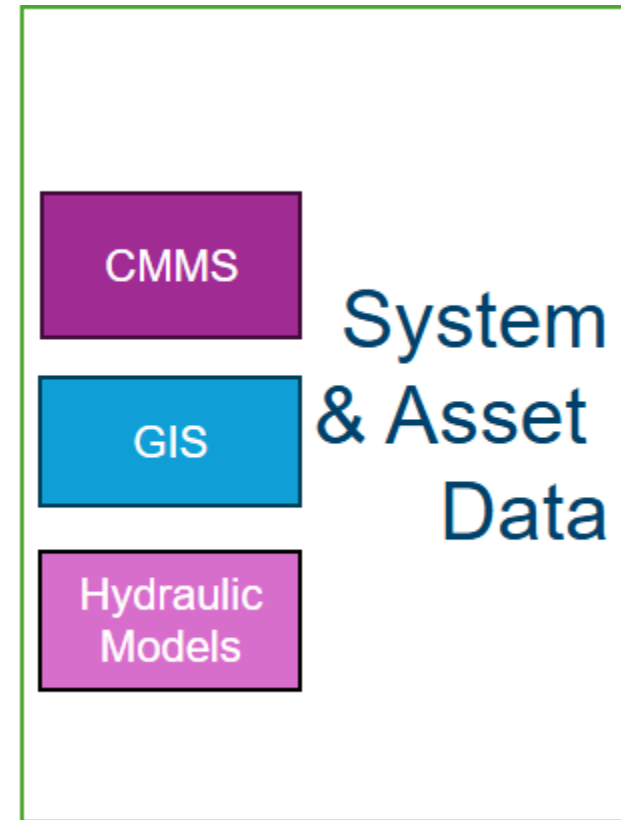
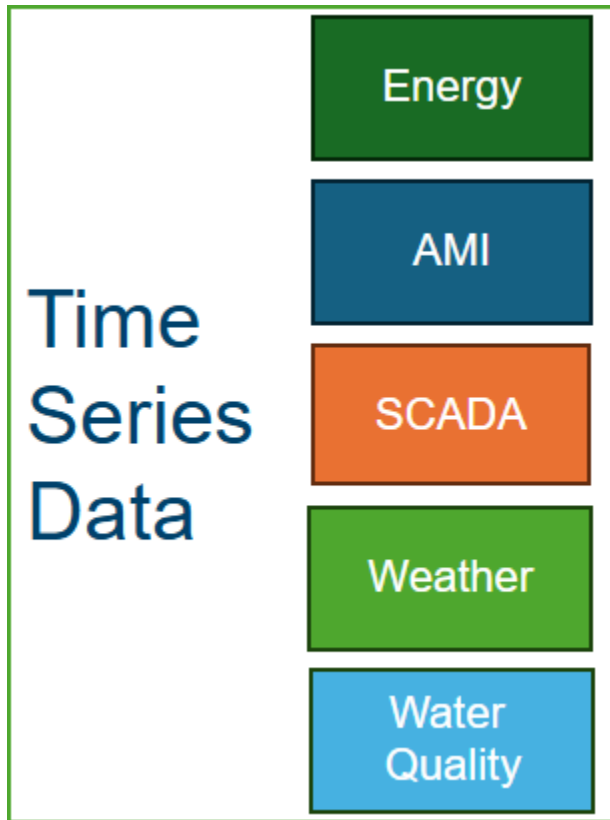


Enterprise Data Management

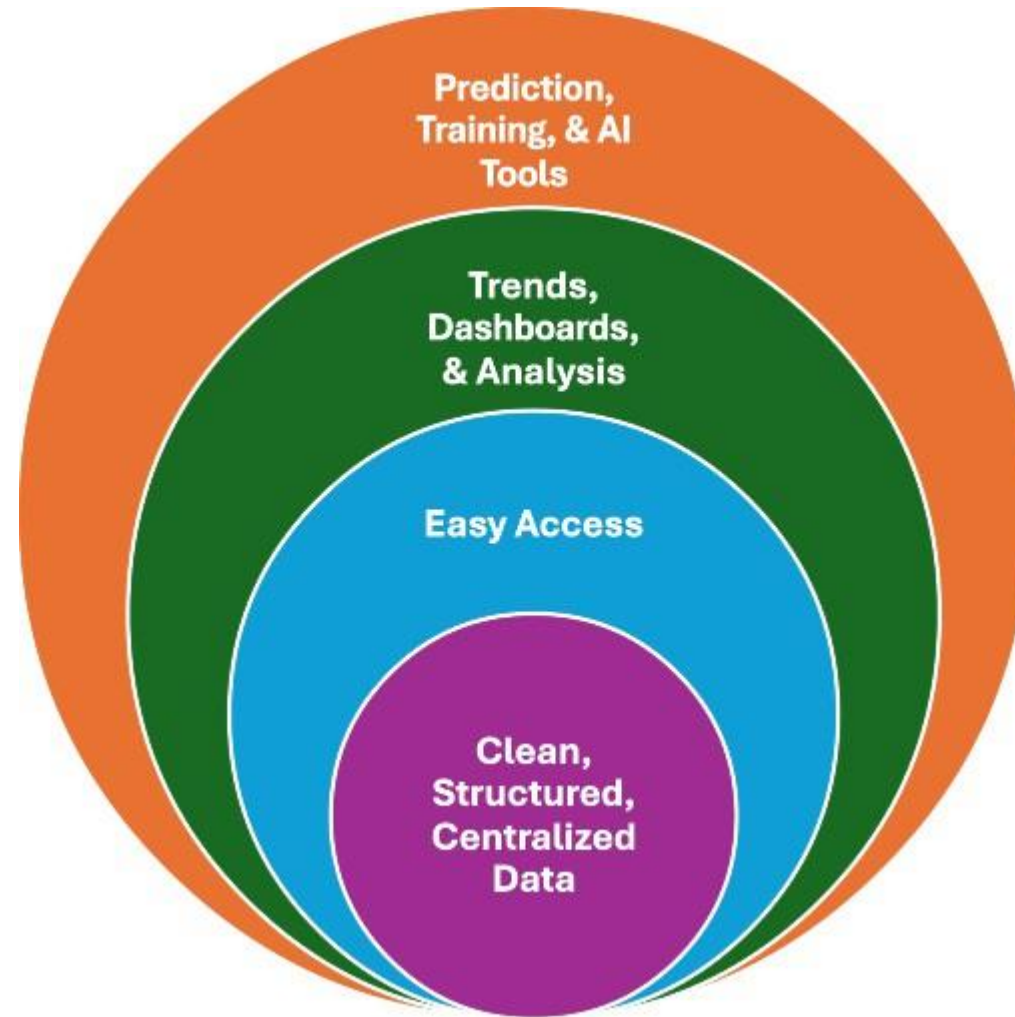
- Supports Resiliency Action Plan
- Optimizes capital planning & operations
- Leverages previous investments
- Streamlines regulatory compliance
- More informed decision-making
- Staff development & training
- More value to customers



Data Sources



Development of Enterprise Tools



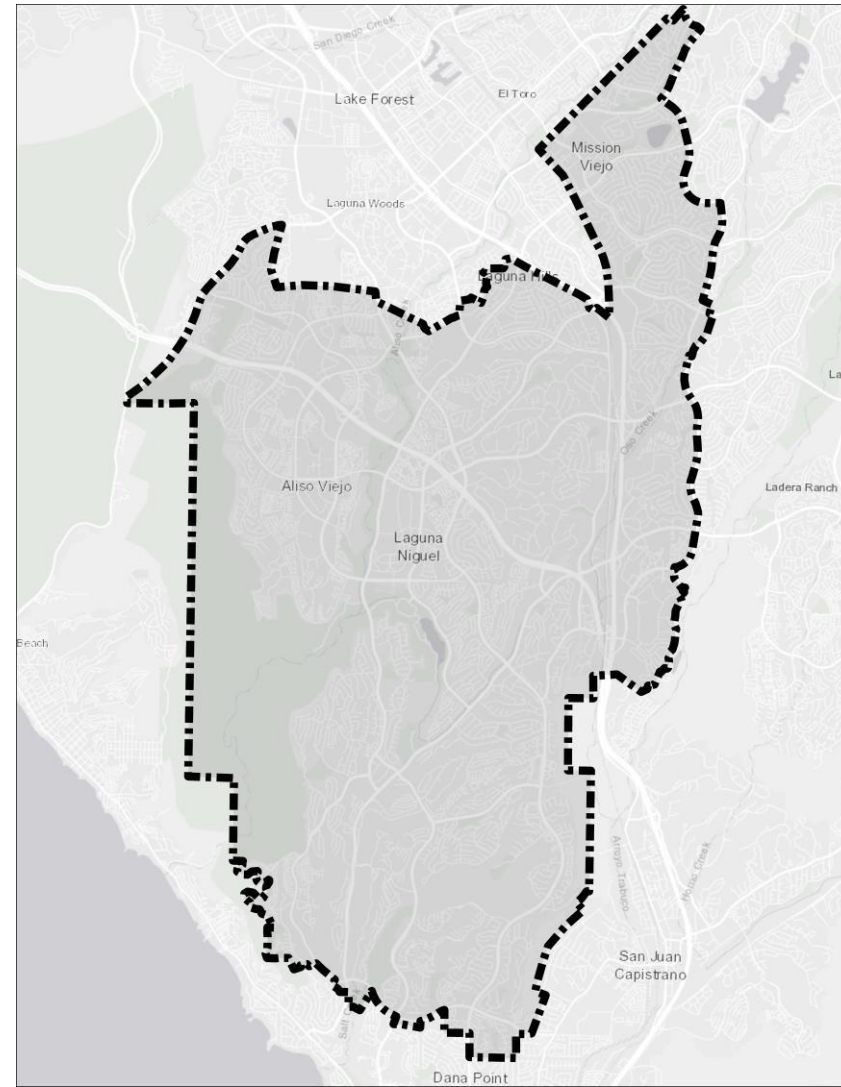
Water Loss Audit

Current Insight

Spatial scale: Districtwide

Frequency: Once per year

Difficult determining when & where

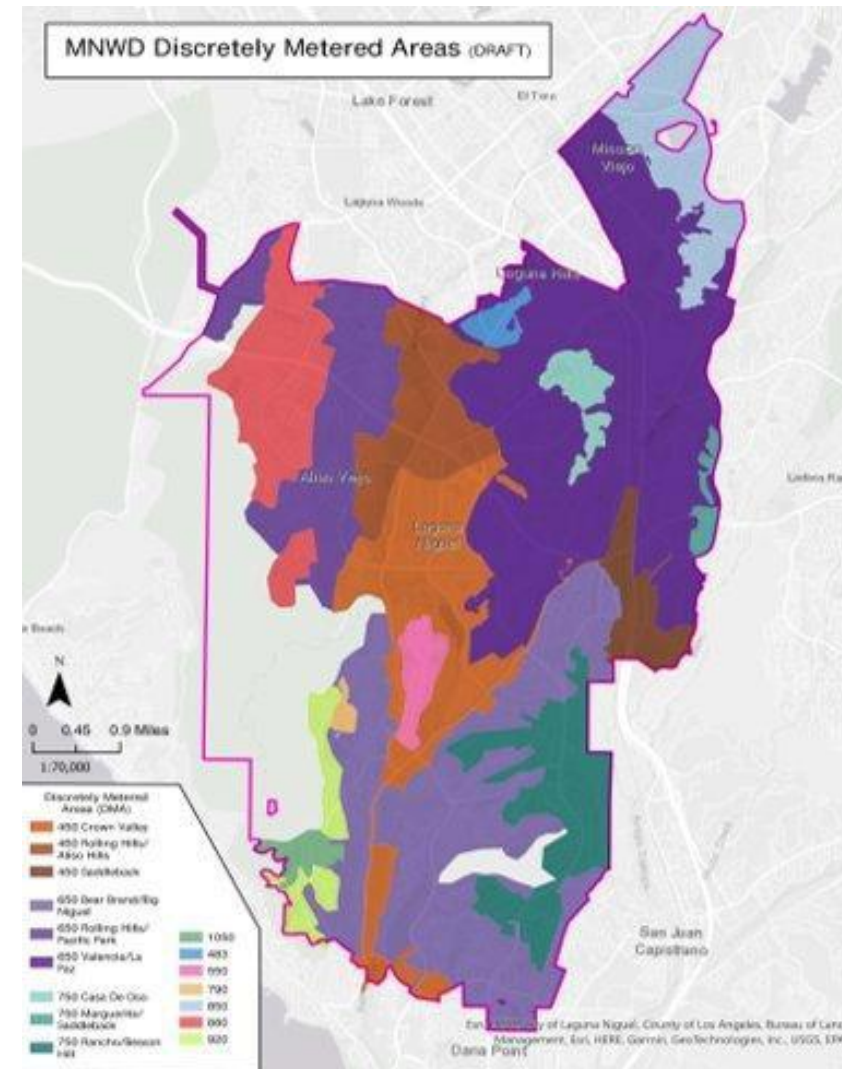
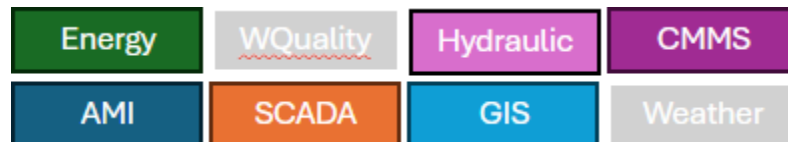


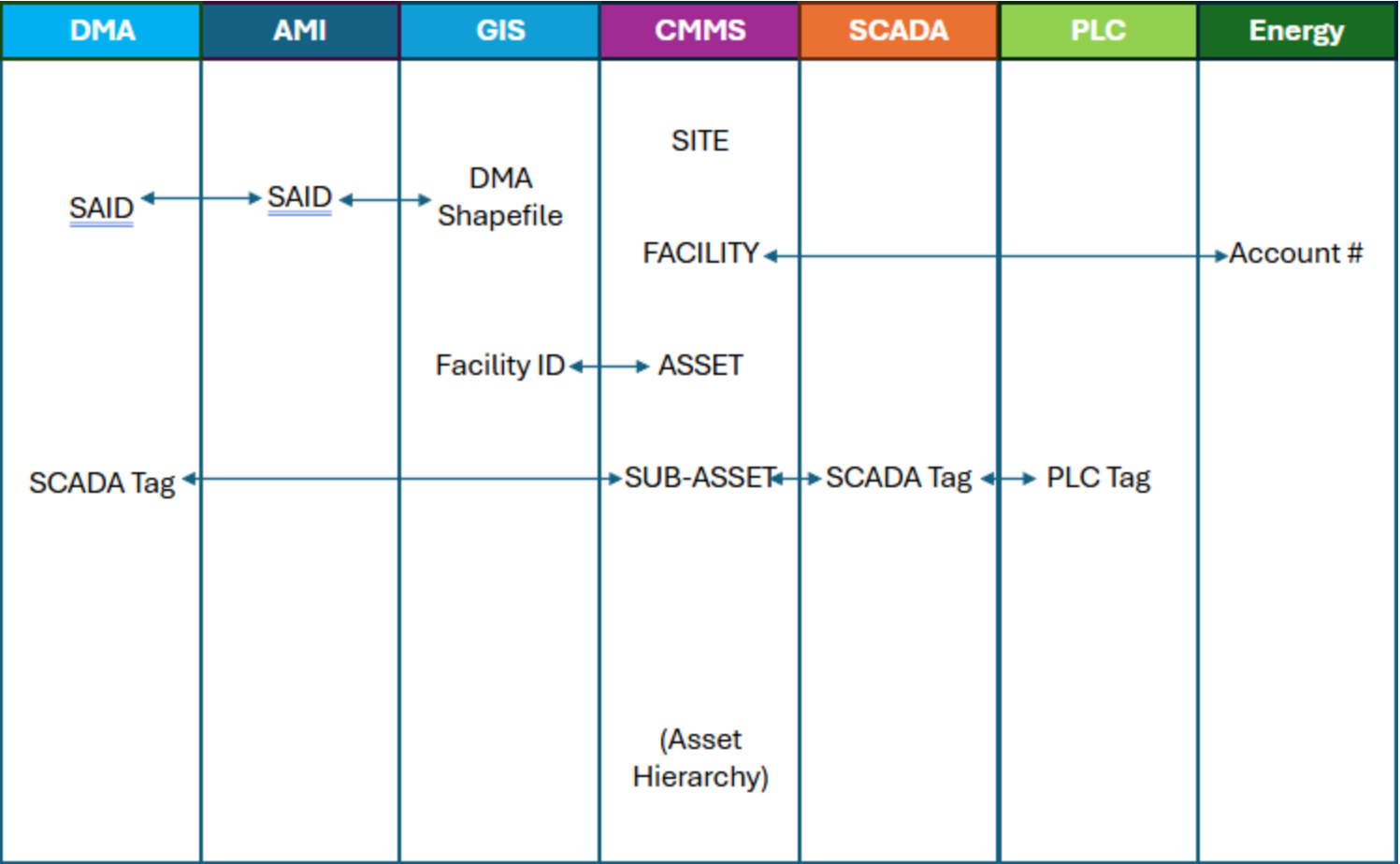
Leak Insights

Digital Water Loss Zones

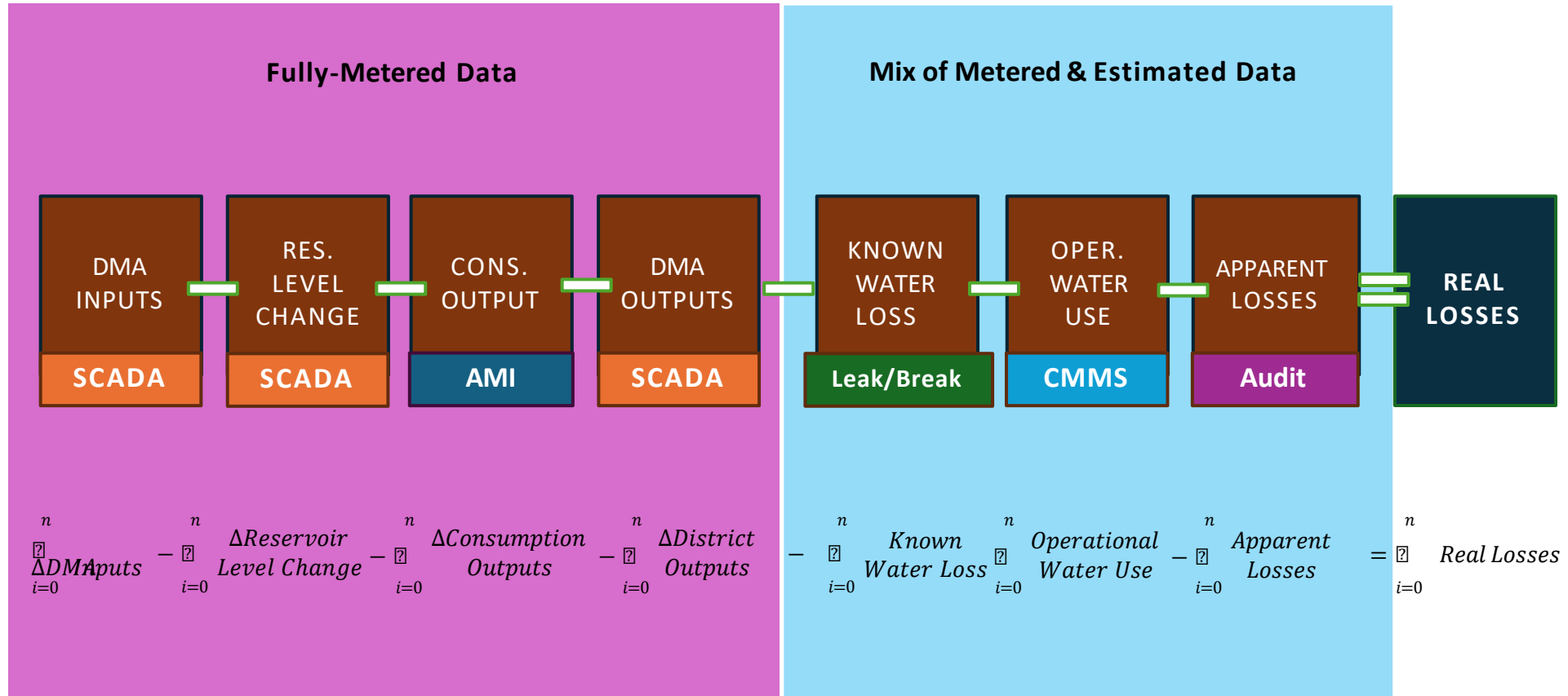
Spatial scale: Multiple Zones

Frequency: Monthly or weekly

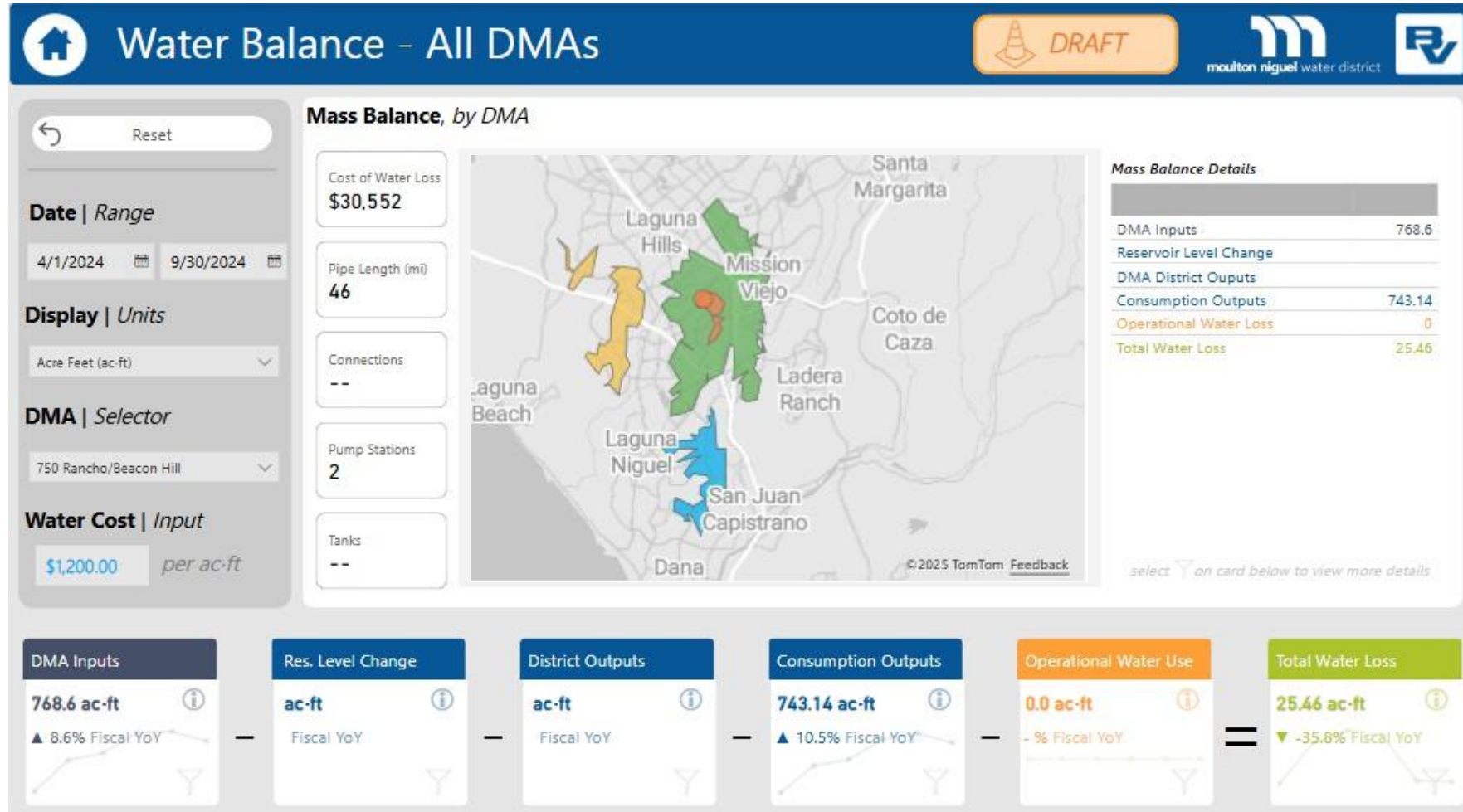




DMA Water Loss Mass Balance



Draft Water Loss Dashboard





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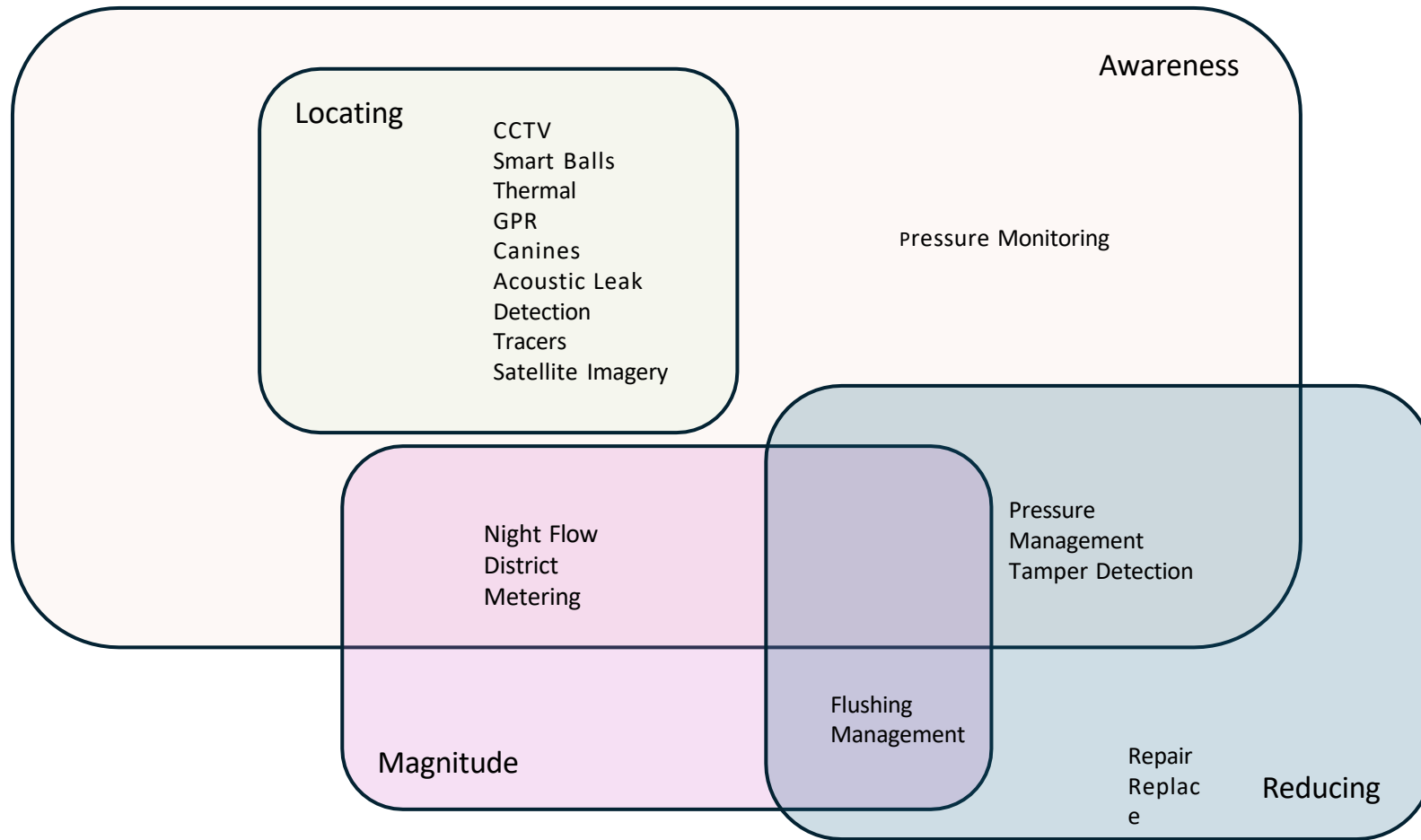


REDUCING REAL WATER LOSSES

TRAVIS SMITH, KAMSTRUP



Technologies

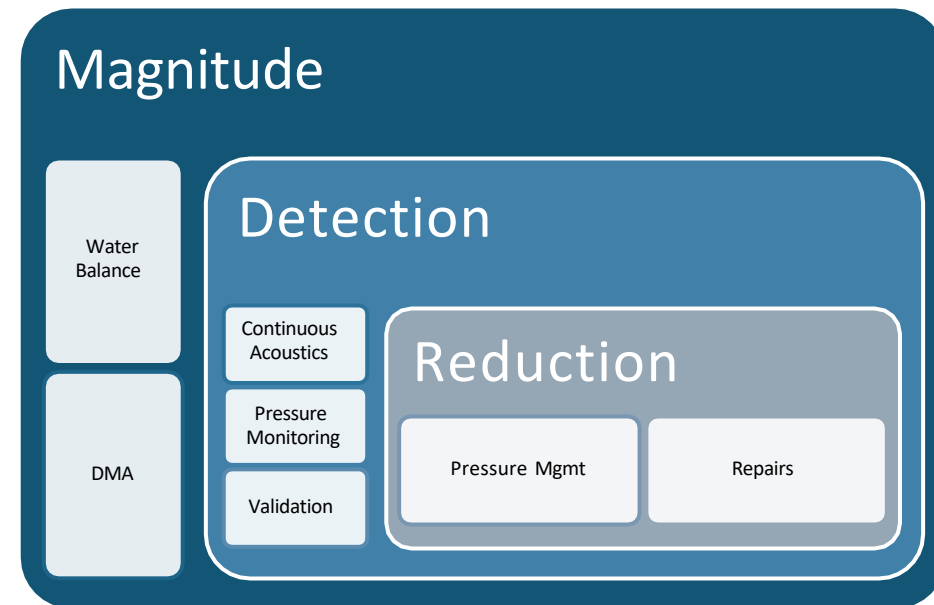


Solution vs Technology

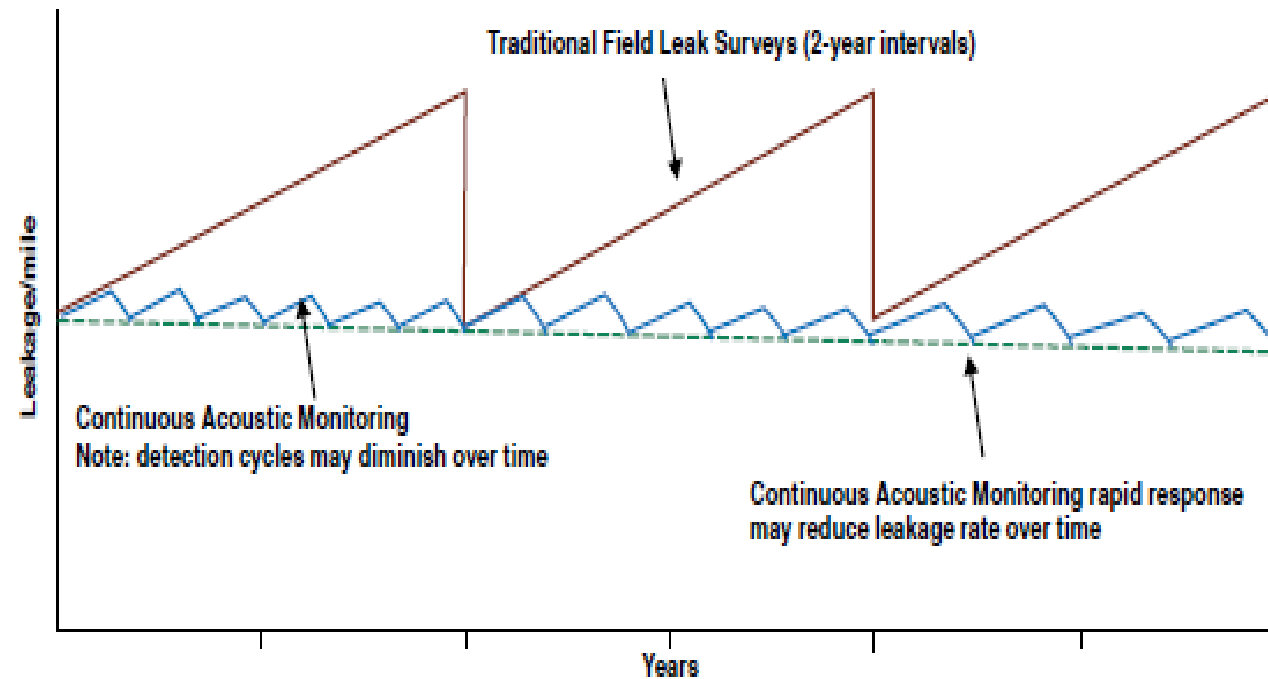
Technology	Magnitude	Awareness	Location	Effectiveness	Capex	Opex
Water Audits						
DMA						
Pressure Monitoring						
Acoustic Surveys						
Continuous Acoustic Monitoring						
Other Surveys						

Nesting of Solutions

- Magnitude – Water Balance and Audits
- Detection – Continuous Acoustics, Pressure Monitoring
- Validation – Correlators
- Reduction- Pressure Management



Continuous vs Surveys



Courtesy of Echologics

Figure 5-26 Impact of CAM on RR and leakage reduction



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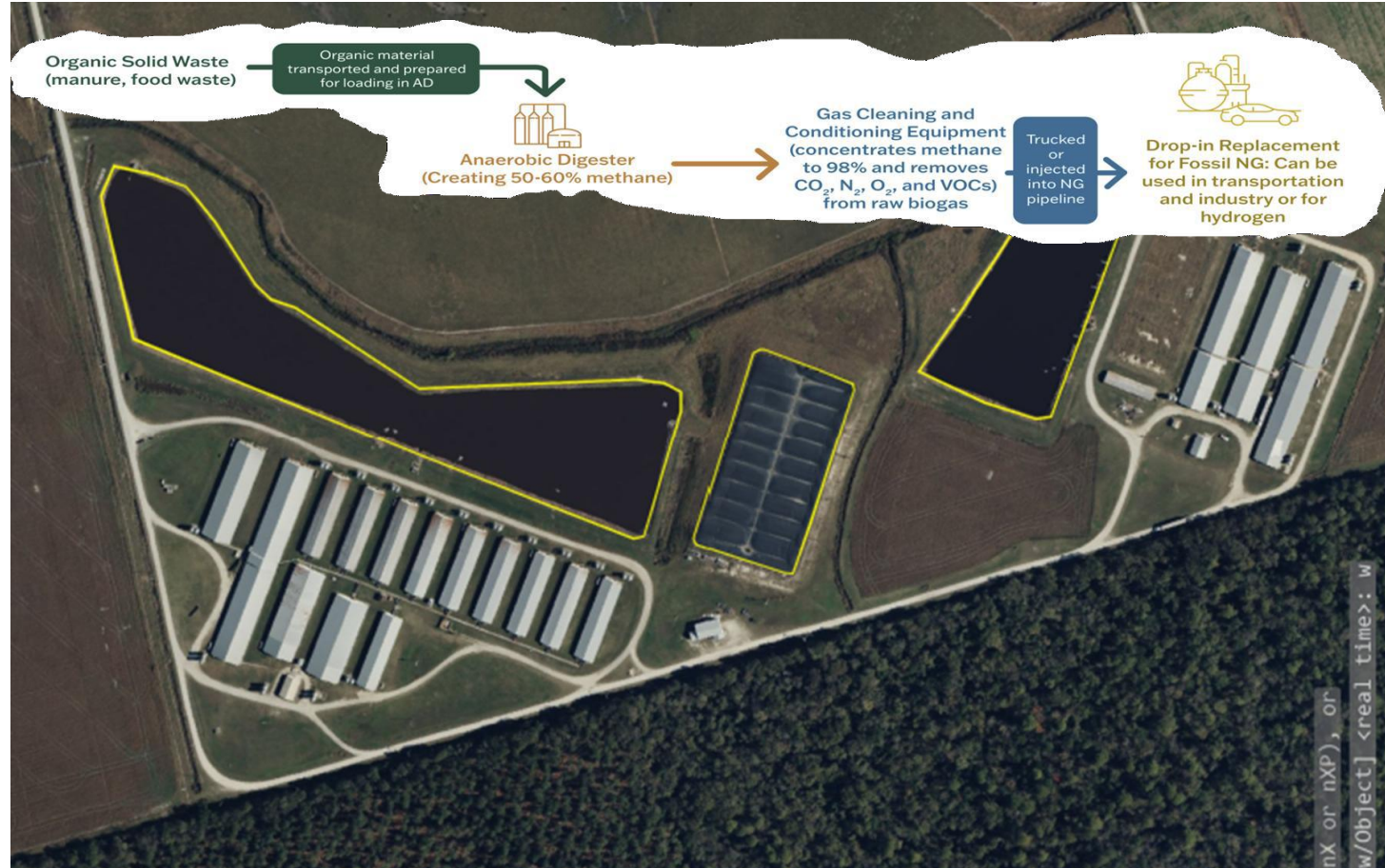
ANDREW MCCARTHY
CAVANAUGH



Leakage Emissions Initiative

- Following Water Loss 2022 in Prague, The IWA WLSG proposed an initiative that seeks to quantify the impact unchecked leakage has concerning avoidable carbon emissions.
- The goal was to update the water balance to include an accounting on the carbon emissions for each balance component with a specific initial focus on Leakage.

Animal Agriculture = Aha Moment!



Leakage Emissions Initiative

Improving our air by preserving our water



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[Meet The Team](#)

[Resources](#)

[Meeting Recaps](#)

[Collaborate](#)

A wide-angle photograph of a waterfront promenade. In the foreground, there is a paved area with a herringbone pattern of grey bricks. A dark blue metal railing runs across the middle ground. Beyond the railing is a calm body of water, likely a lake or a wide river, under a clear, light blue sky. The text is overlaid on the image, centered horizontally and slightly above the bottom edge.

As a result of Water Loss 2022 in Prague, the IWA WLSG proposed an initiative that seeks to quantify the impact that unmanaged leakage has concerning avoidable carbon emissions. Through this initiative we will be linking unchecked leakage to carbon emissions, in an effort to educate those outside the industry on the ecological importance of managing non-revenue water.

AWWA Free Water Audit Software

Water Balance



Water Audit Report for: Citizens Water - Indianapolis/Morgan

Audit Year: 2021

Jan 01 2021 - Dec 31 2021

Data Validity Tier: Tier IV (71-90)

FWAS v6.0

American Water Works Association.
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Volume from Own Sources (VOS) (corrected for known errors) 46,119.270	System Input Volume 46,483.696	Water Exported (WE) (corrected for known errors) 719.673	Billed Water Exported				Revenue Water (Exported) 719.673
		Authorized Consumption 37,295.862	Billed Authorized Consumption 37,147.825	Billed Metered Consumption (BMAC) (water exported is removed) 37,147.825	Revenue Water 37,147.825		
				Billed Unmetered Consumption (BUAC) 0.000			
			Unbilled Authorized Consumption 148.037	Unbilled Metered Consumption (UMAC) 55.167		Non-Revenue Water (NRW) 8,616.198	
				Unbilled Unmetered Consumption (UUAC) 92.870			
		Water Supplied 45,764.023	Apparent Losses 2,004.136	Systematic Data Handling Errors (SDHE) 92.870			
				Customer Metering Inaccuracies (CMI) 1,818.397			
				Unauthorized Consumption (UC) 92.870			
			Water Losses 8,468.161	Real Losses 6,464.025	Leakage on Transmission and/or Distribution Mains Not broken down		
		Leakage and Overflows at Utility's Storage Tanks Not broken down					
Leakage on Service Connections Not broken down							

AWWA Free Water Audit Software

Water Balance



Water Audit Report for: "Traditional" Water/Energy Source

Audit Year: 2021

Jan 01 2021 - Dec 31 2021

Data Validity Tier: Tier IV (71-90)

FWAS v6.0

American Water Works Association.
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		Water Exported (WE) (corrected for known errors)	Billed Water Exported						Revenue Water (Exported)		
		719.673	726							719.673	726
Volume from Own Sources (VOS) (corrected for known errors) 46,119.270 47,552	System Input Volume 46,483.696 48,933	Water Supplied	Authorized Consumption 37,295.862 37,641	Billed Authorized Consumption		Billed Metered Consumption (BMAC) (water exported is removed)		Revenue Water			
				37,147.825		37,492 37,147.825		37,147.825			
				37,492		0 0.000		37,492			
				Unbilled Authorized Consumption		Unbilled Metered Consumption (UMAC)		Non-Revenue Water (NRW)			
			148.037		56 55.167						
			149		Unbilled Unmetered Consumption (UUAC)						
			94 92.870								
			Systematic Data Handling Errors (SDHE)		94 92.870		8,616.198				
			Customer Metering Inaccuracies (CMI)		1,835 1,818.397		8,696				
			Unauthorized Consumption (UC)		94 92.870						
Water Imported (WI) (corrected for known errors) 364.426 368		Water Losses	8,468.161 8,547	Real Losses		Leakage on Transmission and/or Distribution Mains					
				6,464.025		Not broken down					
				6,525		Leakage and Overflows at Utility's Storage Tanks					
						Not broken down					
						Leakage on Service Connections					
						Not broken down					

Water Balance Real Loss
Reported Leakage Through Repairs
Background Leakage

6,464 Mgal
500 Mgal
2,219 Mgal

 = Metric Tons of CO2/Yr.

Estimate of Unreported Real Loss 3,745 Mgal (Recoverable)

