Tapping into Water Loss:
Using Water Audit Data for Resilience Planning in the Delaware River Basin

Michael Thompson, P.E.

October 9, 2025
SEPA AWWA & WWOAP
Joint Fall Conference

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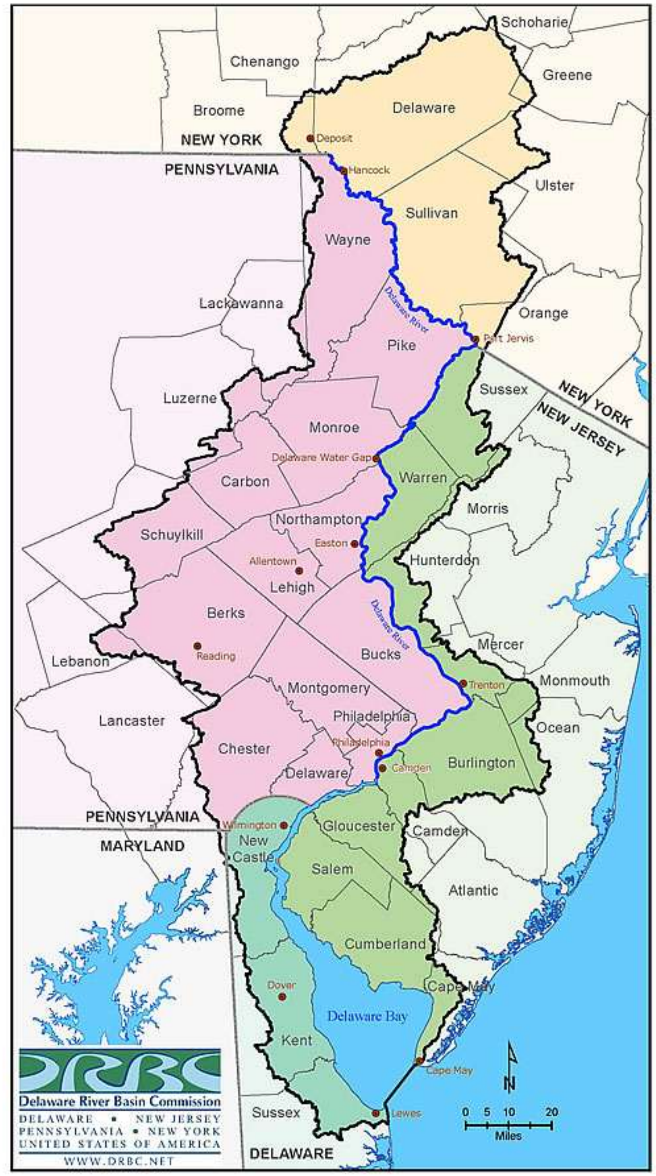
Basin highlights…

- 330 miles long
- interstate boundary
- un-dammed
- 13,539 square miles
- 8.6 million people live here
- ½ of New York City’s water supply
- 6.4 billion gallons/day withdrawn
- $21B in economic value
- Cools 98 TWh of energy in 2020



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What is the Delaware River Basin Commission?

Established by interstate compact in 1961, a regional body with the force of law to oversee a unified approach to managing a river system without regard to political boundaries.

Delaware | New Jersey | New York | Pennsylvania | Federal Gov't (USACE)

“provide trusted, effective and coordinated management of our Basin's shared water resources.”

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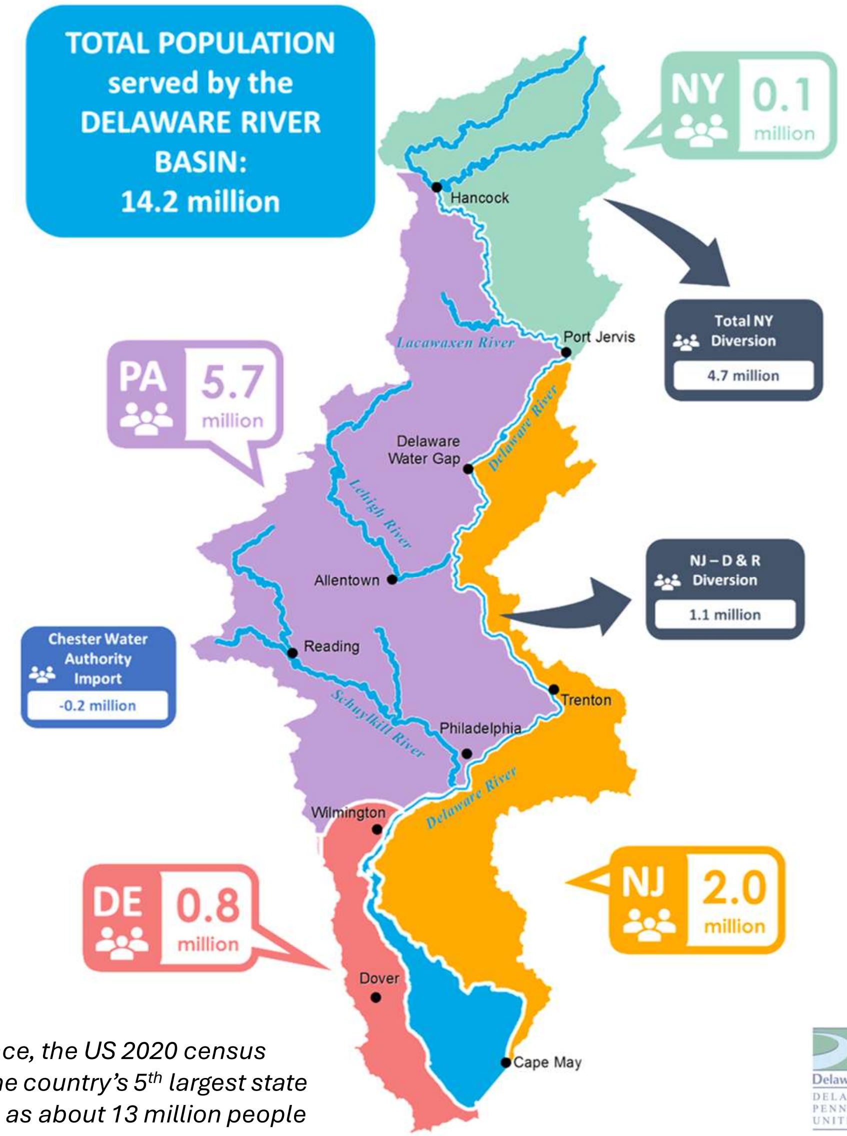
Over 14 million people rely on the Delaware River Basin for drinking water

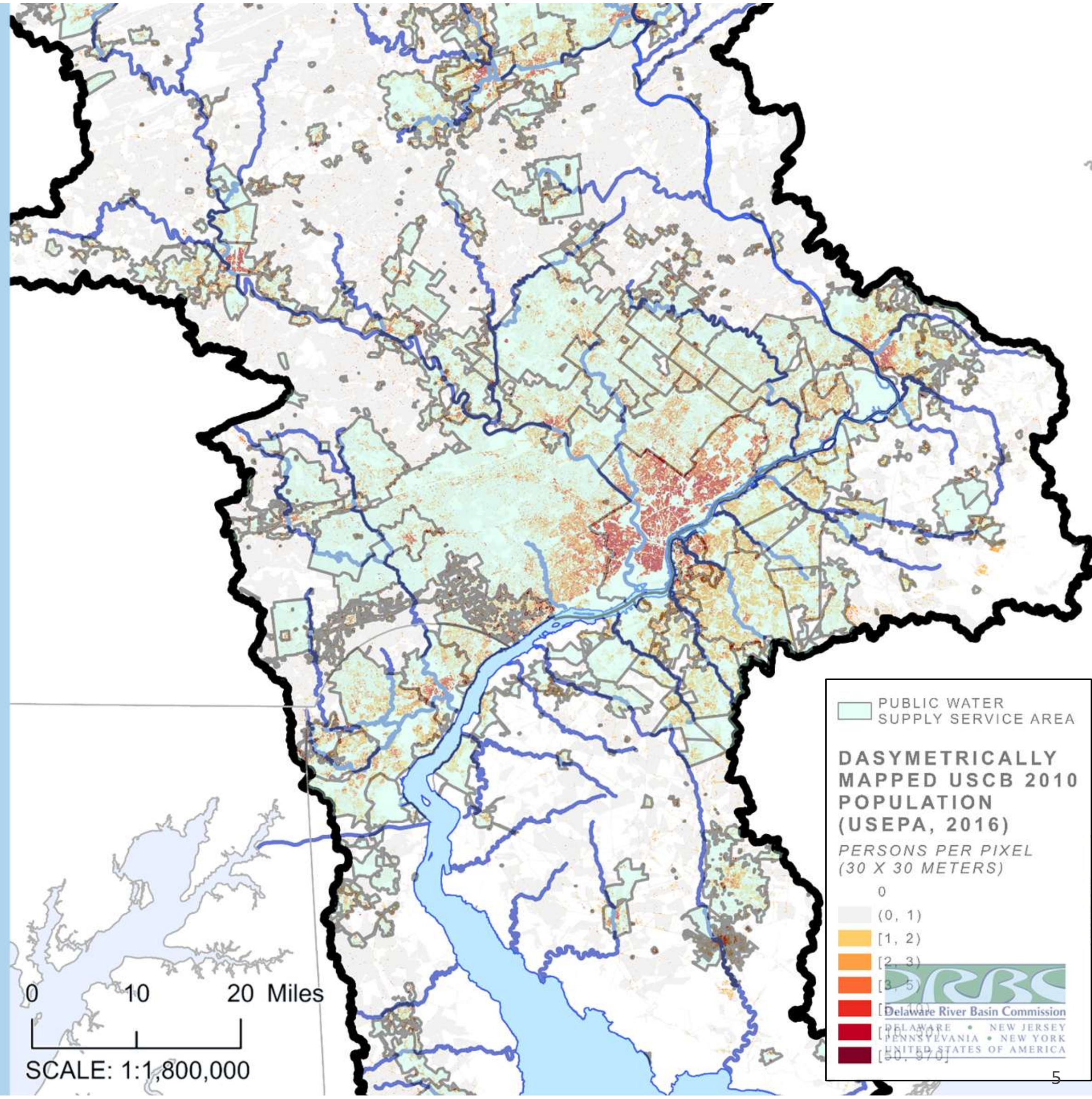


For reference, the US 2020 census reported the country's 5th largest state population as about 13 million people (Pennsylvania).

Most people in the Basin rely on public water supply

8.629 million people
live in Delaware River Basin (2020 Census)

7.366 million people
live inside public water supply service areas
~ 85% of the population



The DRBC "Water Audit Program" applies to around 300 water systems

29,000 miles of water main (enough to circle the Earth)

2.5 million service connections (active and inactive)

2000
International Water Association publishes research standardizing methods to quantify water loss

2006
DRBC staff participate on the American Water Works Association (AWWA) Water Loss Control Committee (WLCC) and help publish the first AWWA Free Water Audit Software (FWAS)

2007-2009
DRBC undergoes rulemaking process
Adopted Res 2009-1 to amend the Water Code
Applies to systems which:
"distribute water supplies in excess of an average of 100,000 gallons per day (gpd) during any 30-day period"

2013
The first mandatory water audits are due for CY2012

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“A Comprehensive Assessment of the Delaware River Basin Commission’s Water Audit Program (2012-2021)”

DRBC audit program

Visit the website:

https://www.nj.gov/drbc/programs/supply/water-audit-program.html


A Comprehensive Assessment of the Delaware River Basin Commission’s Water Audit Program (2012-2021)

WATER

A Comprehensive Assessment of the Delaware River Basin Commission’s Water Audit Program (2012-2021)

A Comprehensive Assessment of the Delaware River Basin Commission’s Water Audit Program (2012-2021)

DRBC Report No: 2023-7

Prepared by Michael Y. Thompson, Sara C. Sayed, and Chad E. Pindar

Authorization

This work is being conducted in accordance with Article 3 Section 3.6(c) of the Delaware River Basin Compact (PL 87-328, 75 Stat. 688). More specifically, the project is outlined in Section 2.2.1.3 (Water Supply Management: Conservation, Special Area Management, and Permitting) of the DRBC Water Resources Program FY2024-2026 (DRBC, 2023).

Acknowledgements

First and foremost, the authors express gratitude to all utilities and staff who have been completing the AWWA Free Water Audit Software reports over the past decade. Thank you for your coordination year after year, and for working with DRBC to get the best data feasible. As the adage goes, you cannot manage what you do not measure – and because of your efforts, it is possible to perform analyses such as this to help plan for a sustainable future.

The authors express their gratitude to: Allan Lambert and Kate Stanton-Davies (Water Loss Research & Analysis Ltd) for sharing valuable knowledge of the industry’s history, reviewing the draft report, and for assistance related to their ongoing research on System Correction Factors; to George Kunkel (Kunkel Water Efficiency Consulting) and Gary Trachtman (Arcadis US, AWWA WLCC) for their discussions on meter testing/accuracy, and for providing valuable insight after reviewing a draft report; and to Margaret Hunter (New Jersey American Water) for her assistance in compiling the additional data needed for the pilot study on System Correction Factors. Additionally, the authors would like to acknowledge the help and expertise of the DRBC Water Management Advisory Committee (WMAC).

Scope and Organization

The purpose of this study is to perform a comprehensive assessment of the ten years of data collected though the Delaware River Basin Commission's water audit program (Delaware River Basin Water Code §2.1.8). A detailed background on water system efficiency is presented, with a specific focus on how the industry has arrived at its current practices (i.e. top-down approaches to water balances with standardized terminology). A review of the most recent year of data (CY2021) summarizes specific metrics measured by the AWWA Free Water Audit Software, followed by assessments of observed trends (2012-2021). Investigations are performed to estimate possible reductions of real water loss (i.e., leakage) across the Delaware River Basin. Multiple recommendations are made at the end of this report to help move the water audit program in the Delaware River Basin from monitoring progress, to promoting progress.

DRBC 2023-7
December 2023

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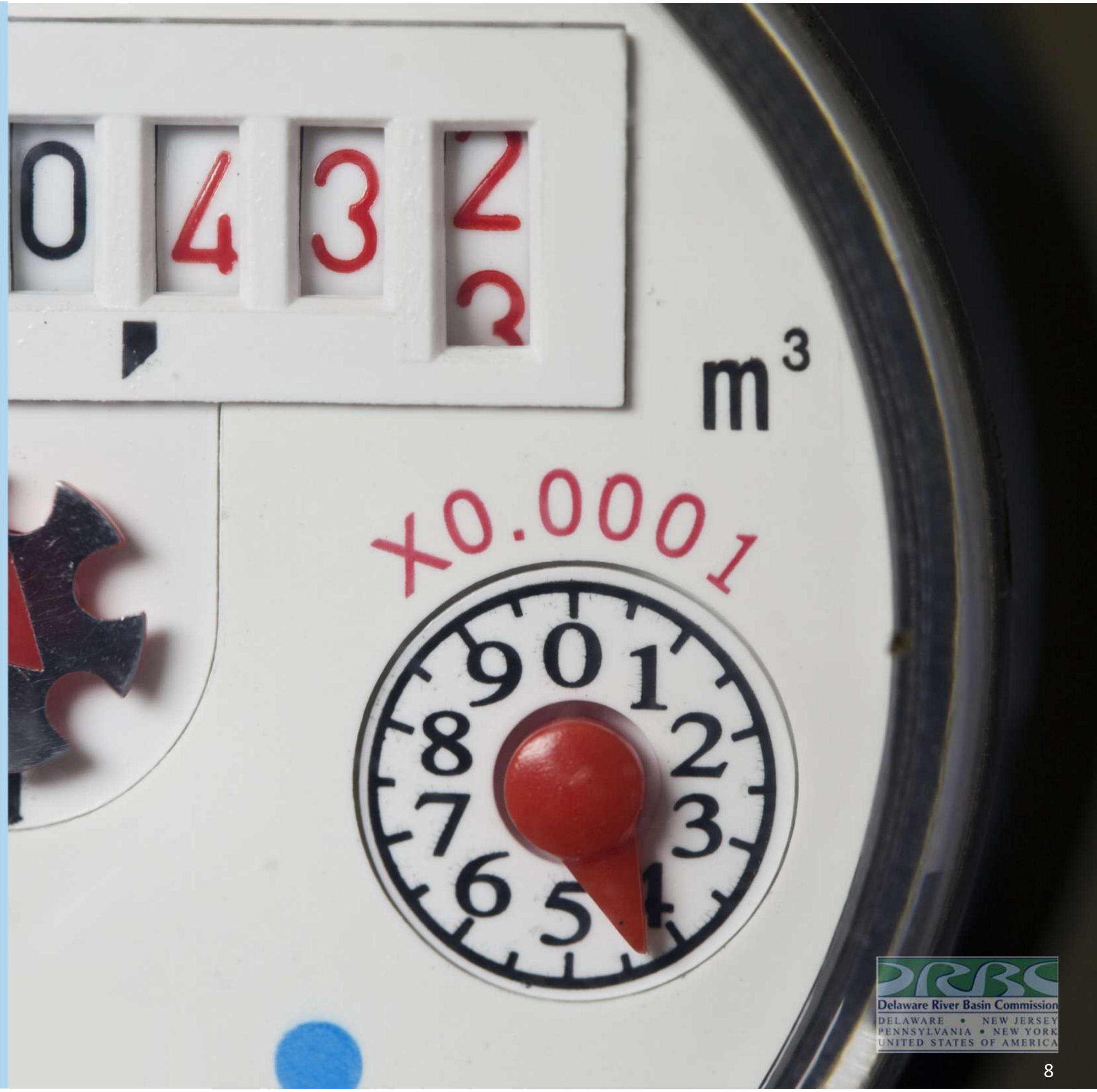
Section 3

Data management and review



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What does the dataset look like?

Statistics for the DRBC's Water Audit Program (2012-2024)

	First Year	Last Year	Expected	Missing	v4.1	v4.2	v5.0	v6.0	Received	Compliance	Filtered Dataset
2012	305		305	63	3	239			242	79%	197
2013		2	305	44	2	257	2		261	86%	200
2014		2	303	43	1	96	163		260	86%	167
2015			301	35		7	259		266	88%	175
2016			301	11		1	289		290	96%	183
2017	1		302	8			294		294	97%	188
2018	1	5	303	7			296		296	98%	192
2019	5	3	303	18		1	284		285	94%	201
2020	1	2	301	13			150	138	288	96%	207
2021		3	299	6			6	287	293	98%	187
2022		3	296	12			4	280	284	96%	194
2023			293	17			1	275	276	94%	192
2024	1		294	16			1	277	278	95%	204

Filtering Criteria

1. Cannot be backfilled report data
2. Losses >= 0
3. CMI < 25% of Total Water Loss
4. ILI 1 < ILI <20
5. BMAC > 1,000 gal/connection/month

Data backfill example...

YEAR	VOS
2012	121.000
2013	
2014	
2015	
2016	93.230
2017	75.545
2018	82.466
2019	
2020	80.712
2021	94.000

→

YEAR	VOS
2012	121.000
2013	93.230
2014	93.230
2015	93.230
2016	93.230
2017	75.545
2018	82.466
2019	80.712
2020	80.712
2021	94.000

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Comparison (2021)

Water Audit Reference Dataset (WARD)
A product compiled by the AWWA Water Loss Control Committee which includes Level 1 validated water audits for calendar year 2018 from 1,124 utilities in:

- Quebec (Canada)
- California
- Georgia

Real Loss on y-axis in all plots

"Filtered" data from the Delaware River Basin aligns with Level 1 validated data fairly well

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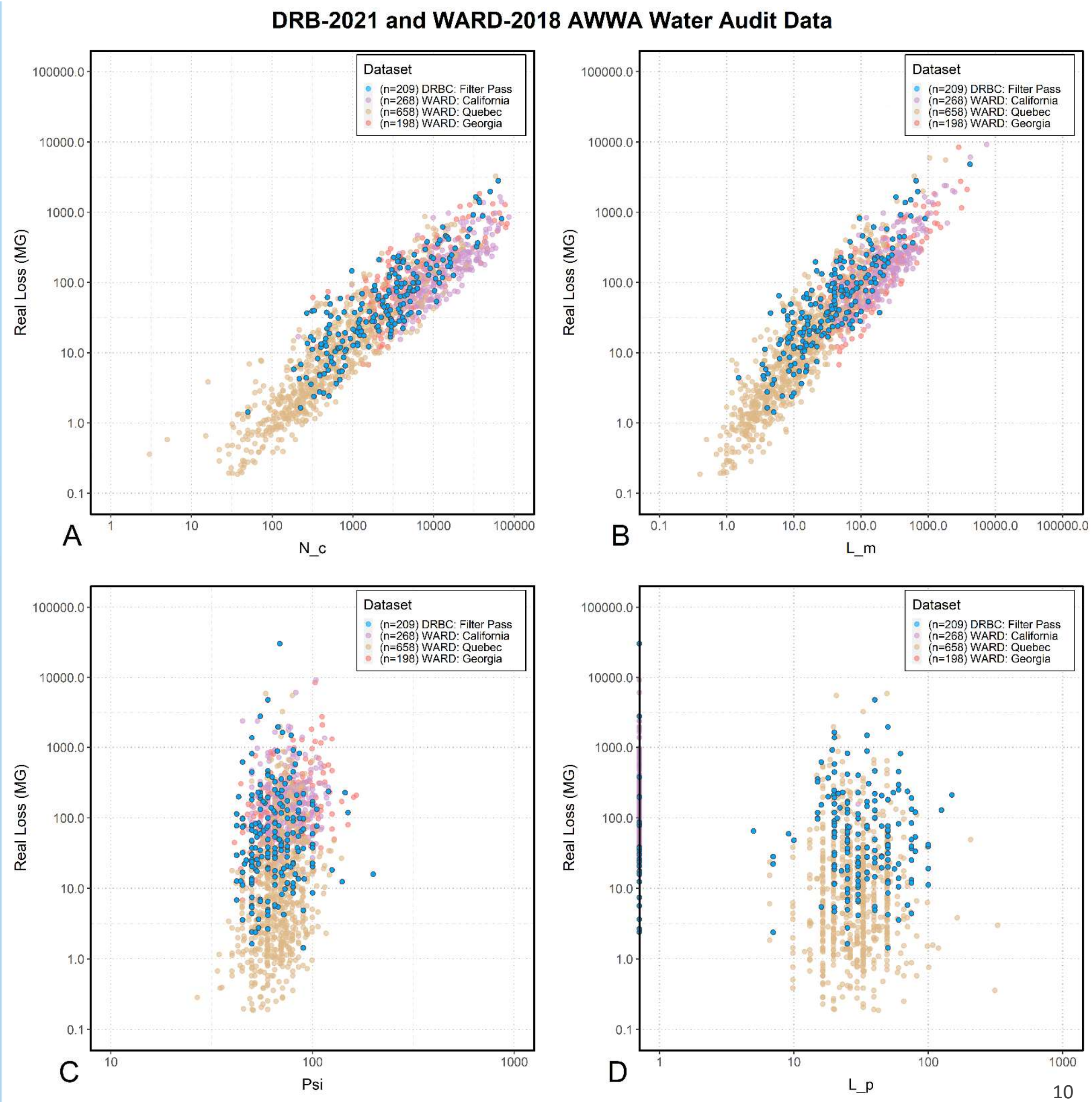


Section 4 & 5

Water Audit Analysis (2021)
and trends (2012-2021)

…

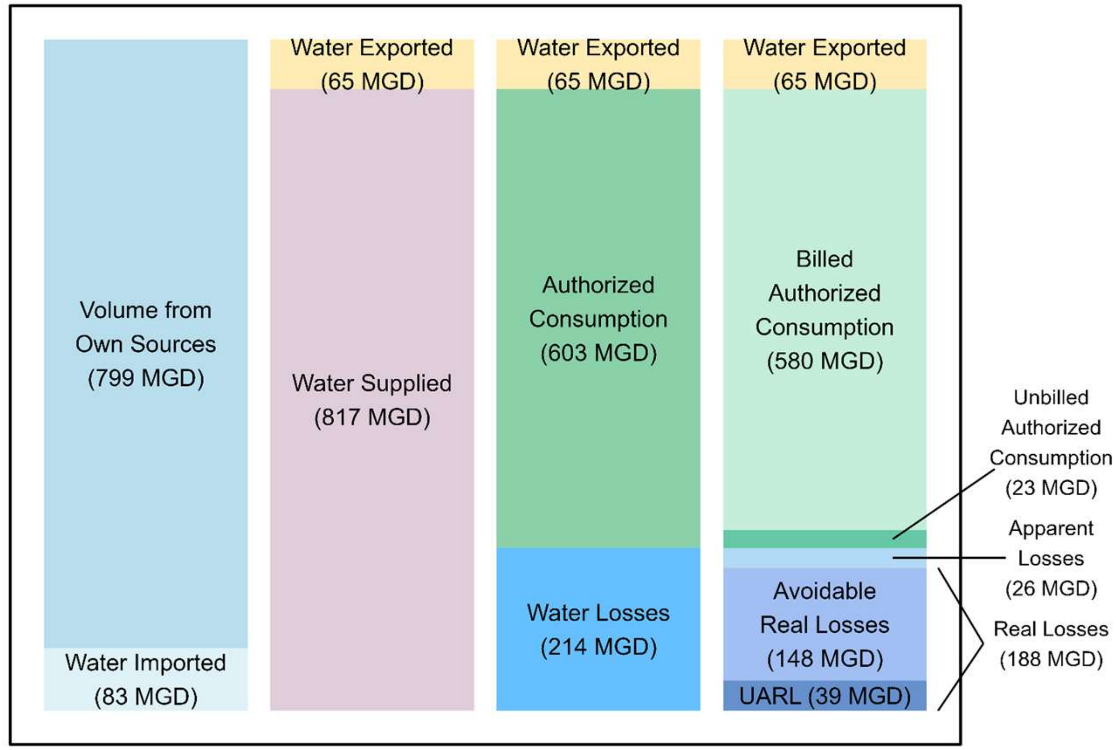
updated 😮

Basin wide, 2024

- Aggregate data for 294 reports
- Net “Import-Export” = 18 MGD
- Water supplied = 817 MGD

UARL (39 MGD)

- Not all real losses can be resolved
- Addition of UARL to the water balance adds some context to Real Loss volume
- The word “avoidable” used here as the antonym to “unavoidable”, but perhaps there is better terminology …



CY2024 aggregate water balance from 294 reports submitted by systems within the Delaware River Basin. Note that the UARL=39 MGD summation is based on standard UARL calculations performed for all systems regardless of operating pressure or number of connections (if ILI<1, UARL was replaced with the observed real loss value). Note that summation errors may be present due to rounding (e.g. 188 = 148.4 + 39.3).

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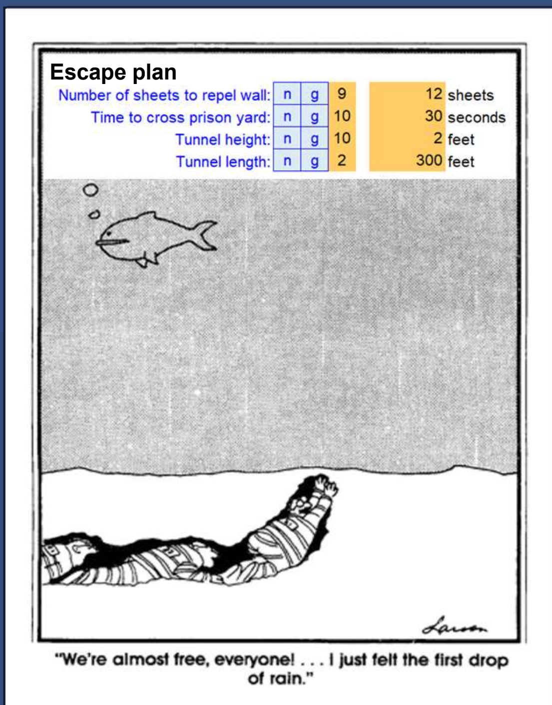
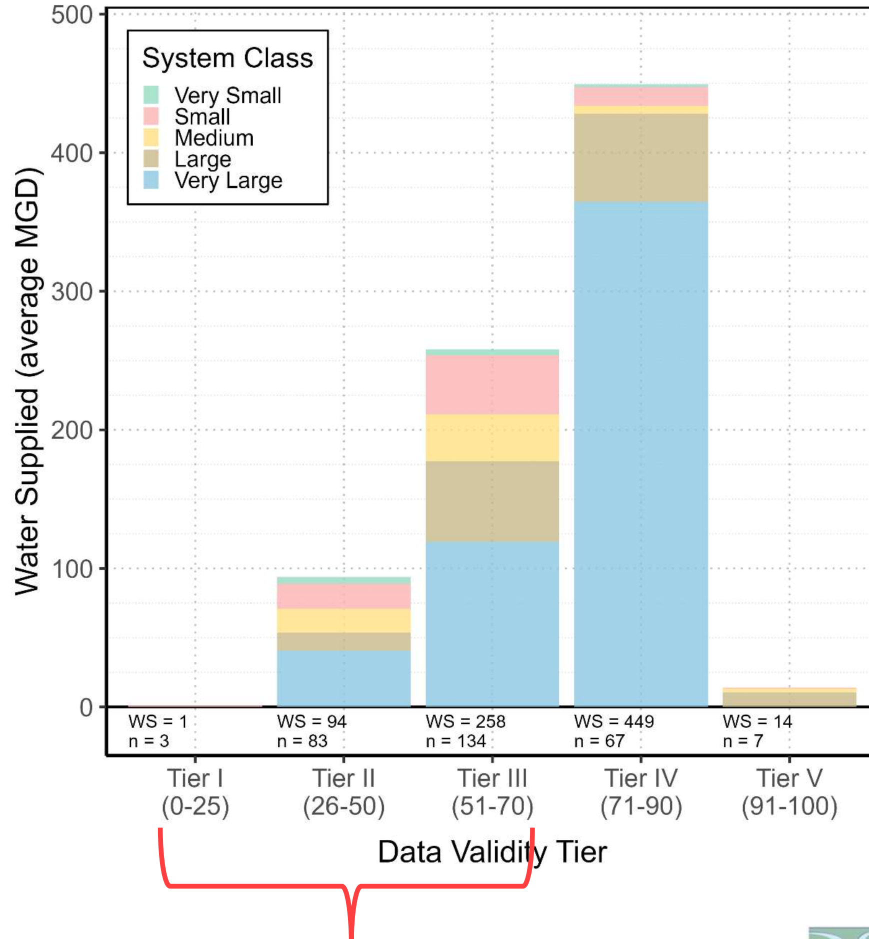
“Are you sure?”



CY2024 data “sureness”



There is room for improvement here…
We can look at the Interactive Data Grading response for…

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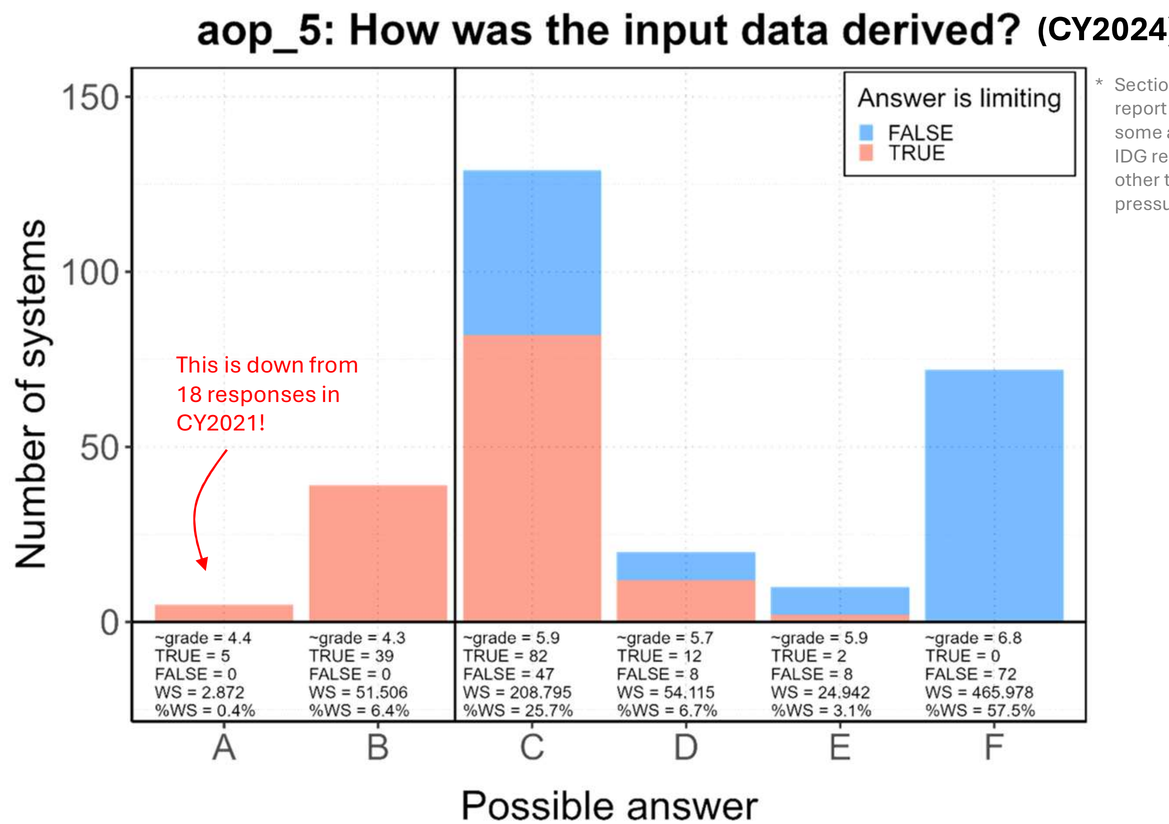
Pressure!



* Section 4.3 of the report dives into some analyses of IDG responses other than pressure.

A Guesstimated

B Loose estimate inferred from field measurements but no analysis nor calculations performed

C Calculated from field data as a simple average

D Calculated from field data as a weighted average compliant with methods described in the M36 Manual

E Derived from hydraulic model where model <u>has not</u> been field calibrated in the last 5 years

F Derived from hydraulic model where model <u>has</u> been field calibrated in the last 5 years

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Real losses

Quoting the 2021 report...

“The volume of real losses has remained relatively constant, with increases in the last two years (2020, 2021).”

Looking at data through 2024...

“???”

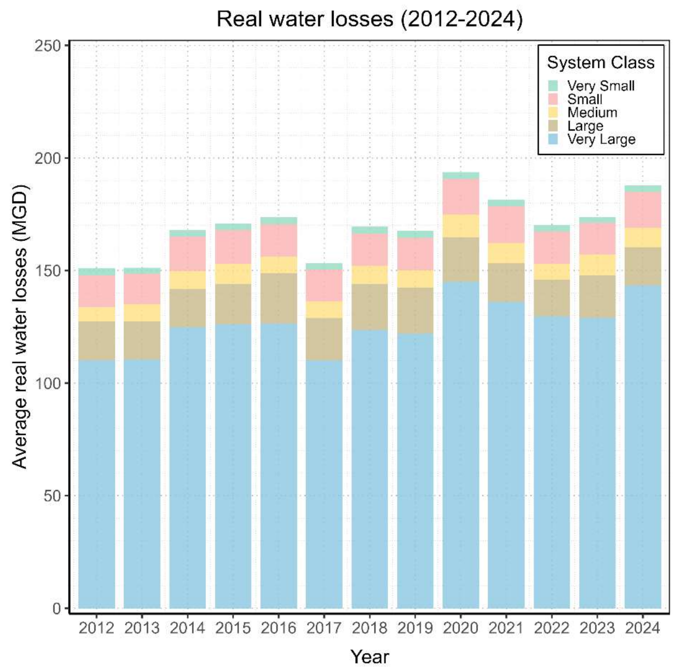

***Table 12:** The annual real water loss volumes by system class previously presented in Table 11, normalized by the 10-year mean and color coded such that values above the mean are red (>1), and values below the mean are blue (<1).*

Year	Very Small	Small	Medium	Large	Very Large	TOTAL
2012	1.05	0.96	0.80	0.93	0.88	0.89
2013	0.95	0.91	0.94	0.92	0.88	0.89
2014	1.03	1.03	0.98	0.92	0.99	0.99
2015	0.96	1.03	1.10	0.97	1.00	1.00
2016	1.08	0.97	0.90	1.21	1.01	1.02
2017	0.95	0.96	0.90	1.02	0.87	0.90
2018	1.04	0.97	1.01	1.09	0.98	1.00
2019	1.06	0.98	0.96	1.11	0.97	0.99
2020	1.00	1.08	1.25	1.08	1.15	1.14
2021	1.07	1.10	1.11	0.93	1.08	1.07
2022	0.97	0.98	0.85	0.89	1.03	1.00
2023	0.87	0.95	1.15	1.03	1.02	1.02
2024	0.96	1.08	1.05	0.92	1.14	1.10

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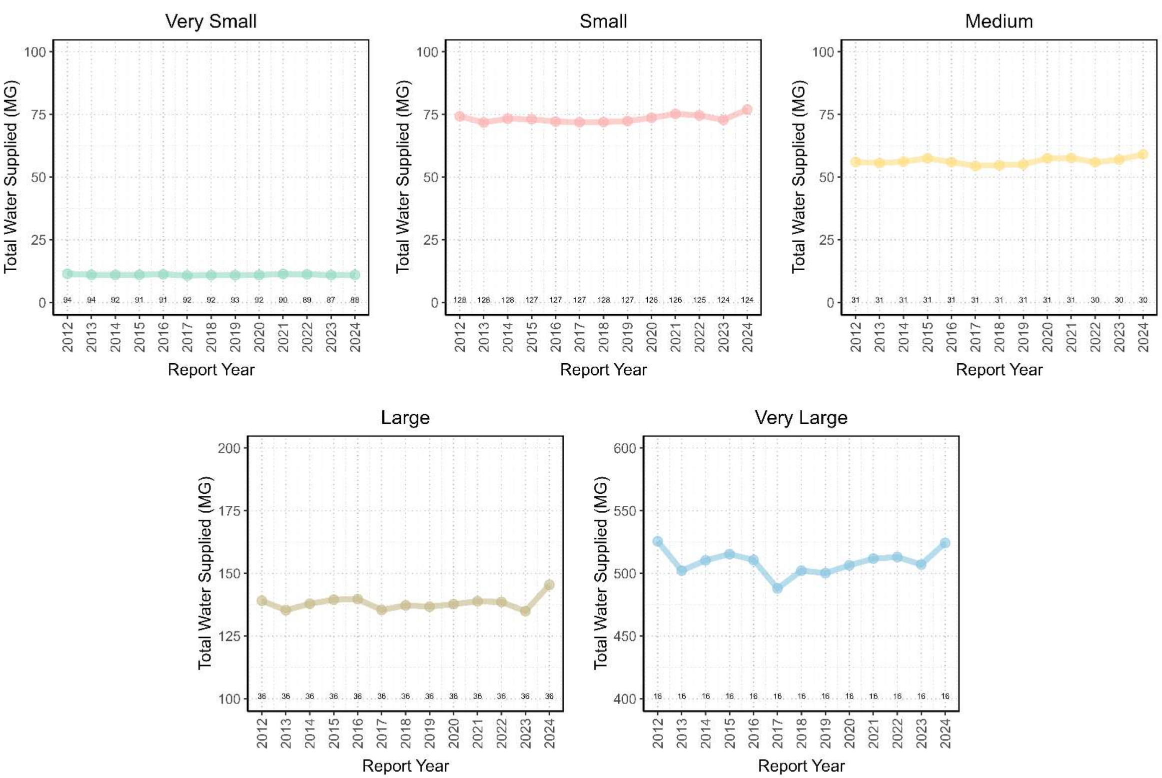
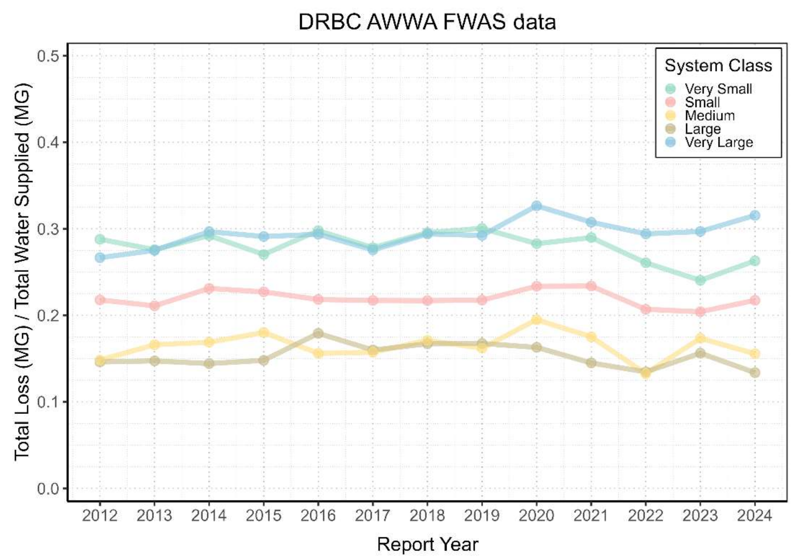
Start at the beginning...

Total Water Supplied by System Size



Percentages



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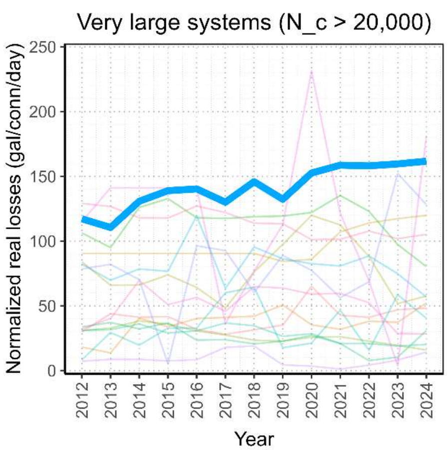
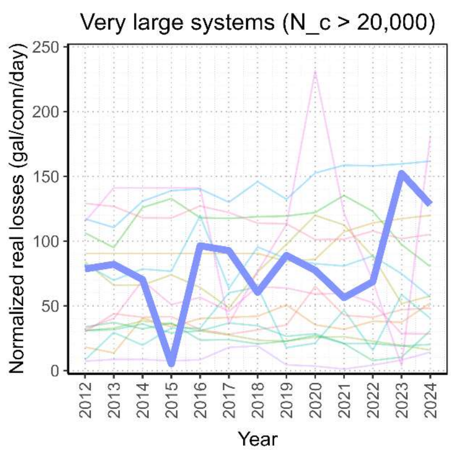
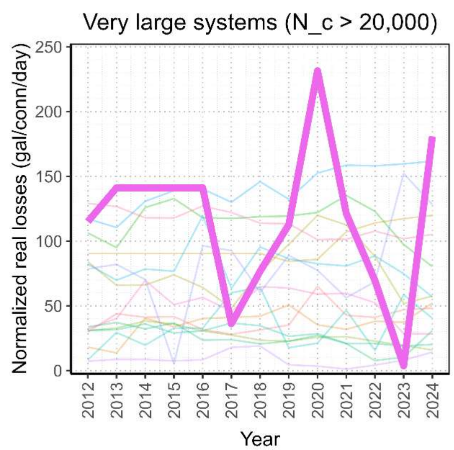
Look at the Key Performance Indicators (KPIs)



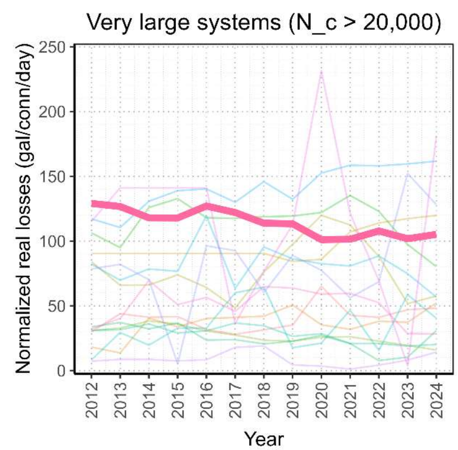
One of the largest systems reporting a steady increase in normalized real losses from about 110→150+ gcd over 13 years



Another system which in the last 2 years has gone from <100 gcd to ~140-150 gcd



An example of a system which has apparently had issues with reporting consistency. Known staff turnovers in recent years



An example system reporting gradual decreases in real loss KPI from about 130 →100 gcd

Urban centers with older infrastructure have unique challenges to overcome

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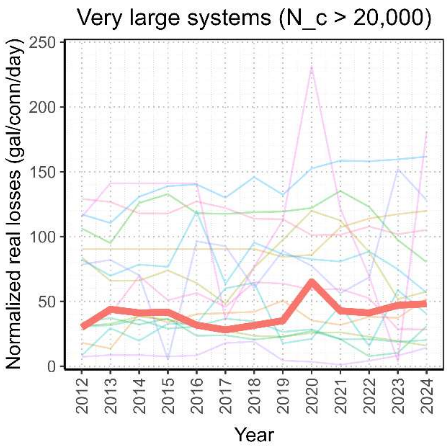
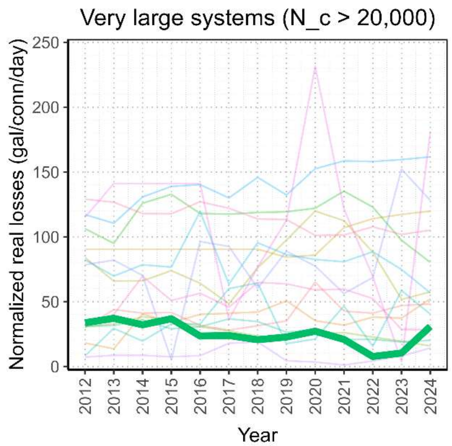
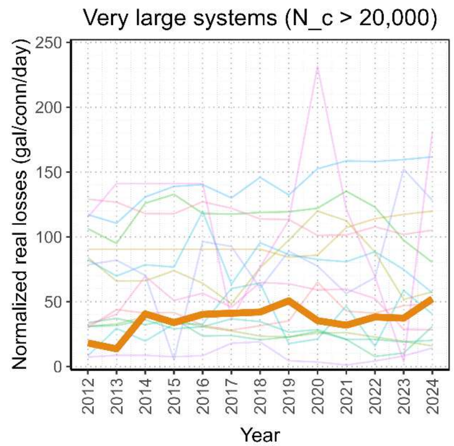
Look at the Key Performance Indicators (KPIs)



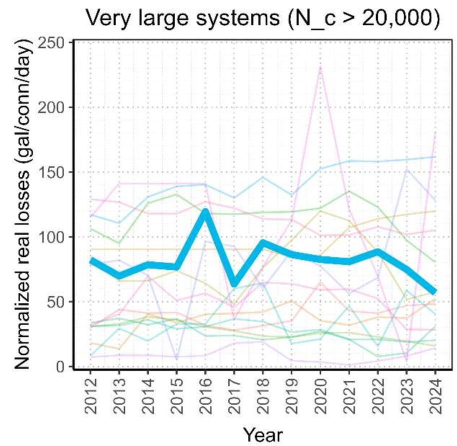
One of the largest privately owned and operated systems reporting *slight* gradual increases in normalized real losses.



Another private system which has helped with conjunctive use to alleviate dependance on groundwater in suburban areas



An example of a private water system which has remained relatively constant at a real loss metric of about 40-50 gcd for 10 years.



A private system operating around 80-90 gcd since 2018, possibly trending down to a reported ~60 gcd in 2024.

Many of these systems serve suburban areas and likely also have newer infrastructure

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Section 6

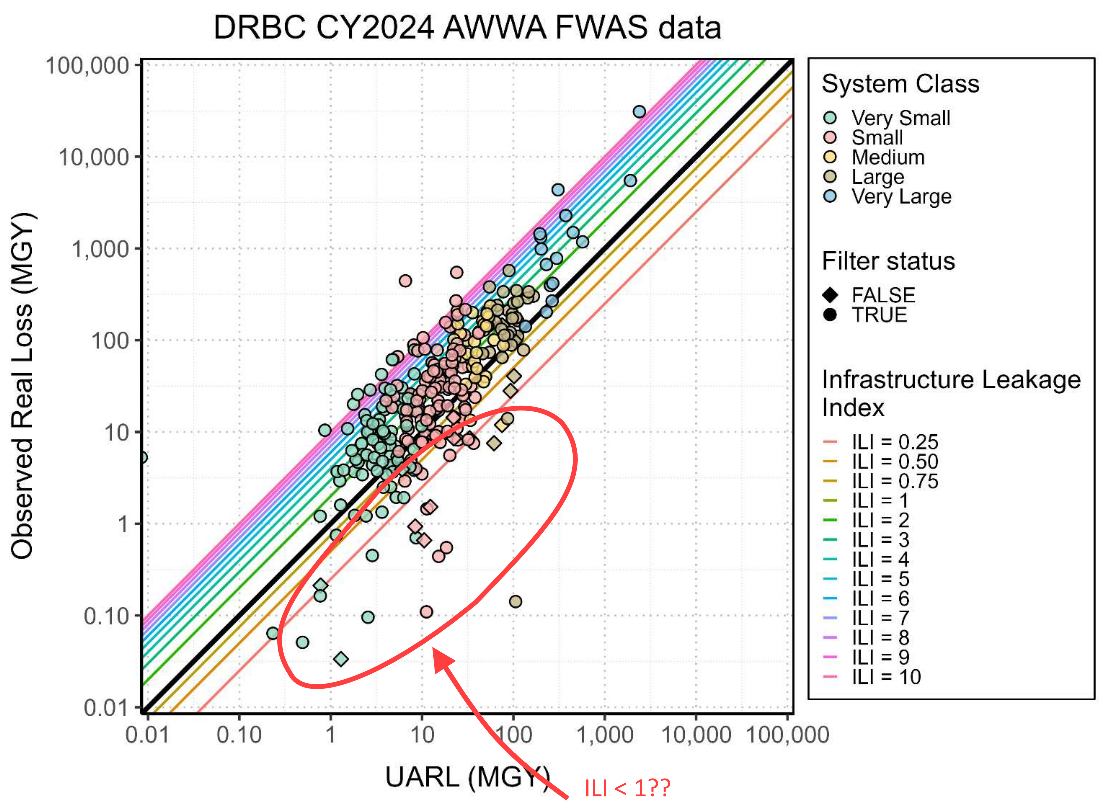
Real Loss Reduction Potential Analyses

Real Loss Reduction Potential: ILI Analysis

- Performed a Frontier Analysis as well – comparable results, more computational effort
- Cross-plot: Real Loss vs. UARL
- Each system decreases losses vertically to meet different ILI thresholds
- Economic Level of Leakage (ELL) would greatly improve overall estimates – all systems decreasing to ILI=1 is not realistic

----

- All above ILI=10 reduce to ILI=10 → 20 MGD
- All above ILI=3 reduce to ILI=3 → 92 MGD
- All above ILI=1 reduce to ILI=1 → 144 MGD



ILI < 1??
Likely a function of (1) less-than-reliable data, or (2) below recommended limits on ILI and could benefit from SCF

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Real Loss Reduction Potential: ILI Analysis

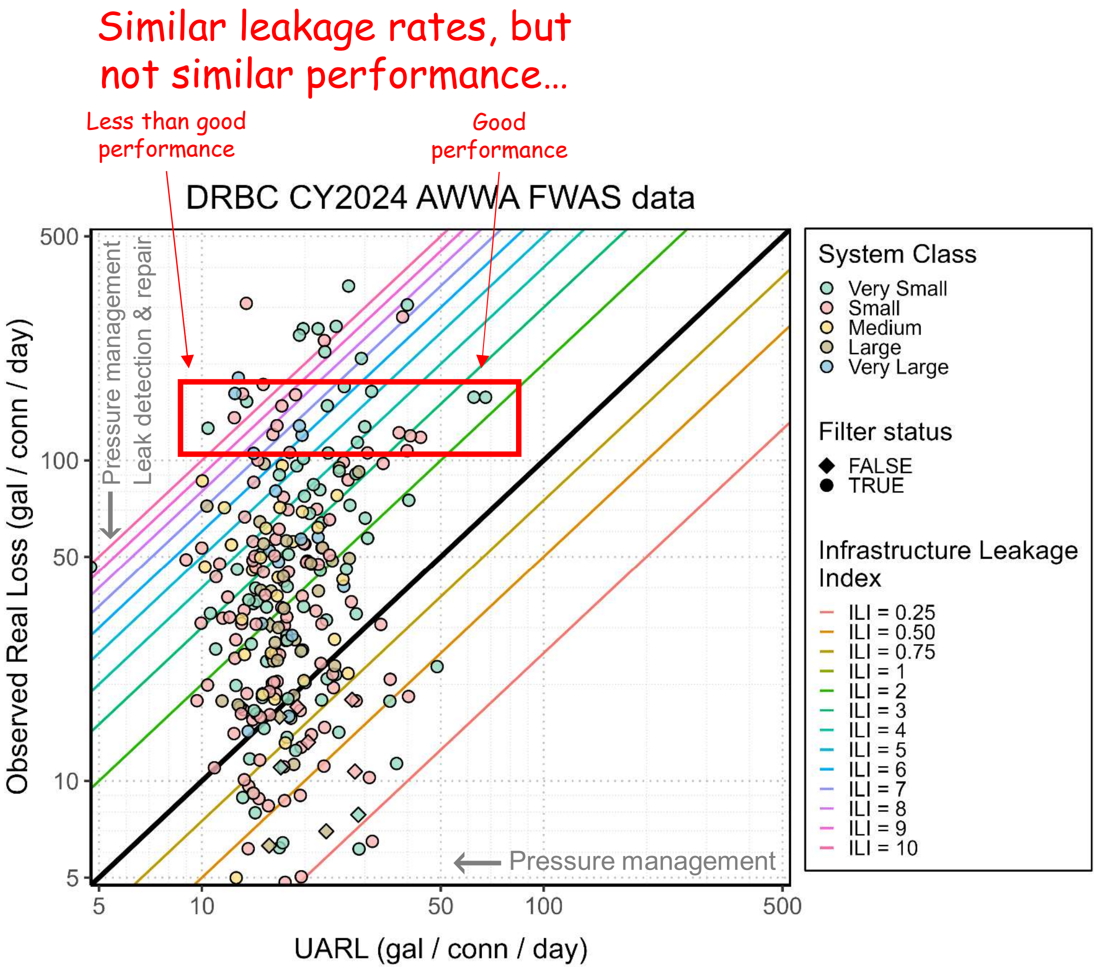
Can also be viewed as unit rates

- Incorporates the Unit Rate of Real Losses (gcd)
- Possibly more versatile for systems, managers and planners
- Divide the UARL equation by N_c

$$UARL\ (gcd) = \left(5.41\,\frac{L_m}{N_c} + 0.15\ + 7.5\ L_p\right) \times P_{AO}$$

Musing on P_{AO} and ILI

Pressure and leakage are directly related (i.e., orifice equation) – decreases in P_{AO} should be reflected in leakage, adjusting ILI accordingly



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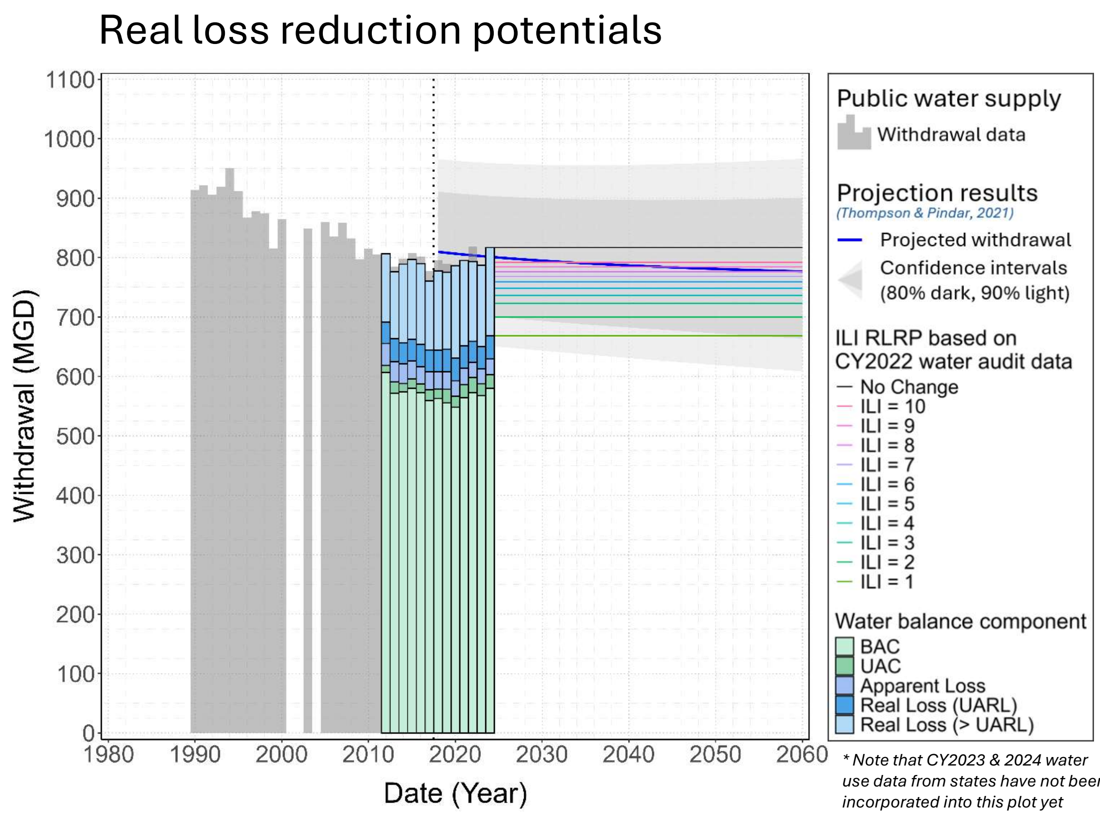
RLRP: So what?

> "The decrease in projected withdrawals (based on current operational trends) is equivalent in magnitude to systems above ILI=7 reducing to ILI≈7"

- There is room for improvement e.g. ELL are not included in assessment. ILI=1 not a realistic scenario and ELL analyses may help improve understanding.
- Is it possible the projection may reach an inflection point? Continued population growth outweighs reductions?



* Note that CY2023 & 2024 water use data from states have not been incorporated into this plot yet (grey bars)

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What if the Drought of Record happens again?

Why is this important?

2024 (“Normal” flow) | **Delaware River near Trenton, New Jersey** | **1963 (Drought of Record)**

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We never know the Worth of Water, till the Well is dry.

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DRBC website

DRBC audit program

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