

**UPDATE:**

Water Audit Trends in the Delaware River Basin: 2012-2021

# Water Management Advisory Committee (WMAC)

Sara Sayed

Michael Thompson, P.E

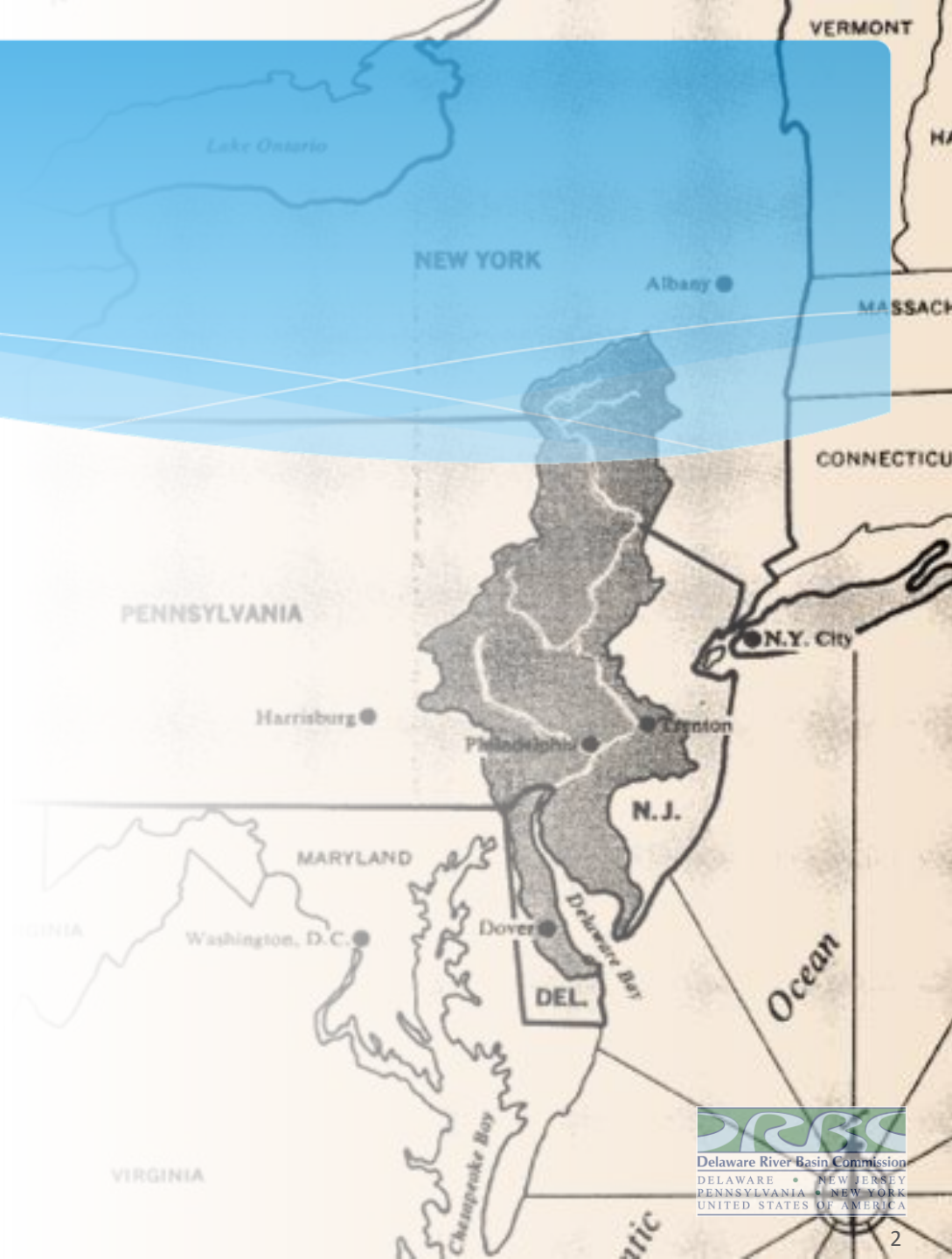
February 8, 2023

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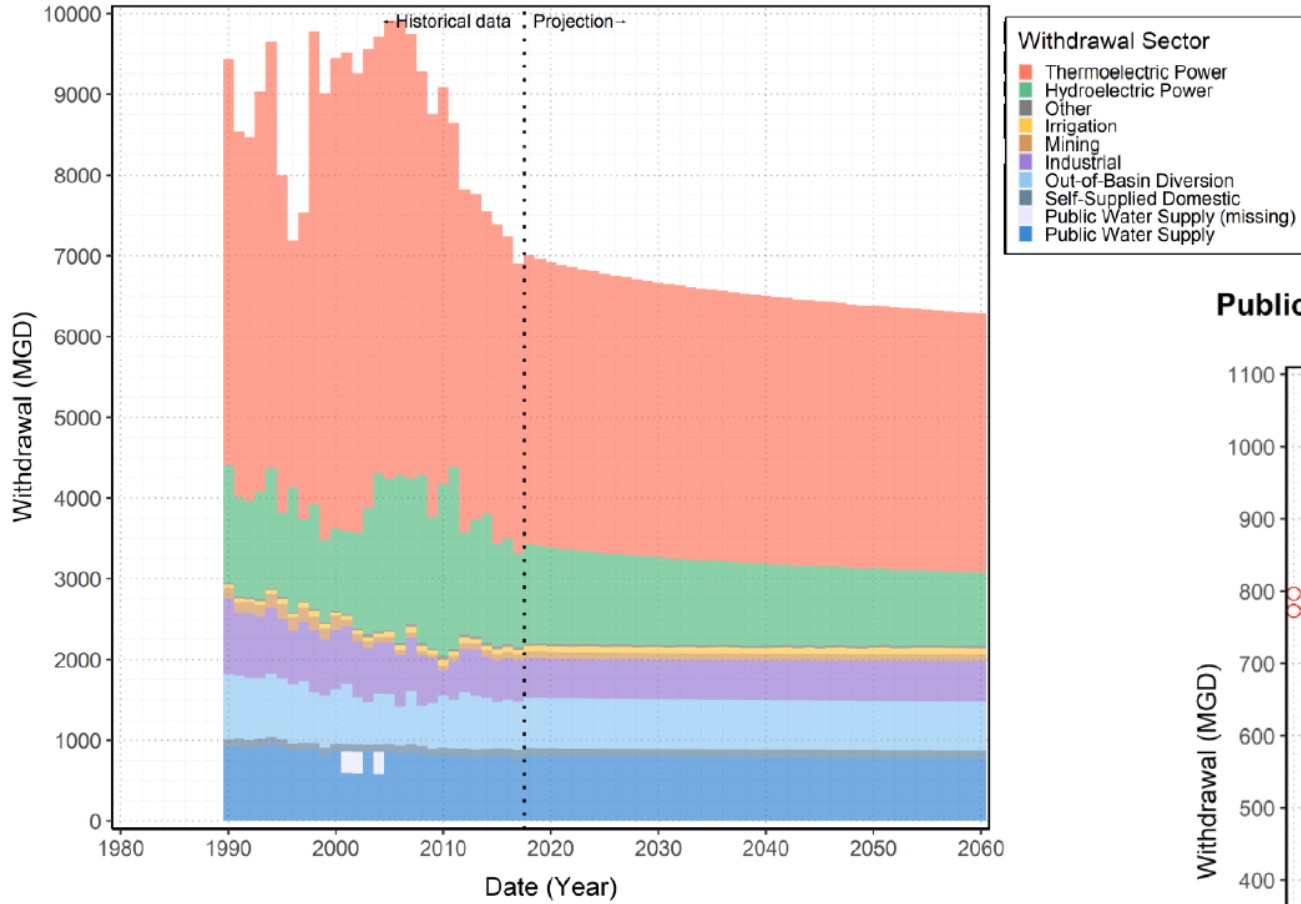


# Outline

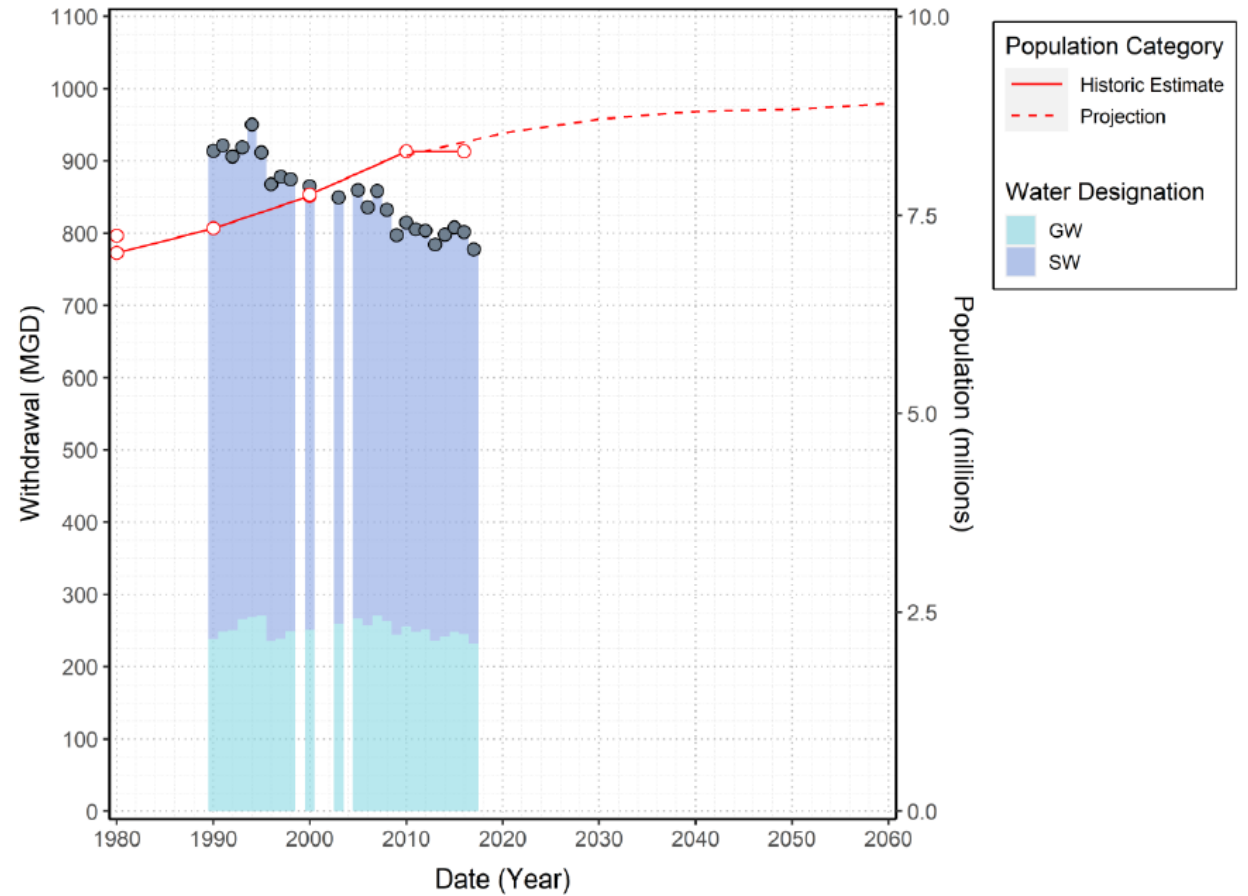
1. Background
  - a. *Water Loss Control: Historical Context*
  - b. *Water Audits in the Delaware River Basin*
2. Extent of data collected by DRBC
3. Previous DRBC publications
4. Summary of CY2021 water audits
5. Planned trend analyses



Historical and projected water withdrawals from the Delaware River Basin



Public water supply withdrawals from the Delaware River Basin with comparison to the in-Basin population



# 1a. Water Loss Control: Historical Context

## (Brackett, 1904) J. NEWWA

*Report On The Measurement, Consumption and Waste of Water Supplied to the Metropolitan Water District*

- Data on towns recently 100% metered
- Quantify water losses via meter calculations
- Meters only been used “but a few years”, error not more than 2-3%
- Conclusion: “a large percentage of water delivered into the mains from the reservoir or pumps is **unaccounted for** by the meters.”

## (Hazen et al., 1916) NEWWA Committee on Meter Rates –

- *Analysis on the “Amount of Water Not Accounted For”*
- *Assessed 35 systems across the country*
- *“The water not accounted for averaged 27.0 per cent. of the total output.”*

## (Metcalf et al., 1912) NEWWA Committee of Water Consumption

### **%UFW becomes an accepted indicator**

“In general, it may be said that if, in a well-metered system, the water-unaccounted-for does not exceed 25 per cent, of the total pumpage, the practice is good.”

### **MORE RESEARCH!**

- **(Howson, 1928)** 44 systems, %UFW of 26.5%, or approximately 31 gallons per capita per day unaccounted for
- **(Mabee, 1928)** 121 cities, %UFW averaged 24.72%
- **(Whitman, 1932)** 12 cities, %UFW averaged 25%

## **AWWA “Water Work Practice”** 1926 Textbook

“‘Water unaccounted for’ is that portion of the water flowing into a distribution system which is not delivered to the consumers.”

# 1a. Water Loss Control: Historical Context

**(Case, 1950)** “No specific percentage of unaccounted-for water can be regarded as satisfactory for all water systems... Many factors must be considered before it can be said that the unaccounted-for figure is too high or too low.”

**(Cook, 1939)** “The term “unaccounted for water” means but little, as it is too easy, with present day methods, to account for water...”

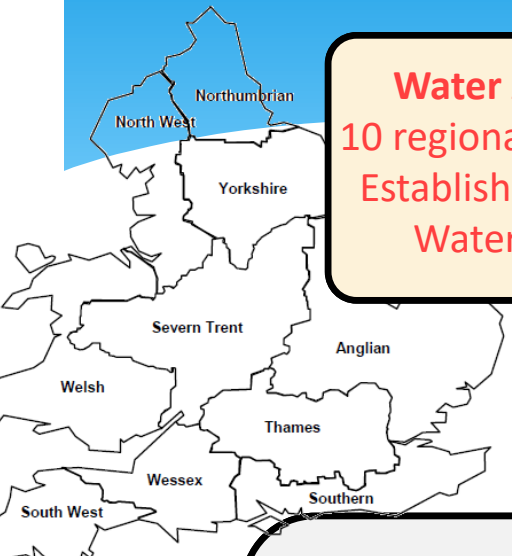
**(Haydock, 1947)** “Unaccounted-for water means different things to different people... In a completely metered system, unaccounted-for water can therefore be described as **nonrevenue-producing water.**”



## **Problems with %UFW:**

1. Components of UFW can be accounted for
2. Many measures for a percentage – %UFW is a percentage of what?
3. Total supply contains UFW... therefore 30%UFW → 10%UFW ≠ 20% less UFW
4. Comparison between systems not equivalent, for example:
  - 2 systems with 1,000 connections & loss = 50 gal/conn/day [gcd]
  - System-A average demand of 150 gcd, the %UFW = 33% (50/150).
  - System-B average demand of 200 gcd, the %UFW = 25% (50/200).
  - Same level of leakage efficiency (50 gcd), System-B seemingly performs better using a percent based indicator simply because each person uses more water (or has a high-use industrial customer).

# 1a. Water Loss Control: Historical Context



**Water Act 1973:**  
10 regional authorities  
Established National  
Water Council

**Water Act 1989:**  
privatized water industry  
(authorities -> companies)  
create National River Authority  
which were passed the power of licensing  
abstractions -> NRA

(NRA, 1992): “The NRA will not normally grant further abstraction licenses for additional water ...unless leakage levels are at, or steps have been taken... to achieve, the economic level by the methods set out in Technical Report No. 26”

**UK National Water Council - 1980**  
“Leakage Control Policy and Practice”  
(aka Report 26)

- Two methods to calculate leakage via estimating ‘unmetered’ water (UFW). Supported two metrics:
  - Urban: gal / property / hour
  - Rural: gal/ mile of main/ hour
- Showed leakage control could be “cost-effective”

**Water Act 1983:**  
Abolished National Water Council



1988-92 drought & public pressure / focus on water losses

**1991-1994 UK National Leakage Control Initiative**  
“Managing Leakage” series of 8 reports to update the 1980 “Report 26”

- Developed a Water Balance & terminology
- Burst and Background Effects (BABE)

DISTRIBUTION INPUT (DI)				
WATER TAKEN (WT)			DISTRIBUTION LOSSES (DL)	
Water Delivered (WD)		DOU	Distribution Losses (DL)	
Water Delivered through Supply Pipes (WDS)		Miscellaneous Water Taken (WTM)		Distribution Losses (DL)
Measured (WDSM)	Unmeasured Use (WDSU)	Unmeasured Supply Pipe Losses (WDSL)	Miscellaneous Water Taken (WTM)	Distribution Losses (DL)

Figure 4.8 Glossary of Terms (from ‘Managing Leakage’)

# 1a. Water Loss Control: Historical Context

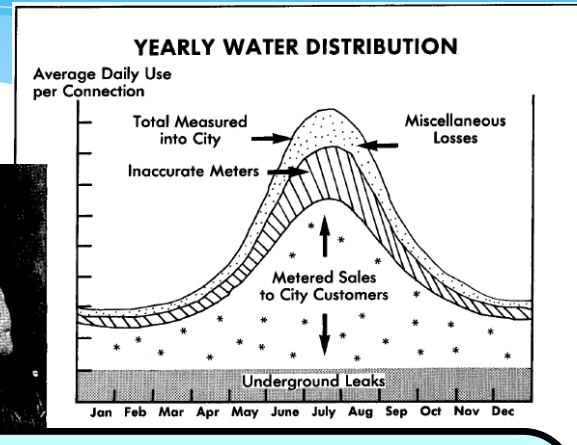
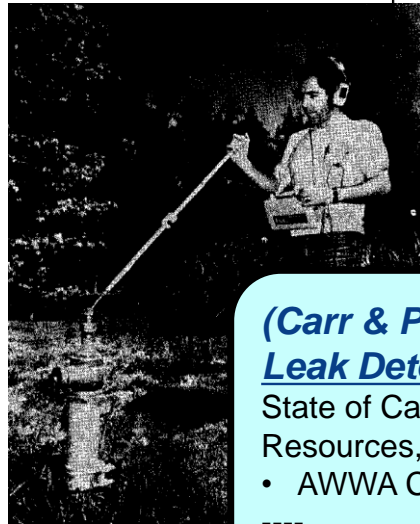
AWWA national survey of water works and subsequent analysis of data (every 5-years)

## A Statistical Analysis of Water Works Data for 1945

By G. J. Schroepfer, A. S. Johnson, H. F. Seidel and M. B. Al-Hakim

A paper presented on Sept. 1, 1948, at the Minnesota Section Meeting, Winnipeg, Man., by G. J. Schroepfer, Prof. of San. Eng., Univ. of Minnesota; A. S. Johnson and H. F. Seidel, Instructors in Civ. Eng., Univ. of Minnesota; and M. B. Al-Hakim, Graduate Student of San. Eng., Univ. of Minnesota, Minneapolis, Minn.

Year(s) of survey	No. systems
1945	462
1950	416
1955	497
1960	821
1965, 1970	861, 768
1976, 1978, 1980	760, 1350, 1397

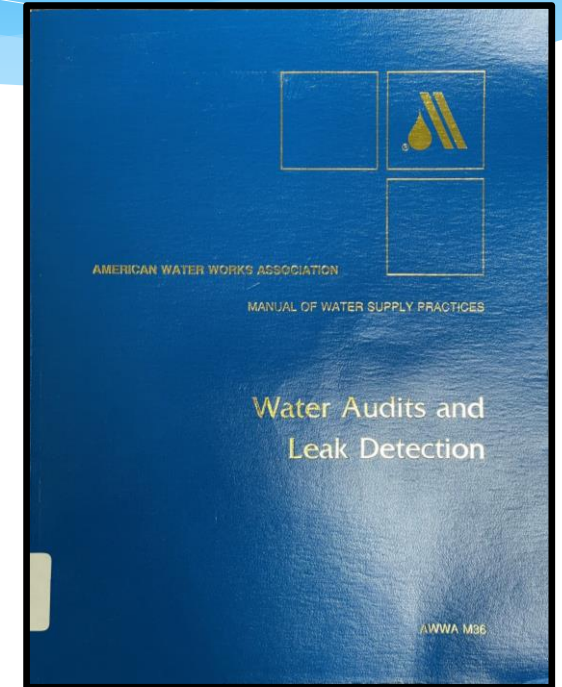


### (Carr & Pike, 1986) : Water Audit and Leak Detection Guidebook

State of California Department of Water Resources, Water Conservation Office

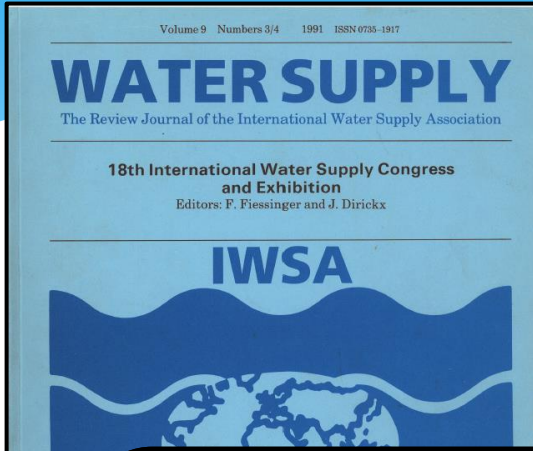
- AWWA California-Nevada Section

- Does not mention UFW
- Introduction to the "Water Audit Worksheet"
- Corrections for meter error & reading lag
- Quantifiably estimates leakage



1990 – AWWA M36 Manual

# 1a. Water Loss Control: Historical Context



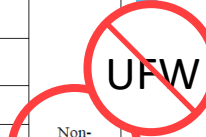
**1991 International Water Supply Association (IWSA<sup>1</sup>) Report:**  
 “Report on Un-accounted for Water and the Economics of Leak Detection”  
 (Cheong, 1991)

Identifies problems and unnecessary misunderstandings arise due to the differences in definition & calculation of UFW

**1996 IWA Operation and Maintenance Committee Task Force**

- (1) prepare a recommended basic standard terminology for calculation of real and apparent losses
- (2) review and recommend preferred performance indicators for international comparison of losses

A	B	C	D	E
System Input Volume	M <sup>3</sup> /year	Billed Authorised Consumption	Billed Metered Consumption (including water exported)	Revenue Water
		Unbilled Authorised Consumption	Billed Unmetered * Consumption	M <sup>3</sup> /year
Water Losses	M <sup>3</sup> /year	Apparent Losses	Unbilled Metered Consumption	Non-Revenue Water**
		Real Losses	Unbilled Unmetered Consumption	
M <sup>3</sup> /year			Metering Inaccuracies	
			Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	
		M <sup>3</sup> /year		M <sup>3</sup> /year



2

(Lambert et al, 1999)

A review of performance indicators for real losses from water supply systems

A. O. Lambert\*, T. G. Brown†, M. Takizawa‡ and D. Weimer§, \*International Water Data Comparisons Ltd; †AWWA, North American Representative to UFW Task Force; ‡Tokyo Metropolitan Waterworks Japan; and §Neckarwerke Stuttgart AG, Germany

$$U\text{ARL} = (5.41 L_m + 0.15 N_c + 7.5 L_c) \times P \times 365$$

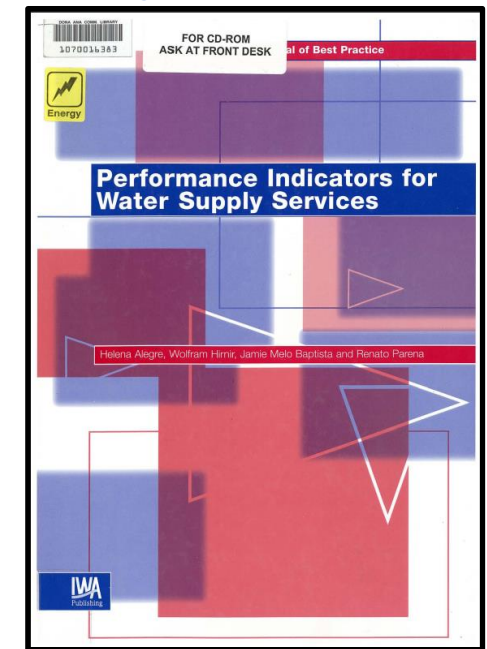
$$L_c = N_c * L_p$$

$$I\text{LI} = C\text{ARL} / U\text{ARL}$$

where,

- U<sub>ARL</sub> = unavoidable annual real losses.....gallons per year
- C<sub>ARL</sub> = current annual real losses .....gallons per year
- I<sub>LI</sub> = infrastructure leakage index.....dimensionless
- L<sub>m</sub> = length of mains.....miles
- L<sub>p</sub> = average length of customer service connection piping feet
- N<sub>c</sub> = number of service connections .....dimensionless
- L<sub>c</sub> = total length of customer service piping.....miles
- P = average operating pressure .....psi

(Algeres et al, 2000)



<sup>1</sup>The International Water Supply Association (IWSA) formally merged with International Association on Water Quality (IAWQ) in 1999 to form the International Water Association (IWA), after ongoing discussions since 1996 (Reiter, 2022).



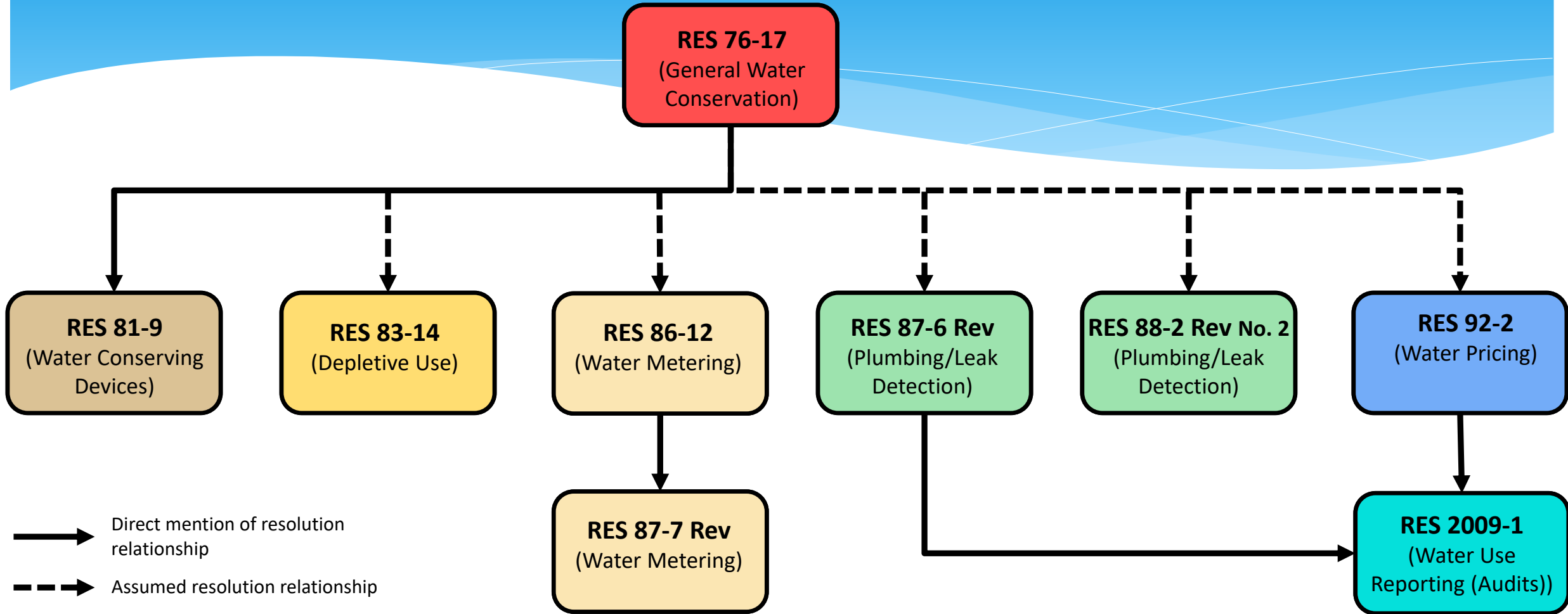
# 1b. Water Audits in the Delaware River Basin

- 1976:** (RES 76-17) Program TO REDUCE WATER USE IN BASIN
- 1981:** (RES 81-9) Information on water conserving devices and procedures
- 1983:** (RES 83-14) Depletive Use reduction during drought
- 1986:** (RES 86-12) Source & Service Metering
- 1987:** (RES 87-6 Rev) Leak Detection & Repair
- 1988:** (RES 88-2 Rev No. 2) Conservation Plumbing Standards
- 1992:** (RES 92-2) Water Conservation Pricing
- 1998:** (RES 98-21) Dissolve GWAC & WCAC, establish WMAC
- 2000:** IWA published “Performance Indicators for Water Supply Services”
- 2009:** AWWA published M36 3<sup>rd</sup> edition with IWA/AWWA Water Audit Methodology
- 2006-09:** Water Loss Accountability (**WMAC involvement**)
- 2009:** (RES 2009-1) Update water code to include water audit reporting
- 2009-11:** “Water Audit” Rule Outreach / Voluntary Implementation (DRBC workshop and webpages)
- 2012:** First year for use of new water audit (AWWA FWAS v4.2) – due in 2013, received 250 reports
- 2015:** AWWA FWAS v.5 required
- 2021:** AWWA FWAS v.6 required – 10 years of audits

**Note: RES 98-21 (1998)**

Dissolves the Ground Water Advisory Committee (GWAC) and the Water Conservation Advisory Committee (WCAC), establishes the Water Management Advisory Committee (WMAC)

# 1b. Water Audits in the Delaware River Basin



# 2. Extent of data collected by DRBC

**Table:** Summary of AWWA FWAS reports submitted to DRBC.

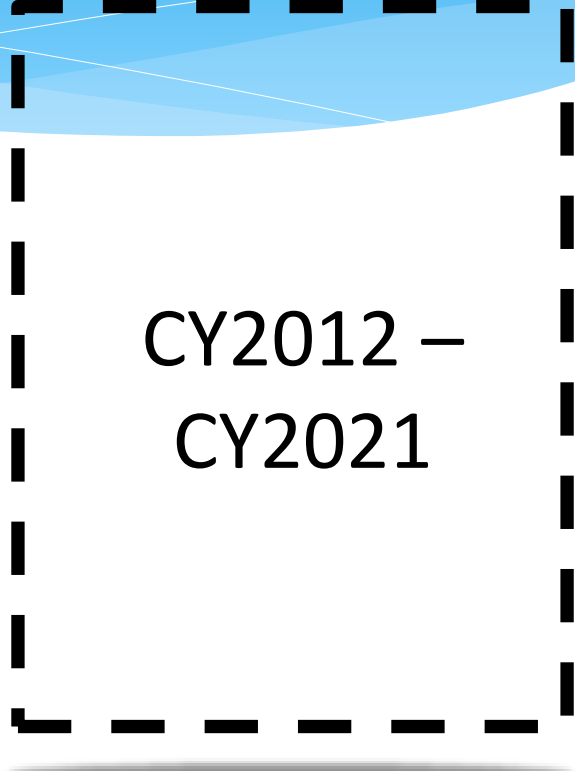
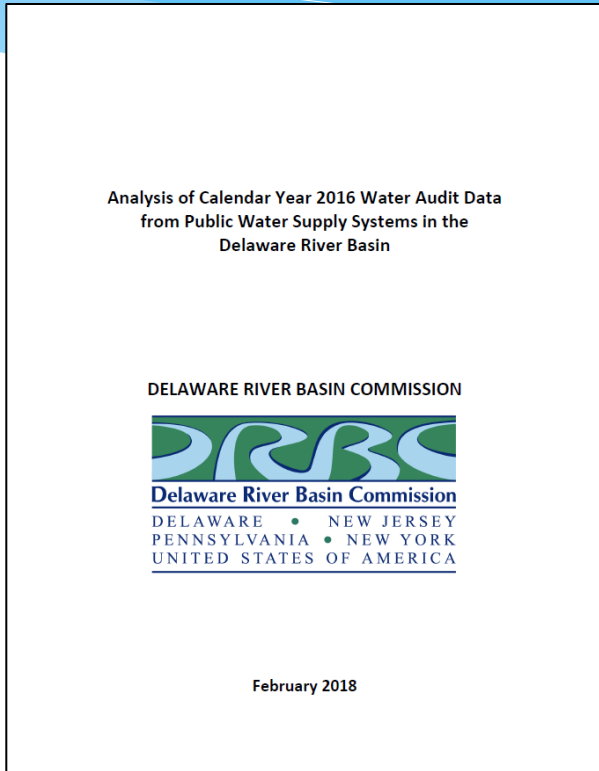
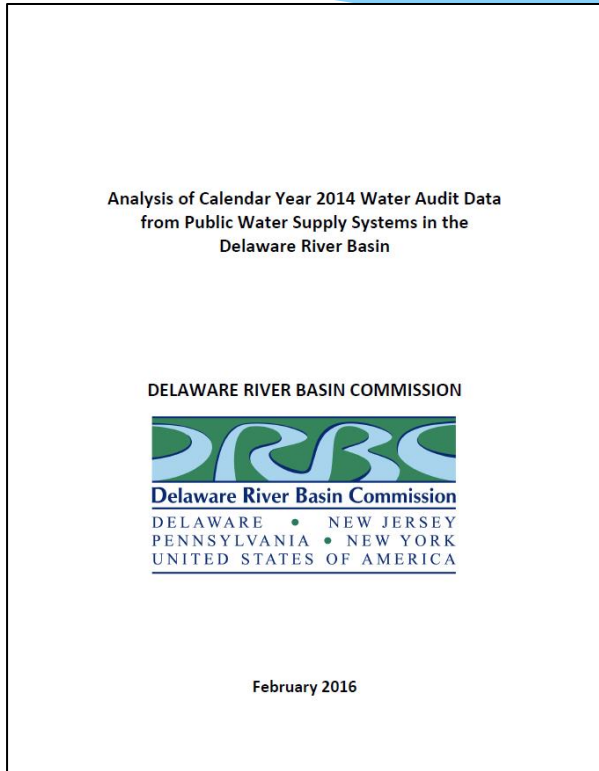
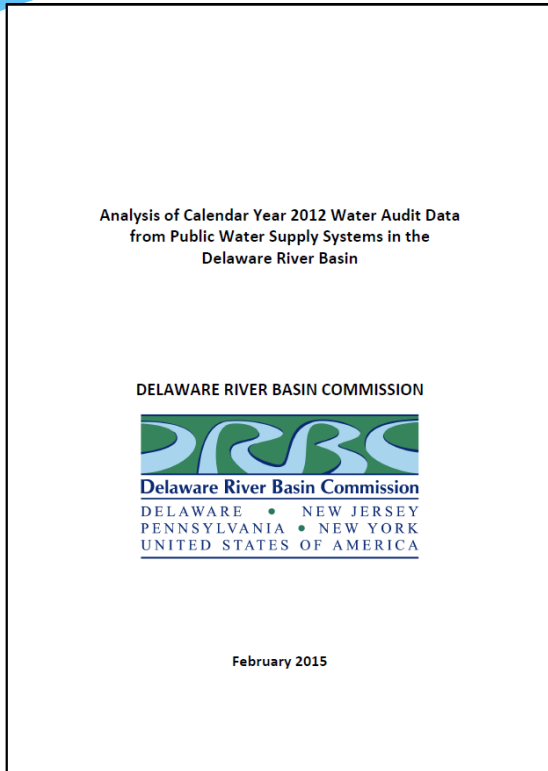
Year	v4.1	v4.2	v5	v6	Received
2012	3	247			250
2013	2	264	3		269
2014	1	97	169		267
2015		7	269		276
2016		1	299		300
2017			302		302
2018			305		305
2019		1	294		295
2020			156	140	296
2021			4	288	292

# 3. Previous DRBC publications

## CY2012 Data

## CY2014 Data

## CY2016 Data



**Link:**

<https://www.nj.gov/drbc/library/documents/wateraudits/CY2012audit-report.pdf> Data

**Link:**

<https://www.nj.gov/drbc/library/documents/wateraudits/CY2014audit-report.pdf>

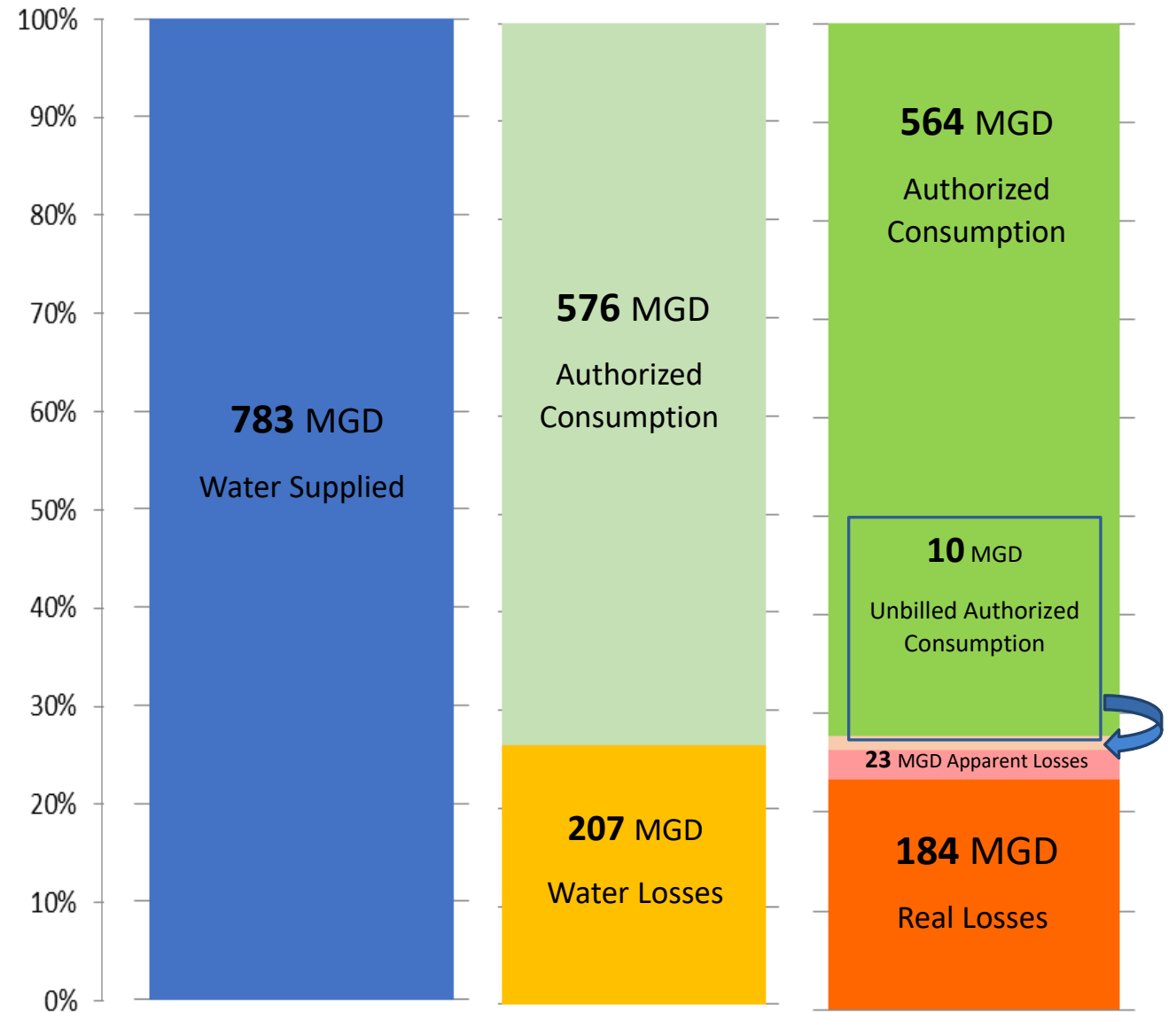
**Link:**

<https://www.nj.gov/drbc/library/documents/wateraudits/CY2016audit-report.pdf>



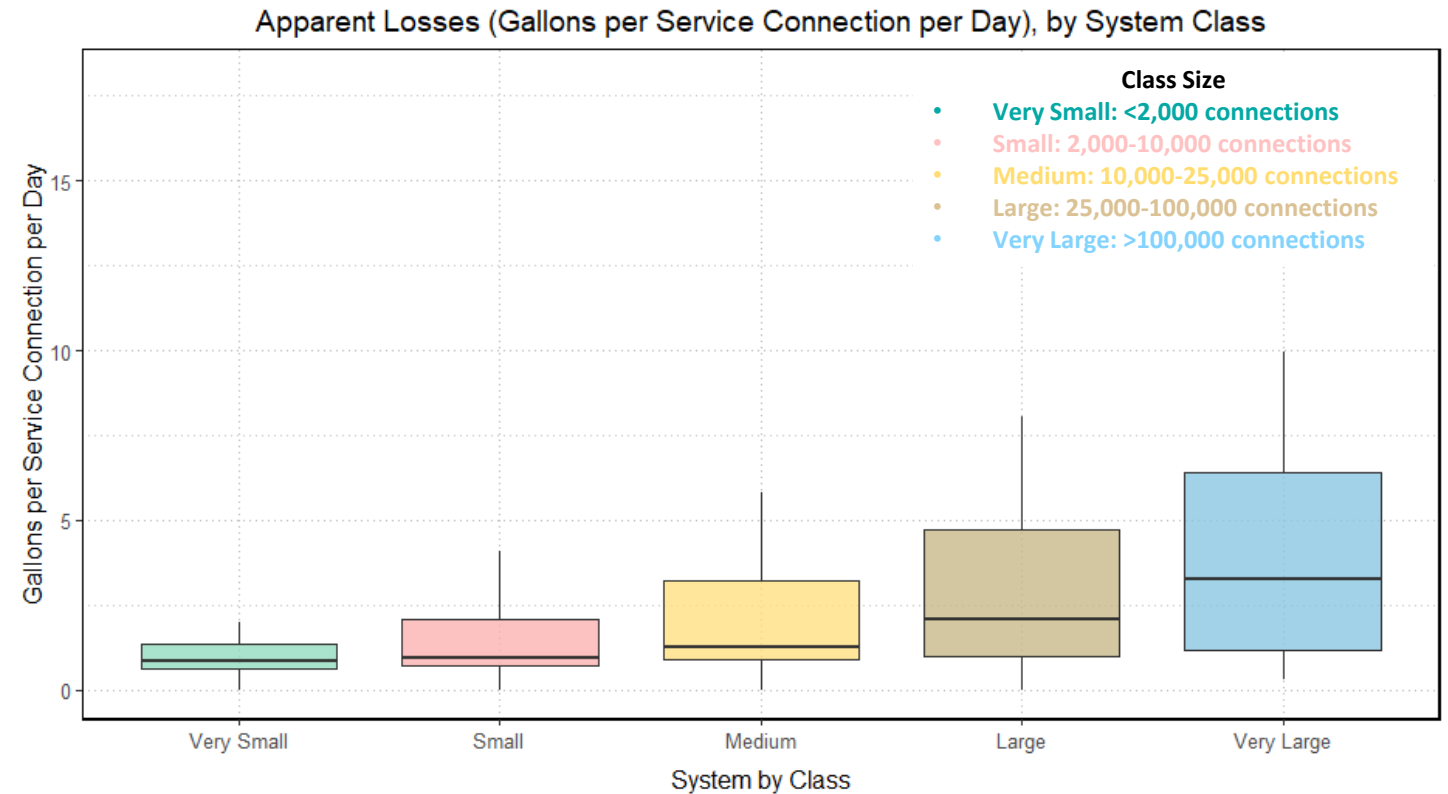
## 4. CY2021 Water Summary

- **304** systems supplying an average of **783 MGD** in the DRB
- **207 MGD total water loss** from distribution systems



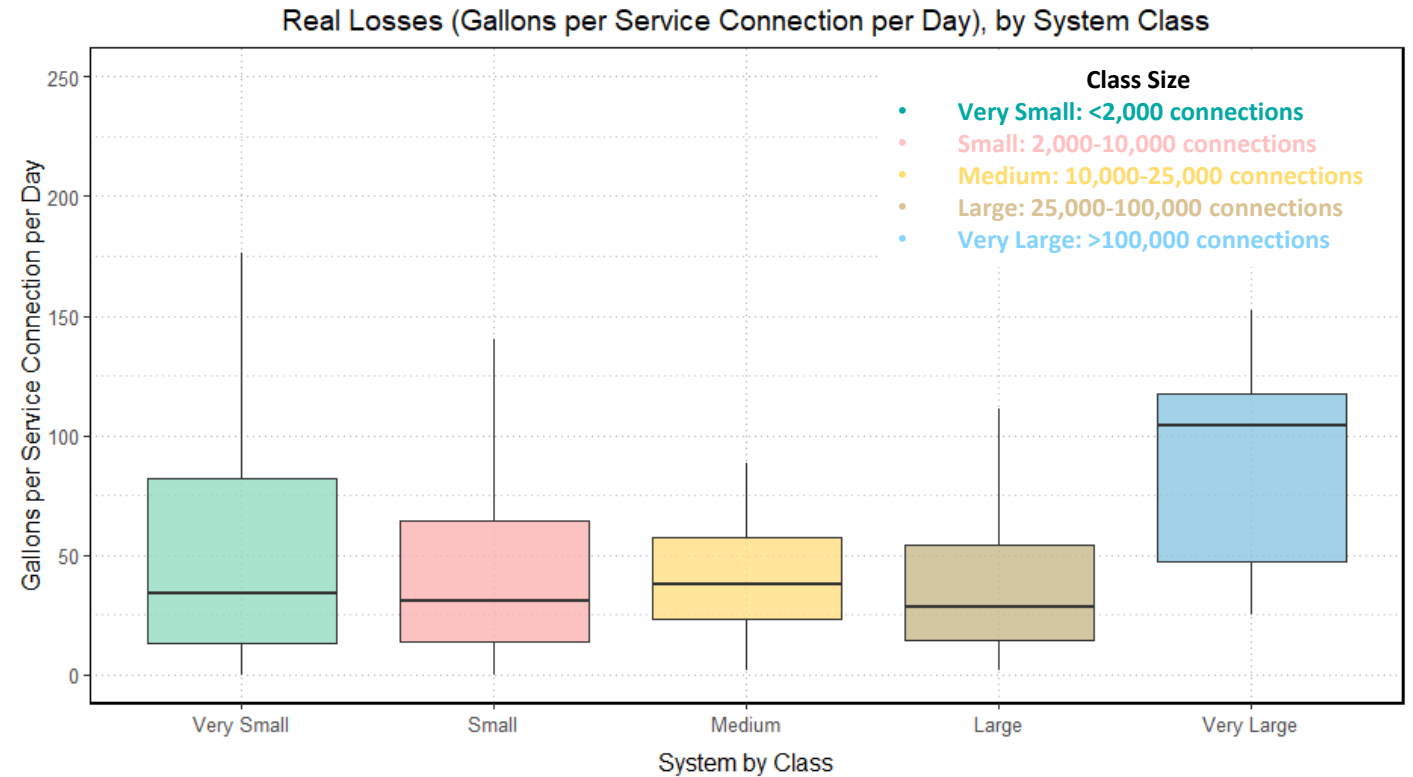
## 4. CY2021 Water Summary

- Apparent losses can come from **customer meter inaccuracies, unauthorized consumption and system data handling errors**
- Highest median apparent loss in very large systems (>100,000 connections)



## 4. CY2021 Water Summary

- Real losses = **physical water losses** from the system
- Highest median real loss occurs in very large systems (110 gal/con/day)
- High real loss is seen all size categories



# 5. Planned Trend Analysis

- DRBC has compiled **10** years of water audits (CY2012-CY2021)
- At this scale, trend work is very limited
  - Most analyses have occurred on a system-by-system level or statewide
- Analysis of 10 years of water audits assess effectiveness of water audit program
- Results of this work to help guide WMAC with next steps in the program
  - Data validation?
  - Reduction potentials?
- Publication anticipated **Q2 2023**

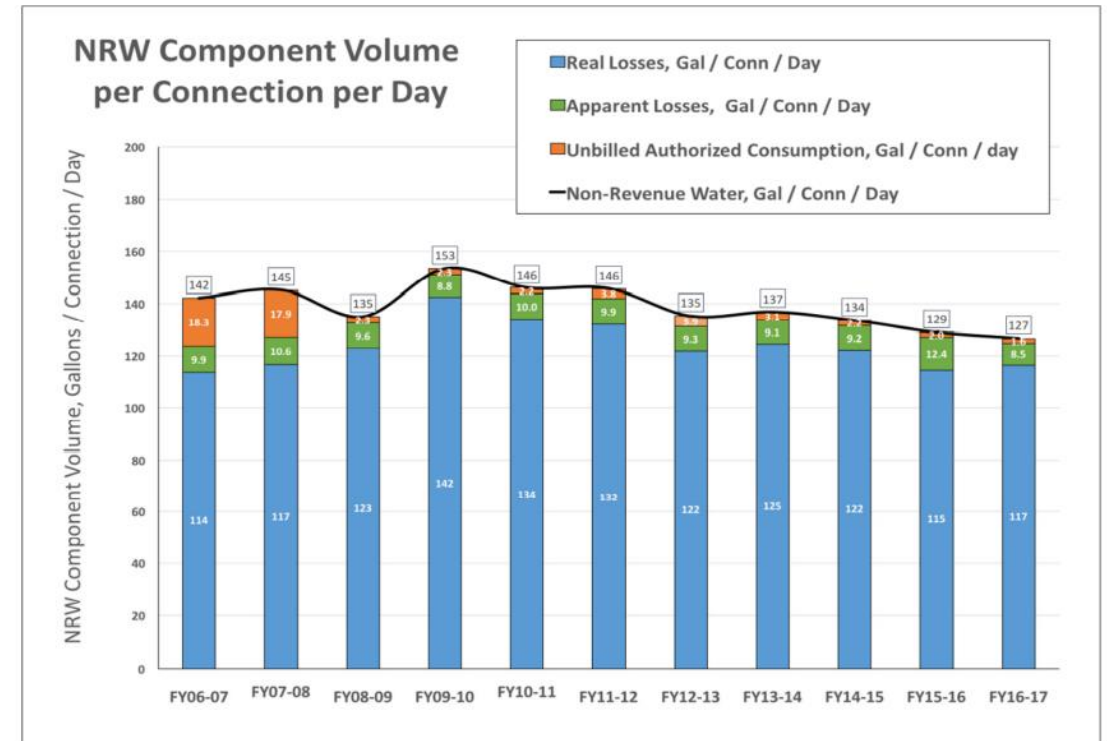


FIGURE 2.4. NASHVILLE MWS NRW COMPONENT UNIT VOLUMES

Adopted from AWWA



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