



Water Loss Levels in Pennsylvania Water Utilities: A Summary of Standardized Water Audit Data

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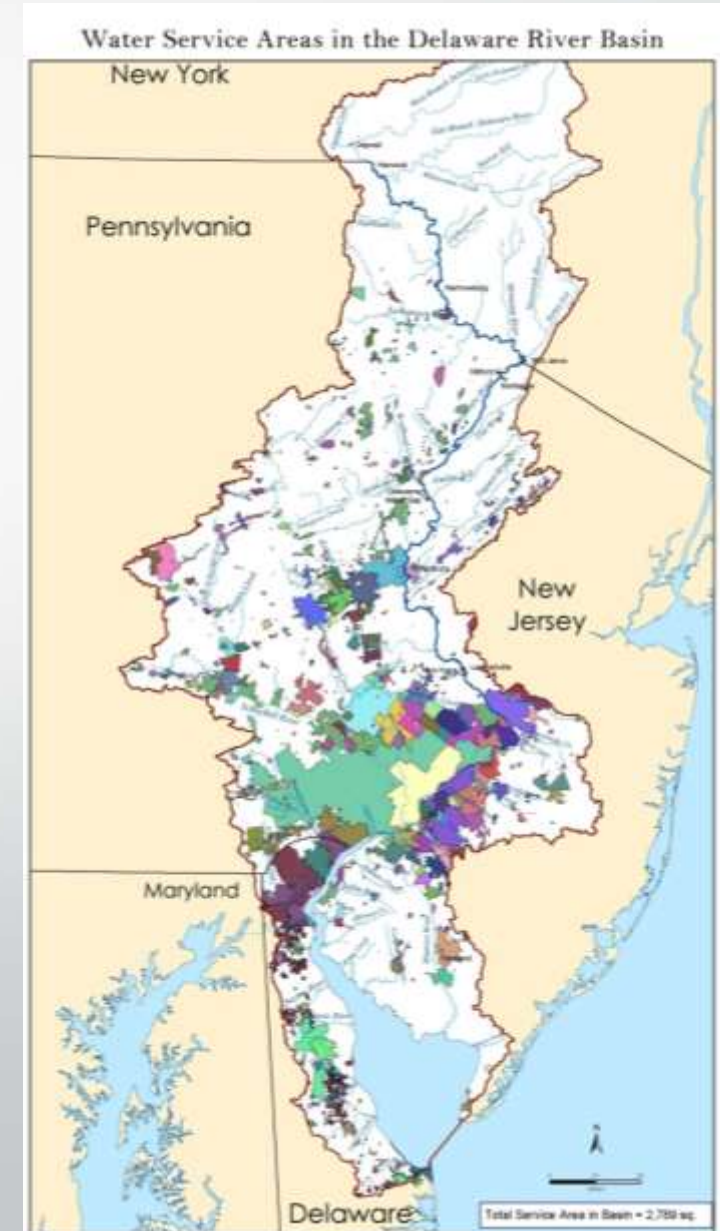
PA AWWA Section Annual Loss Conference 2016

Bethlehem, PA

May 12, 2016

Pennsylvania Water Audit Data Collection

- Delaware River Basin Commission
 - Since 2012
 - Applies to all utilities in the Delaware River Basin
 - Data is Filtered by DRBC Staff
 - Data is assembled in the AWWA Compiler Software
- PA Public Utility Commission
 - Since 2009
 - Applies to privately held water companies
 - Data is available in self-reported form on PUC website
- Combined filtered PUC/DRBC dataset includes **155 utilities** for data from 2013
- No water audit requirement exists for many water utilities in PA




Collecting the Data

AWWA Free Water Audit Software Reporting Worksheet (Top Portion)

The Reporting Worksheet is the primary Data Input Worksheet. Input data on this portion of the Reporting Worksheet include::

- Volumes of supply
- Consumption
- Apparent Loss
- Real Loss is calculated
- Data Gradings



AWWA Free Water Audit Software:
Reporting Worksheet

WAS v5.0
American Water Works Association.
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? Click to access definition

Water Audit Report for: << Please enter system details and contact information on the Instructions tab

+ Click to add a comment

Reporting Year:

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

PLEASE CHOOSE REPORTING UNITS FROM THE INSTRUCTIONS SHEET BEFORE ENTERING DATA

To select the correct data grading for each input, determine the highest grade where the utility meets or exceeds all criteria for that grade and all grades below it.

WATER SUPPLIED

<----- Enter grading in column 'E' and 'J' ----->

Volume from own sources: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	Master Meter and Supply Error Adjustments Pent: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> Value: <input style="width: 50px;" type="text"/>
Water imported: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	<input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> Pent: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> Value: <input style="width: 50px;" type="text"/>
Water exported: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	<input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> Pent: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> Value: <input style="width: 50px;" type="text"/>

WATER SUPPLIED: 0.000

Enter negative % or value for under-registration
Enter positive % or value for over-registration

Click here: ? for help using option buttons below

Pent: 1.25% ? Value:

Use buttons to select percentage of water supplied OR value

Pent: 0.25% ? Value:

0.25% ? Value:

AUTHORIZED CONSUMPTION

Billed metered: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	
Billed unmetered: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	
Unbilled metered: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	
Unbilled unmetered: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	0.000

Default option selected for Unbilled unmetered - a grading of 5 is applied but not displayed

AUTHORIZED CONSUMPTION: 0.000

WATER LOSSES (Water Supplied - Authorized Consumption) 0.000

Apparent Losses

Unauthorized consumption: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	0.000
---	-------

Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed

Customer metering inaccuracies: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	0.000
Systematic data handling errors: <input style="width: 20px;" type="text"/> ? <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/> <input style="width: 20px;" type="text"/>	0.000

Apparent Losses: 0.000

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses: 0.000

WATER LOSSES: 0.000

NON-REVENUE WATER

NON-REVENUE WATER: 0.000

= Water Losses + Unbilled Metered + Unbilled Unmetered

AWWA Free Water Audit Software Reporting Worksheet (Bottom Portion)

Inputs on this portion of the Reporting Worksheet include:

- System Data
- Cost Data
 - System Operating Cost
 - Customer Unit Retail Cost
 - Variable Production Cost
- Data Gradings

SYSTEM DATA

Length of mains:	+ ? 7	100.0	miles
Number of active AND inactive service connections:	+ ? 6	1,000	
Service connection density:	? 10	10	conn./mile main
Are customer meters typically located at the curbside or property line?		Yes	(length of service line, beyond the property boundary, that is the responsibility of the utility)
Average length of customer service line:	+ ?		
Average length of customer service line has been set to zero and a data grading score of 10 has been applied			
Average operating pressure:	+ ? 6	60.0	psi

COST DATA

Total annual cost of operating water system:	+ ? 5	\$1,000,000	\$/Year
Customer retail unit cost (applied to Apparent Losses):	+ ? 7	\$3.50	\$/1000 gallons (US)
Variable production cost (applied to Real Losses):	+ ? 7	\$3,000.00	\$/Million gallons <input type="checkbox"/> Use Customer Retail Unit Cost to value real losses

WATER AUDIT DATA VALIDITY SCORE:

*** YOUR SCORE IS: 60 out of 100 ***

A weighted scale for the components of consumption and water loss is included in the calculation of the Water Audit Data Validity Score

PRIORITY AREAS FOR ATTENTION:

Based on the information provided, audit accuracy can be improved by addressing the following components:

1: Volume from own sources

2: Customer metering inaccuracies

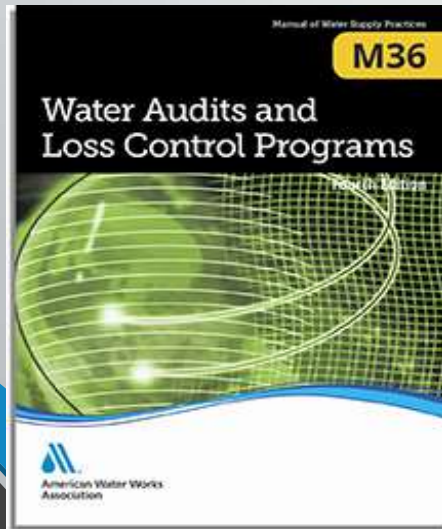
3: Total annual cost of operating water system

AWWA Free Water Audit Software

Data Grading and Validation

Grading reflects the level of proper management of meters and data

New 4th Edition of AWWA M36 Manual provides guidance on grading all components entered into the water audit



AWWA Free Water Audit Software: Reporting Worksheet

Water Audit Report for: << Please enter system details and contact information on the instructions tab >>
Reporting Year: [] []

Please enter data in the white cells below. Where available, metered values should be used; if metered values are unavailable please estimate a value. Indicate your confidence in the accuracy of the input data by grading each component (n/a or 1-10) using the drop-down list to the left of the input cell. Hover the mouse over the cell to obtain a description of the grades

PLEASE CHOOSE REPORTING UNITS FROM THE INSTRUCTIONS SHEET BEFORE ENTERING DATA

To select the correct data grading for each input, determine the highest grade where the utility meets or exceeds all criteria for that grade and all grades below it.

Master Meter Error Adjustments

Category	Input	Grade	Description
WATER SUPPLIED	Volume from own sources:	[?]	n/a (not applicable). Select this grading only if the water utility purchases/imports all of its water resources (i.e. has no sources of its own)
	Water imported:	[?]	1. Less than 25% of water production sources are metered, remaining sources are estimated. No regular meter accuracy testing or electronic calibration conducted.
	Water exported:	[?]	2. 25% - 50% of treated water production sources are metered; other sources estimated. No regular meter accuracy testing or electronic calibration conducted.
WATER SUPPLIED:			
AUTHORIZED CONSUMPTION	Billed metered:	[?]	3. Conditions between 2 and 4
	Billed unmetered:	[?]	4. 50% - 75% of treated water production sources are metered, other sources estimated. Occasional meter accuracy testing or electronic calibration conducted.
	Unbilled metered:	[?]	5. Conditions between 4 and 6
	Unbilled unmetered:	[?]	6. At least 75% of treated water production sources are metered, or at least 90% of the source flow is derived from metered sources. Meter accuracy testing and/or electronic calibration of related instrumentation is conducted annually. Less than 25% of tested meters are found outside of +/- 6% accuracy.
AUTHORIZED CONSUMPTION: [?]			
Enter a positive value, otherwise a default percentage of 1.25% (of billed metered)			
WATER LOSSES (Water Supplied - Authorized Consumption) 0.000			
Apparent Losses			
Unauthorized consumption:		[?]	0.000
Default option selected for unauthorized consumption - a grading of 5 is applied but not displayed			
Customer metering inaccuracies:		[?]	0.000
Systematic data handling errors:		[?]	0.000

Master Meter Error Adjustments: Pcnt: [0.25%] [*] [0] [] Value: []

Master Meter Error Adjustments: Pcnt: [1.00%] [*] [0] [] Value: []

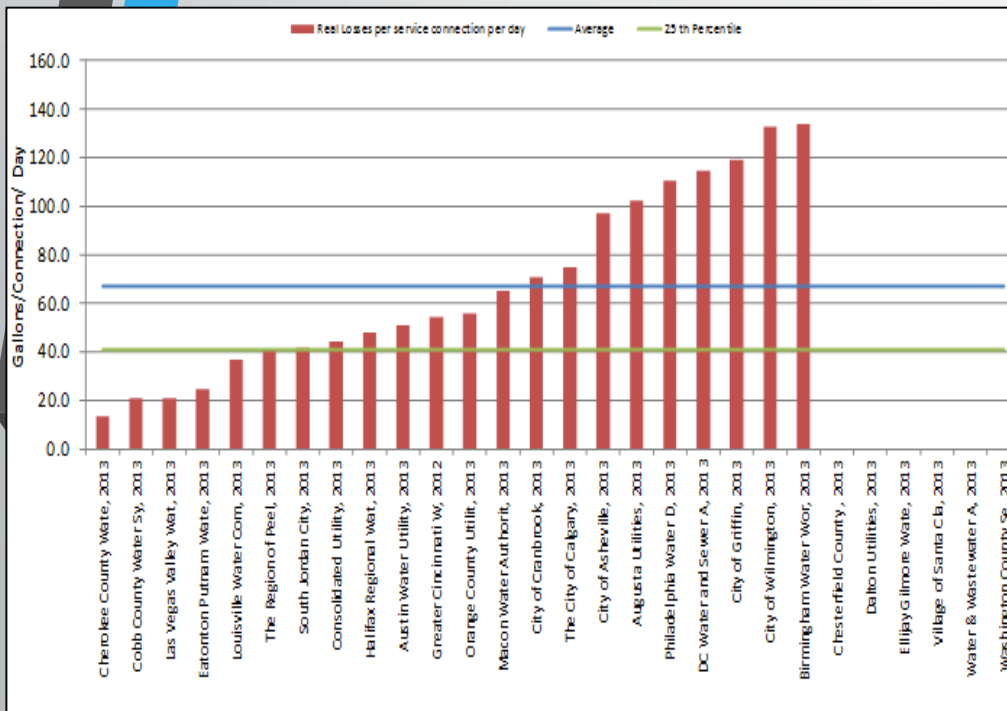
Master Meter Error Adjustments: Pcnt: [0.25%] [*] [0] [] Value: []

Water Audit Data Quality & Validation Levels

- The Data Validation Process includes five levels of data quality which are defined below:
 - **Self-reported** – data has been collected, but not been subject to any in-depth review
 - **Filtered** - have been checked for technical plausibility by employing a screening criteria, such as ILI < 1.0 or > 20.0
- Data validation conducts in-depth review of the data sources and practices of the water utility
 - **Level 1 validated** - focuses primarily on the suitability of the data gradings assigned to the various inputs, with scrutiny on the data inputs to flag gross or egregious errors
 - **level 2 validated** - in-depth investigation of various input data and information of one or more components of the water audit. This is still largely a desk-top activity.
 - **level 3 validated** - Bottom-up review and investigation into a single component or sub-component that collects new or additional data at a field/source level, and provides detailed analysis

AWWA Compiler Software – Easily Assembles Data from Multiple Water Audits into one Spreadsheet that generates Charts

Charts can reveal notable trends



Include on Chart	Run Compiler / View Options Name of City / Utility:	Customer Metering Inaccuracies	Systematic Data Handling Errors	Systematic Data Handling Errors Default Use	Apparent Losses	Real Losses	Water Losses2	Non Revenue Water	Length of Mains	Number of Active and Inactive Service Connection
Yes	City of Asheville	111.220	11.956	Yes	140.844	1,958.789	2,099.633	2,285.180	1236.5	55,256
Yes	Augusta Utilities	202.735	71.603	No	307.087	2,694.886	3,001.973	3,552.620	1213.3	72,235
Yes	Austin Water Utility	828.761	0.001	No	945.924	4,024.607	4,970.531	5,095.921	3707.0	215,960
Yes	Birmingham Water Works Board	557.467	0.001	No	645.000	11,242.159	11,887.159	12,339.569	3941.0	230,018
Yes	The City of Calgary	334.291	82.627	Yes	525.552	8,526.084	9,051.636	9,476.994	3072.7	312,075
Yes	Chesterfield County Rural Water Co., Inc.	6.456	1.598	Yes	9.978	115.171	125.149	130.422	732.0	8,243
Yes	Greater Cincinnati Water Works	308.039	696.500	No	1,096.716	4,873.730	5,970.446	6,972.146	3135.8	246,044
Yes	Consolidated Utility District	17.943	0.300	No	27.152	813.118	840.270	902.268	1301.0	50,510
Yes	City of Cranbrook	0.000	0.000	No	2.798	172.402	175.201	189.193	101.5	6,696
Yes	Cobb County Water System	341.584	16.730	No	404.568	1,347.804	1,752.372	1,764.294	3150.0	178,130
Yes	Dalton Utilities	195.846	15.831	Yes	231.343	1,204.651	1,435.995	1,534.328	1251.0	37,023
Yes	DC Water and Sewer Authority	527.700	1789.500	No	2,449.800	5,621.951	8,071.751	8,748.651	1350.0	134,284
Yes	Ellijay Gilmore Water & Sewer Authority	11.638	1.000	No	15.169	218.215	233.384	283.102	227.0	5,527
Yes	Eatonton Putnam Water and Sewer Authority	2.281	0.511	Yes	5.792	74.506	80.298	101.609	145.0	8,350
Yes	City of Griffin	18.795	1.798	Yes	23.769	510.230	533.999	551.539	212.7	11,733
Yes	Halifax Regional Water Commission	129.981	0.264	No	158.629	1,504.514	1,663.143	1,763.626	1017.2	85,957
Yes	Las Vegas Valley Water District	2638.000	100.000	No	2,998.997	3,025.078	6,024.075	6,030.775	4515.0	397,526
Yes	Louisville Water Company	973.100	150.000	No	1,123.200	4,123.662	5,246.862	7,839.099	4156.0	306,079
Yes	Macon Water Authority	119.744	6.252	No	132.247	1,551.136	1,683.383	1,779.733	1400.0	65,200
Yes	Orange County Utilities Department	104.165	32.920	No	191.107	1,841.418	2,032.525	2,144.747	1745.5	90,402
Yes	Philadelphia Water Department	1490.200	3579.300	No	7,495.000	21,267.500	28,762.500	30,721.500	3178.0	527,205
Yes	The Region of Peel	725.152	1.321	No	855.072	4,717.505	5,572.577	6,079.497	2793.9	315,617
Yes	Village of Santa Clara	1.254	0.250	No	1.740	20.613	22.353	24.947	25.0	752
Yes	South Jordan City	63.709	9.664	Yes	84.822	289.389	374.211	714.143	333.0	19,074
Yes	City of Wilmington	171.726	500.000	No	701.726	1,832.707	2,534.433	2,631.175	410.0	37,751
Yes	Water & Wastewater Authority of Wilson County	5.228	0.020	No	6.170	58.944	65.114	66.494	326.5	7,052
Yes	Washington County Service Authority	14.449	3.485	Yes	24.269	1,047.489	1,071.758	1,139.856	852.5	22,500
Yes	Cherokee County Water & Sewerage Authority	87.701	4.162	Yes	103.643	310.021	413.664	549.551	1234.2	62,708

Placing a Cost Value on Water Losses

- Apparent Losses: Customer losses from:
 - Customer Metering Inaccuracies
 - Unauthorized Consumption
 - Systematic Data Handling Error in Customer Billing Systems
 - These losses are valued at the price of revenue billed to the customer: the Customer Unit Retail Cost (CRUC)
- Real Losses: leakage and storage tank overflows
 - In Pennsylvania and most places, these losses are valued at the Variable Production Costs (VPC), or cost to produce the next million gallons of supplied water
 - For water systems that import supplied water, the VPC = Imported water unit cost
 - In areas where source water resources are stressed and/or the ability to meet future water demands is questionable, then it is appropriate to value real losses at the CRUC

Annual Water Volumes Supplied to Distribution Top 20 Utilities by Volume

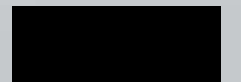
Average daily
volume of
water
supplied for
all 155
systems is
654.4 mgd

System	Volume, mg	Daily Ave, mgd
Philadelphia Water Department	87,417.500	239.5
Aqua-PA: Main/Great Valley/WestWhiteland/Media Systems	28,325.779	77.6
Pennsylvania American Water / Pittsburgh Division	23,288.562	63.8
Pennsylvania American Water / Wilkes-Barre Scranton District # 910	16,763.703	45.9
Allentown, PA	6,701.252	18.4
Bethlehem City	4,855.849	13.3
Reading Area Water Authority	4,841.000	13.3
Pennsylvania American Water / Mechanicsburg Dist # 610	4,020.260	11.0
Pennsylvania American Water / Norristown Dist # 510	3,435.209	9.4
North Wales Water Authority	2,960.000	8.1
Pennsylvania American Water / New Castle /Ellwood # 310	2,702.966	7.4
Lower Bucks County Joint Municipal Authority	2,524.489	6.9
Pennsylvania American Water / Butler Dist #330	2,466.749	6.8
Easton Suburban Water Authority	2,465.840	6.8
Pennsylvania American Water / Hershey Palmyra Dist # 620	2,204.566	6.0
Aqua-PA: Bristol System PWSID # 1090001	2,092.847	5.7
Hazleton City Authority	1,905.300	5.2
Aqua-PA: West Chester System PWSID # 1150098	1,790.013	4.9
Lehigh County Authority - Central Division	1,463.133	4.0
Borough of Pottstown, PA	1,340.000	3.7

How to Assess Water Loss and its Impacts?

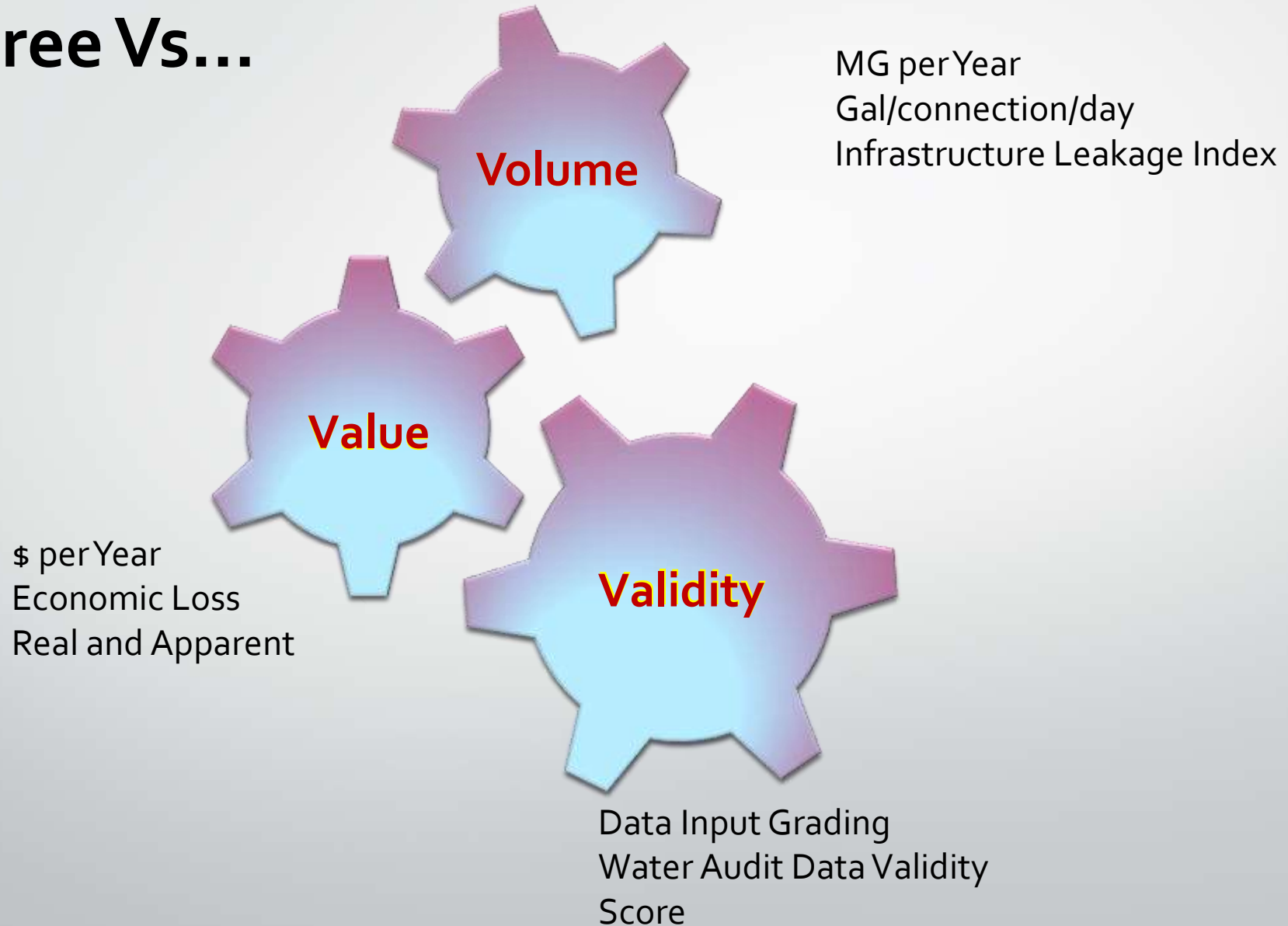
~~Unaccounted for Water (UFW)~~

AWWA Water Audit
Methodology



How to Assess Water Loss and Its Impacts?

Three Vs...



How to Assess Water Loss and Its Impact?

➤ Volume

- Apparent Losses, annual volume
- Normalized apparent losses, gallons/service connection/day
- Real Losses, annual volume
- Normalized real losses, gallons/service connection/day
- Normalized real losses, gallons/mile of pipeline/day (for low density systems)
- Infrastructure Leakage Index (ILI) = Real Loss volume/Unavoidable Annual Real Losses (the UARL is a calculated reference value that includes system specific data: length of mains, # of service connections, average pressure, and length of service lines owned by customers)

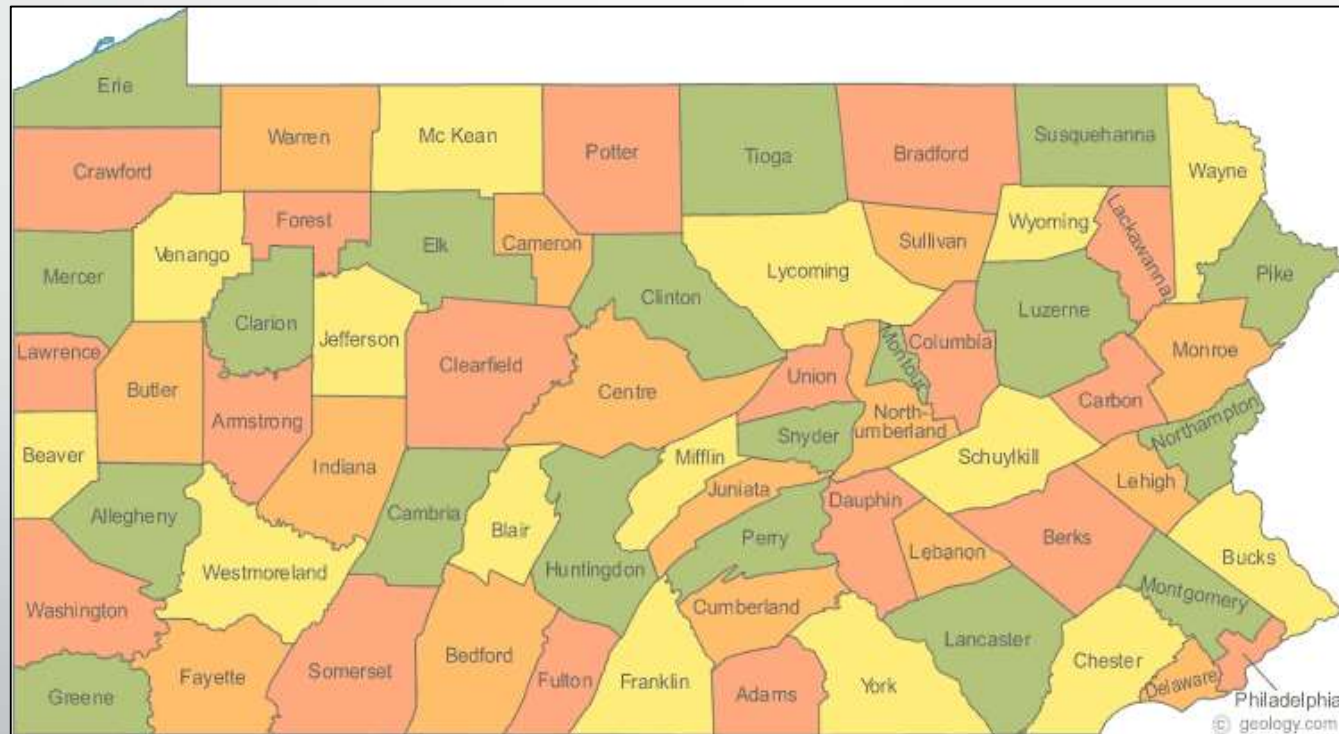
➤ Value

- Customer Unit Retail Costs and Apparent Loss Costs
- Variable Production Costs and Real Loss Costs
- Non-revenue Water percent by cost

➤ Validity

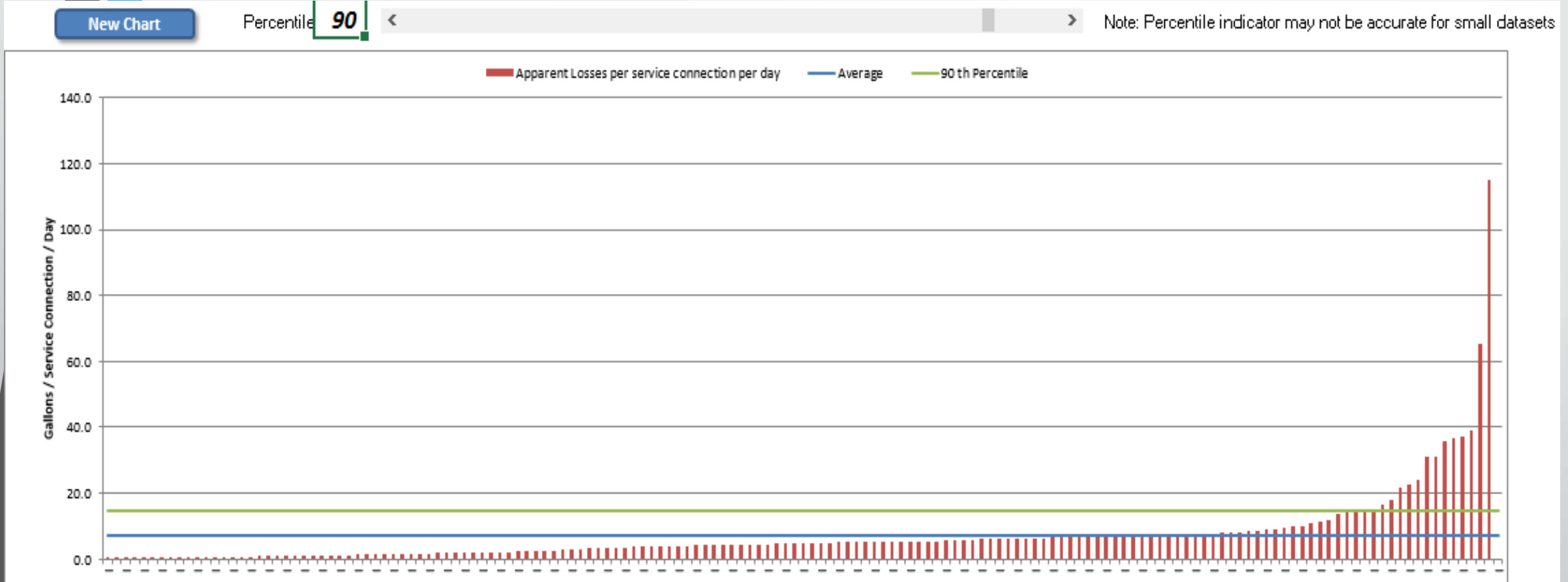
- Data Validity Score

A Look at Water Loss and Cost Data Across Pennsylvania Water Utilities



Source: Geology.com

Apparent (Customer) Losses

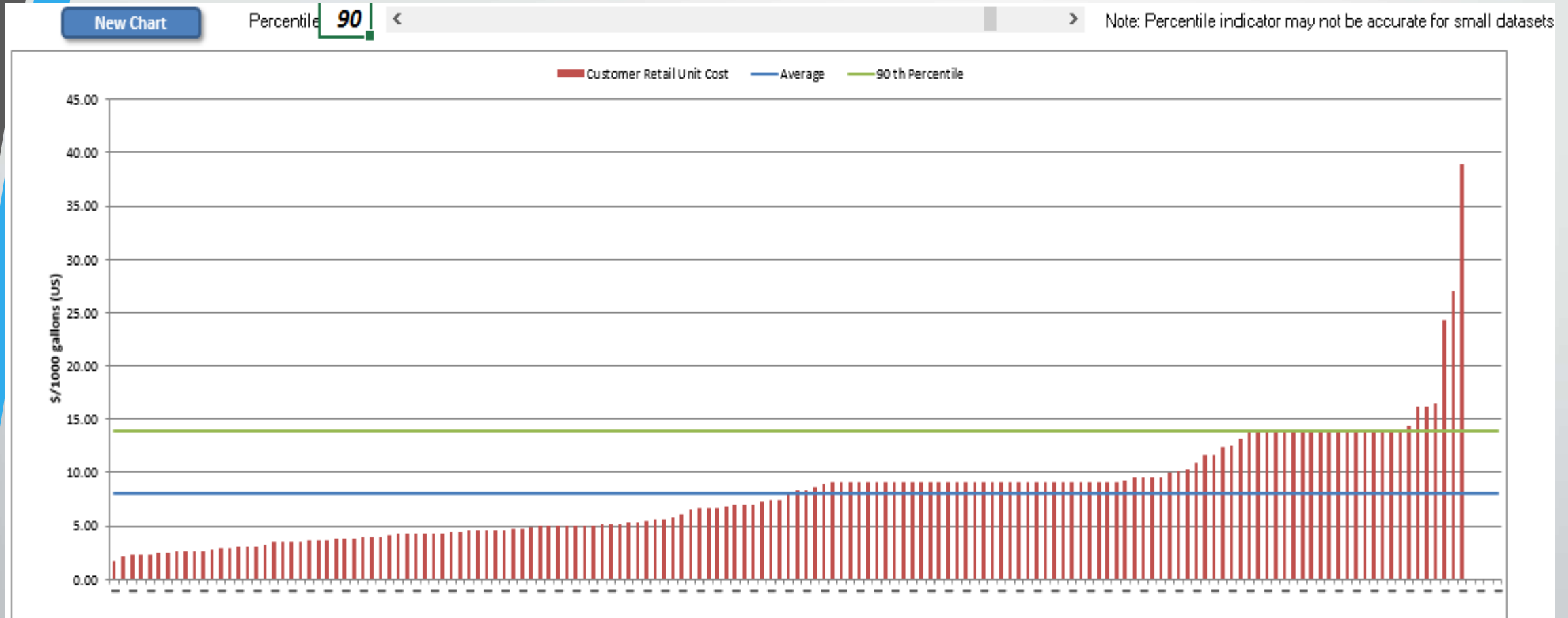


Average = 7.00 gal/service conn/day Median = 4.62 gal/service conn/day

Max = 114.8 gal/service conn/day (system reports only 4 service connections)

Author observation: "Apparent Losses are often not well understood by utilities, and are likely under-stated"

Customer Retail Unit Cost (CRUC), \$/1,000 gallons



Cost is applied to the volume of apparent (customer) losses

CRUC varies widely among utilities

Average \$8.07/1,000 gal Median \$7.84/1,000 gal Max \$39.0/1,000 gal Min \$1.75/1,000 gal

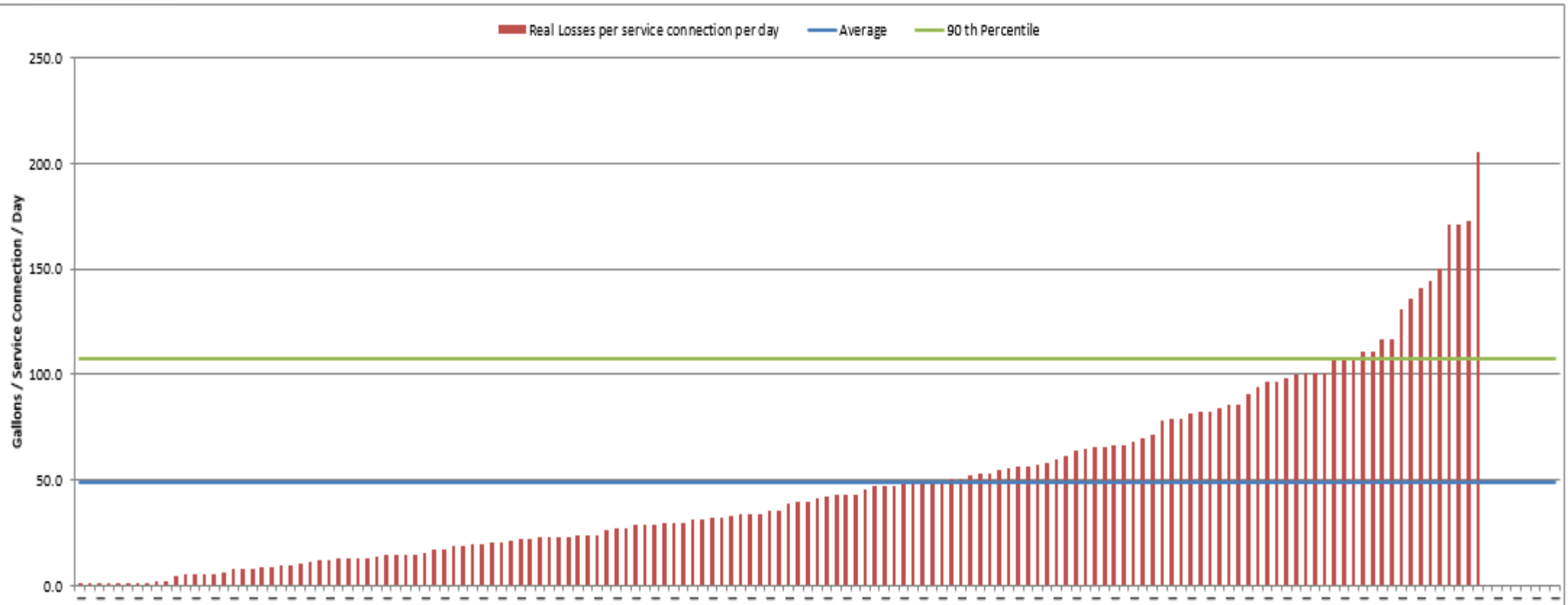
Real (Leakage) Losses

New Chart

Percentile **90**

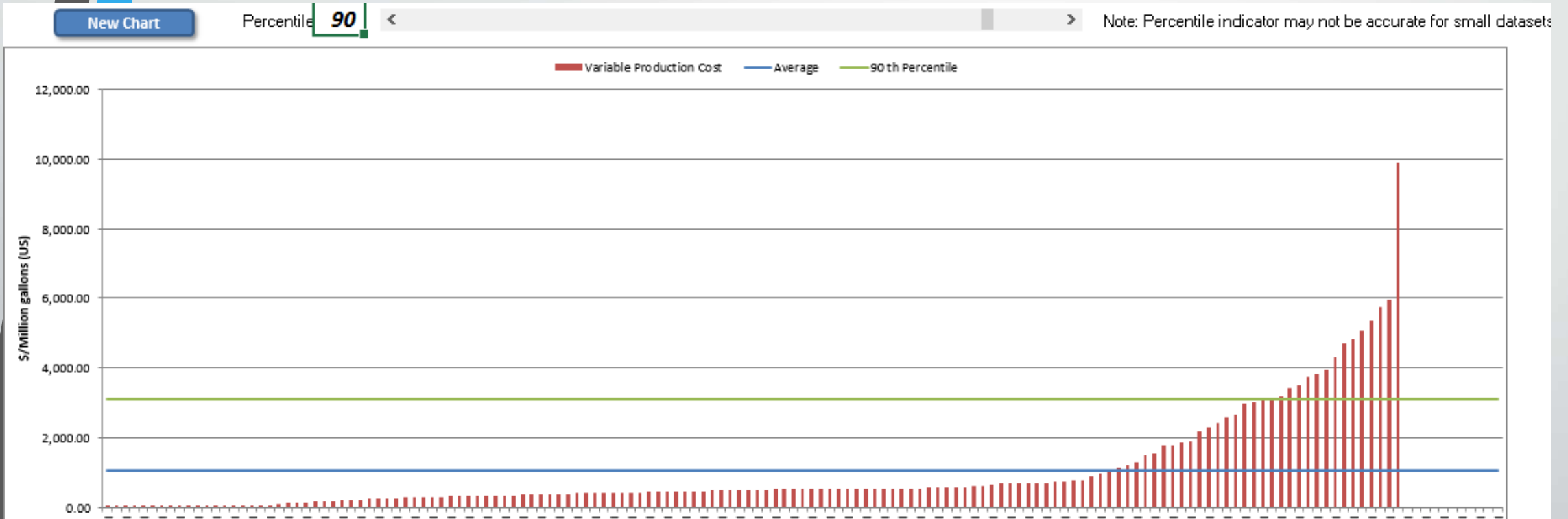


Note: Percentile indicator may not be accurate for small datasets



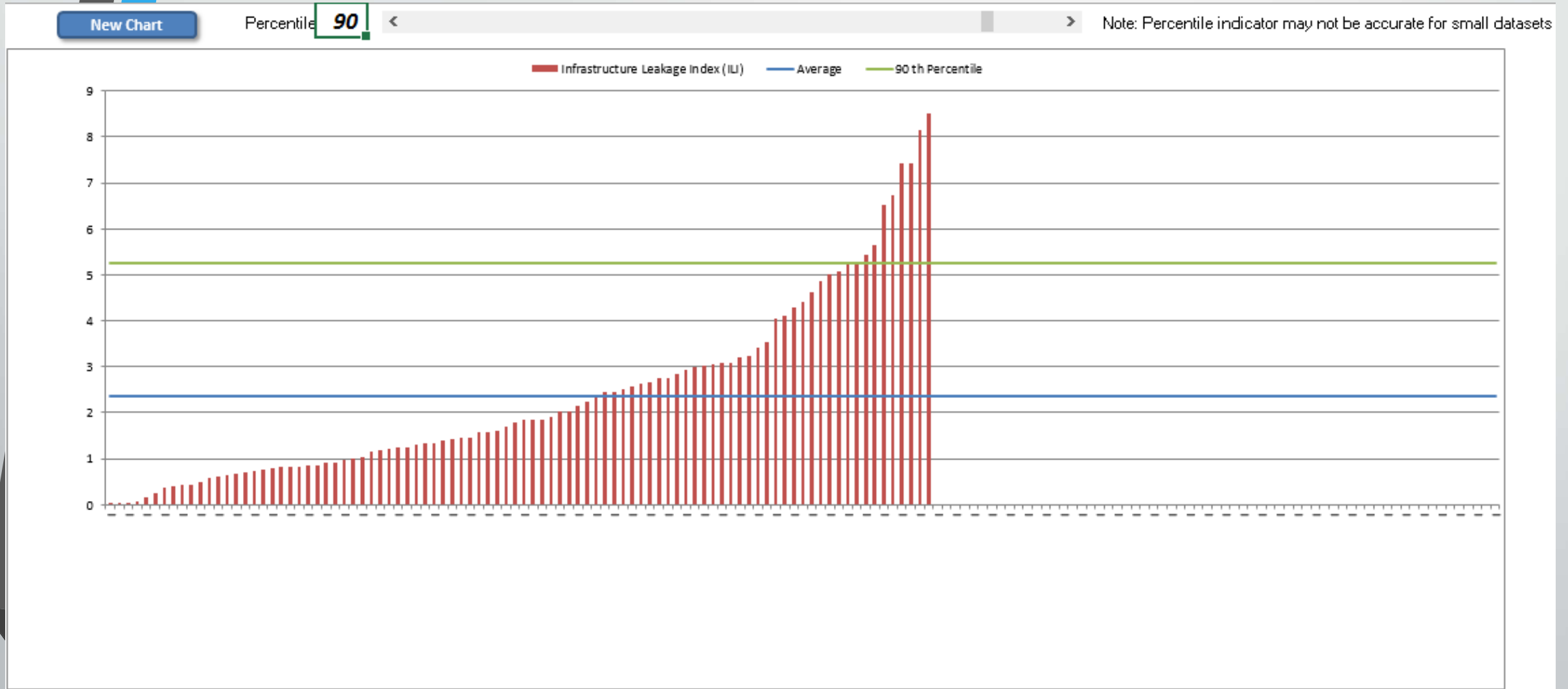
Average = 48.5 gal/service conn/day Max = 205 gal/service conn/day

Variable Production Costs



Average of Dataset: \$1,035/MG Median of Dataset \$501/MG
32 systems have cost over \$1,000 \$per million gallons
When production costs (power, chemicals) increase - so does the cost of leakage!

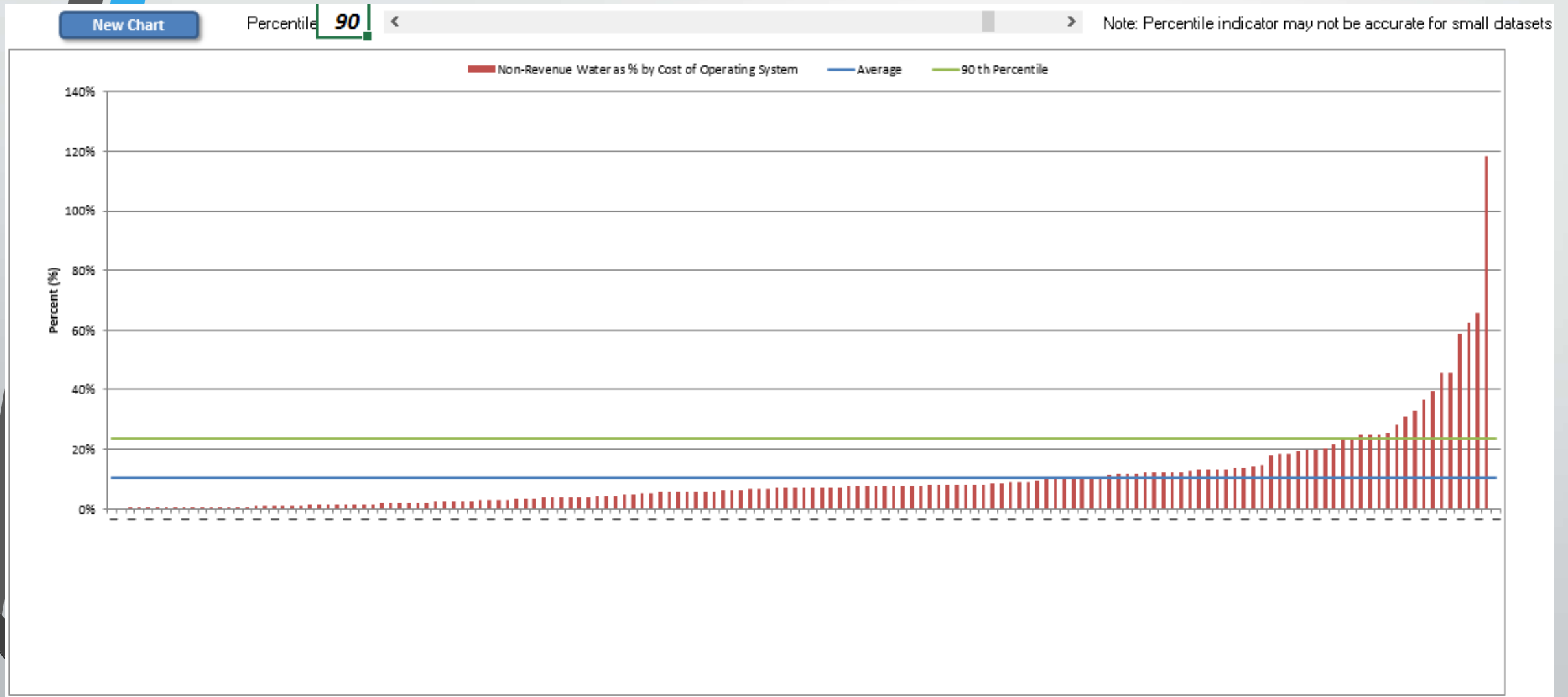
Infrastructure Leakage Index (ILI)



Average of Dataset: 2.36

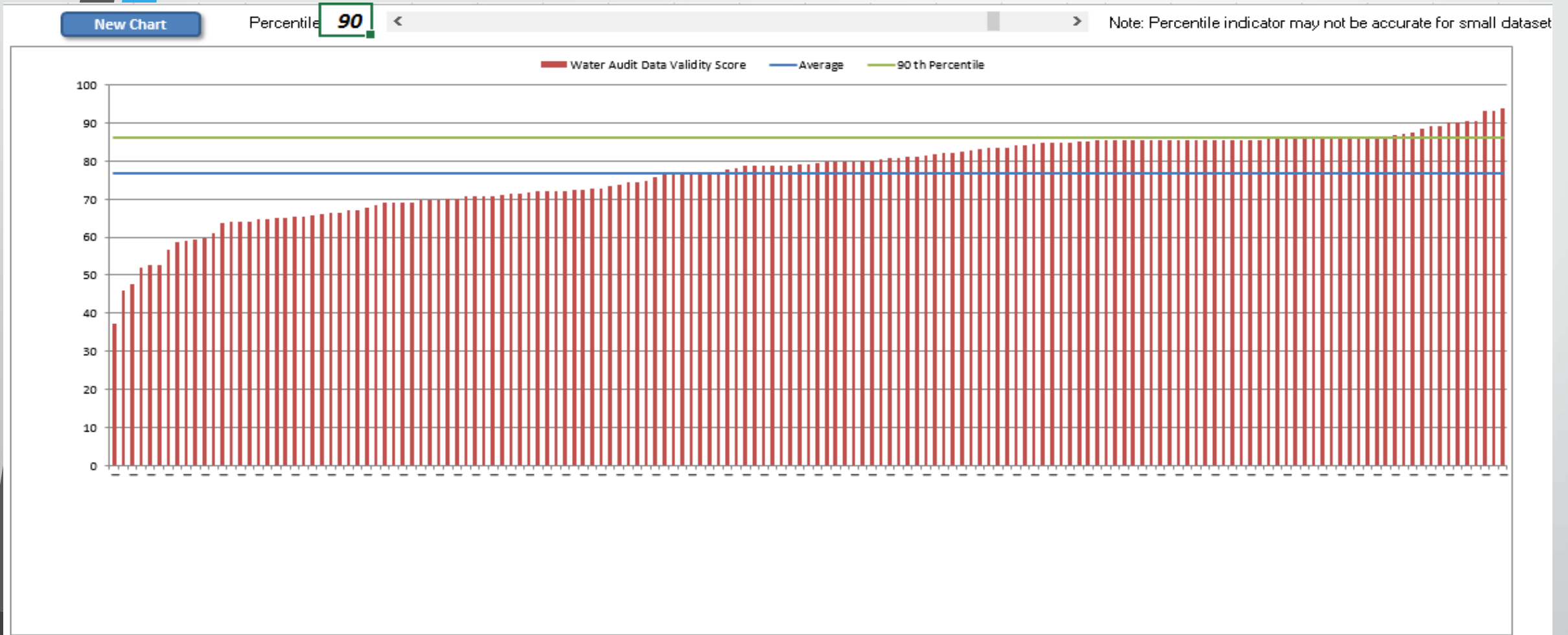
ILI does not apply to very small systems – it is not calculated for 63 small systems

NRW Percent by Cost



Average of Dataset: 10.5% Median of Dataset 7.1%
One system calculates NRW% by cost of over 100% - likely due to high CRUC

Data Validity Score



Average of Dataset: 76.91 Median of Dataset: 79.11
Maximum value 94 Minimum value 37

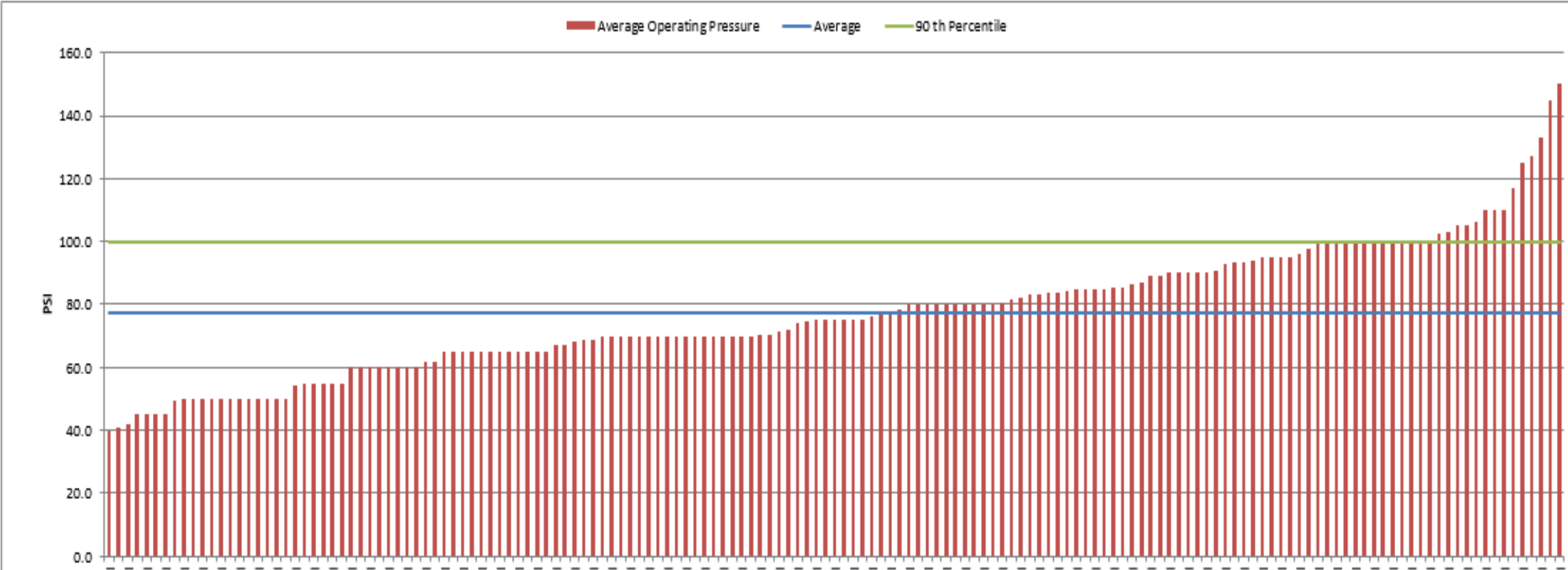
Average Operating Pressure

New Chart

Percentile **90**

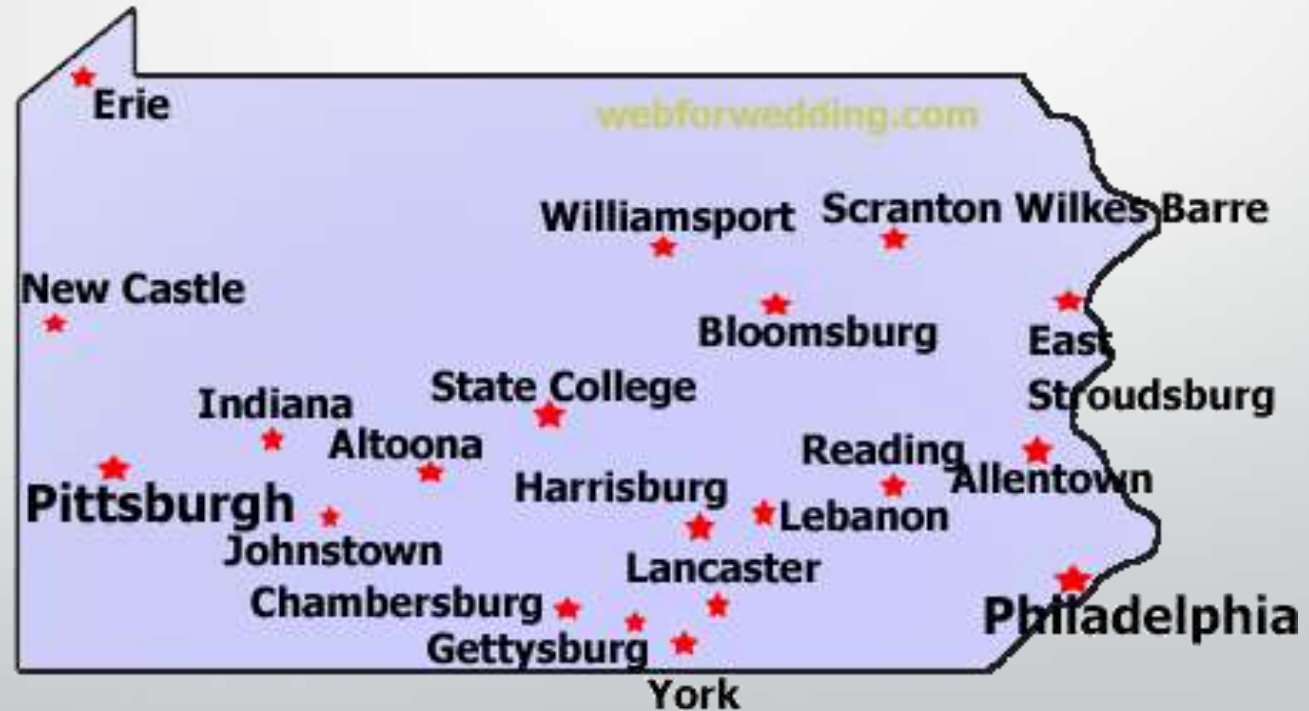


Note: Percentile indicator may not be accurate for small datasets



Ten States Standards quotes 60-80 psi as optimal range for system operating pressures
Average of Dataset: 77.4 psi 27 systems have average pressure greater than or equal to 100 psi
Excessive pressure is known to result in higher leakage and main break levels

A Look at Water and Revenue Losses and the Cost Impact to Pennsylvania Water Utilities



Source: webforwedding.com

Water Losses and Cost Impacts for PA Audited Water Utilities in 2013

- Apparent Loss Volume 11,236,000,000 mg or **11.236 billion gallons**
 - Cost Impact: **\$92.95 million** in uncaptured revenue
- Real Loss Volume 55,382,000,000 mg or **55.382 billion gallons**
 - Cost Impact – **over \$23 million** in excessive production costs (water treatment costs, electric power costs for pumping, other costs)
- Note volume:cost ratios
 - *By volume, real loss is 3 times greater than apparent loss, but:*
 - *By cost, apparent loss cost is 5 times greater than real loss cost*

Findings from North American Water Audit Datasets

High Water Pressure - State of Georgia & AWWA Water Audit Data Initiative (validated)

Table 6-1 ° Assessment of average water pressure levels reported in validated water audits in North American water utilities*¶

Validated Water Audit Data Source	No. of Utility Audits	Average of All Pressure Values (psi)	No. of Utilities With Pressure Over 80 psi	Average Value for Those Systems With Average Pressure > 80 psi
AWWA WLCC 2013†	26	80	12	98.3
Georgia—Large Systems 2011‡	107	77	53	93.7
Georgia—Small Systems 2012‡	100	72	26	105.5
All Utilities	233	76	91	97.7

Water Research Foundation Project 4372b – *Water Audits in the United States: A Review of Water Losses and Data Validity* – 1,636 water audits in five jurisdictions (including DRBC)

Table 5.6 Calculation of total water losses and financial losses

	VOLUME OF LOSSES (MG)	MEDIAN COST	COST OF LOSSES (median)	AVERAGE COST	COST OF LOSSES (average)
Apparent Losses	58,774.78	\$4.67 / 1,000 gal	\$274,478,228	\$8.33 / 1,000 gal	\$489,483,725
Real Losses	297,130.80	\$950.00 / MG	\$282,274,256	\$2,085.28 / MG	\$619,602,300
TOTAL WATER LOSSES	355,905.58	–	\$556,752,484	–	\$1,109,086,025

SUMMARY – Water Loss Levels in PA Water Utilities

- The Delaware River Basin Commission and the PA Public Utility Commission have taken progressive steps by requiring water utilities under their jurisdictional to submit annual water audits
- PA utilities have moderately high losses – like most US utilities
- Great potential exists in PA for utilities to recover additional revenue and reduce production costs
- Consideration should be given to all PA water utilities compiling and submitting standardized water audit data
 - This will require additional coordination with PA DEP and perhaps Susquehanna River Basin Commission (SRBC)

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