TECHNICAL MEMORANDUM DRAFT

City of Galveston, Texas
Non-Revenue Water Analysis – Real Loss Component Analysis, Economic Gap Analysis

PREPARED FOR:	City of Galveston	**DATE:**	October 2018
PREPARED BY:	Cavanaugh	**PROJECT NUMBER:**	WE.18.040
PROJECT DIRECTOR:	Tory Wagoner, P.E.	**PROJECT TEAM:**	Will Jernigan, P.E. Steve Cavanaugh, P.E.

Technical Summary

Cavanaugh conducted a non-revenue water (NRW) analysis for the City of Galveston per standards of the IWA/AWWA Water Audit Method and M36 Manual for Water Audits & Loss Control Programs. In an earlier phase of this project a top-down audit was conducted with Level 1 validation. The results of this audit revealed substantial real loss volume at levels greater than would be expected for a system with the characteristics and operation of the Galveston system. This phase of the overall project utilized a Top-Down Audit completed by staff using calendar year 2017 data. Cavanaugh subsequently completed a bottom-up Real Loss Component Analysis and an economic “gap” analysis. Professional judgment and informed assumptions have been applied where validated data was not available.

Metrics presented in this analysis are in terms of validity, volumes and values of loss. Loss as a percent of water supplied has been deemed by AWWA to be unreliable for managing water loss performance and is not included in this analysis or reporting.

The non-revenue water (NRW) levels revealed from the 2017 water audit are approximately 1,838 million gallons (MG). However, in late 2017, Galveston staff discovered a significant leak that was discharging directly into a storm drainage system. Based on field observations and subsequent flow data analysis, this leak was estimated at approximately 1,700 gallons per minute and based on historical data assumed to have been running for several years. For the audit period, this equates to approximately 807 MG (323 run days). Because of this anomaly in “normal” operation, all information has been analyzed with this single leak broken out as a separate component (“no leak”).

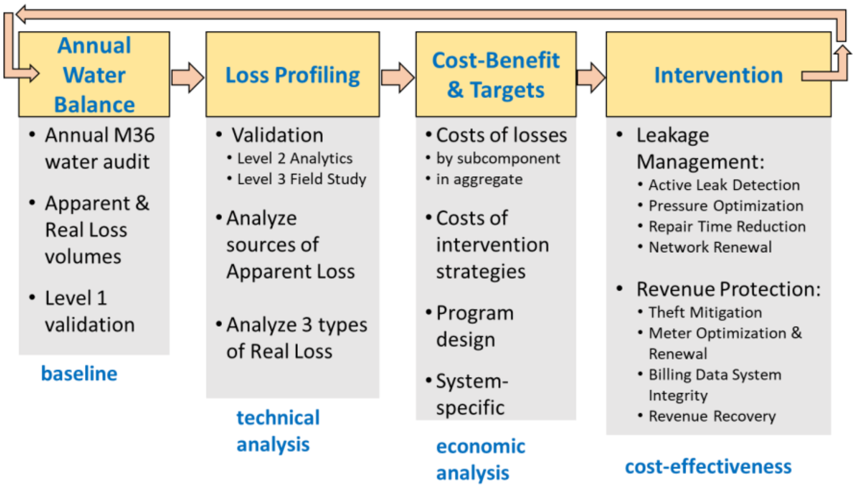
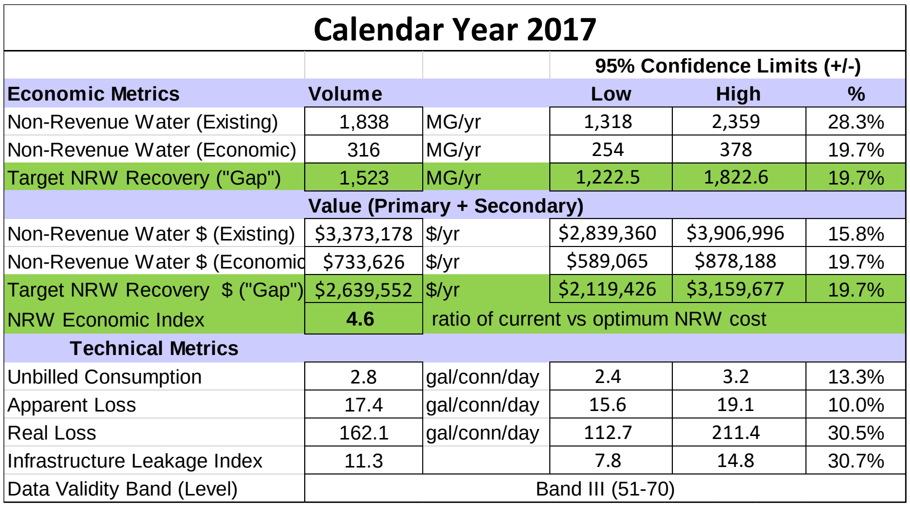


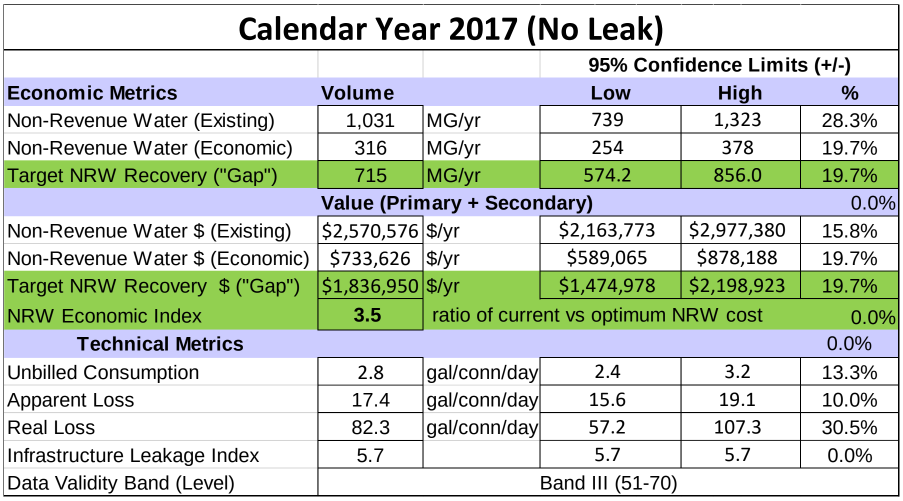
Figure 1 – Four Step Water Loss Control Program

The economic analysis was completed utilizing the blended customer unit retail cost of $7.22/hundred cubic feet ($9,675/million gallons) to value apparent losses and a variable production cost (VPC) of $994/million gallons to value real losses and unbilled authorized consumption. This value represents a combination of primary and secondary costs.

The Infrastructure Leakage Index (ILI) from the preliminary audit was calculated as 11.3. This represents a high level of leakage with real loss levels being approximately eleven times the Unavoidable Annual Real Loss (UARL). As noted, Galveston discovered a major leak during the audit period. Without the leak included, the ILI would be 5.7 for the analyzed audit period.



Calendar Year 2017					
			95% Confidence Limits (+/-)		
Economic Metrics	**Volume**		**Low**	**High**	**%**
Non-Revenue Water (Existing)	1,838	MG/yr	1,318	2,359	28.3%
Non-Revenue Water (Economic)	316	MG/yr	254	378	19.7%
Target NRW Recovery ("Gap")	1,523	MG/yr	1,222.5	1,822.6	19.7%
	Value (Primary + Secondary)				
Non-Revenue Water $ (Existing)	$3,373,178	$/yr	$2,839,360	$3,906,996	15.8%
Non-Revenue Water $ (Economic	$733,626	$/yr	$589,065	$878,188	19.7%
Target NRW Recovery $ ("Gap")	$2,639,552	$/yr	$2,119,426	$3,159,677	19.7%
NRW Economic Index	**4.6**	ratio of current vs optimum NRW cost			
Technical Metrics					
Unbilled Consumption	2.8	gal/conn/day	2.4	3.2	13.3%
Apparent Loss	17.4	gal/conn/day	15.6	19.1	10.0%
Real Loss	162.1	gal/conn/day	112.7	211.4	30.5%
Infrastructure Leakage Index	11.3		7.8	14.8	30.7%
Data Validity Band (Level)	Band III (51-70)				



Calendar Year 2017 (No Leak)					
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Economic Metrics	**Volume**		**Low**	**High**	**%**
Non-Revenue Water (Existing)	1,031	MG/yr	739	1,323	28.3%
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	Value (Primary + Secondary)				0.0%
Non-Revenue Water $ (Existing)	$2,570,576	$/yr	$2,163,773	$2,977,380	15.8%
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Target NRW Recovery $ ("Gap")	$1,836,950	$/yr	$1,474,978	$2,198,923	19.7%
NRW Economic Index	**3.5**	ratio of current vs optimum NRW cost			0.0%
Technical Metrics					0.0%
Unbilled Consumption	2.8	gal/conn/day	2.4	3.2	13.3%
Apparent Loss	17.4	gal/conn/day	15.6	19.1	10.0%
Real Loss	82.3	gal/conn/day	57.2	107.3	30.5%
Infrastructure Leakage Index	5.7		5.7	5.7	0.0%
Data Validity Band (Level)	Band III (51-70)				

Figures 2a & 1b – Overall NRW Metrics with Confidence Ranges (Primary + Secondary Costs)

The total potential for cost reduction and revenue recovery through a comprehensive Water Loss Control Program is $1.84M per year. The economic targets are based on approximately 10% reduction in Unbilled Authorized Consumption, Customer meter performance of 99% accuracy and achievement of the economic level of real losses through proactive leak detection, pressure optimization and proactive management of large transmission mains.

Efforts to lower the volumes of non-revenue water will require capital and operational investment and should be engaged only with a business case justification. Successful implementation of an enhanced non-revenue water management program will take time to develop and the returns gained from intervention can be used to fund further efforts. Based on this preliminary analysis, the potential cost reductions and revenue recovery opportunities are sufficient for continued investment.

Preliminary recommendations are presented below and further described throughout the document.

Focus Area	Guidance for Program Design
Data Validity & Program Management	● Continued data validation including: ○ Work with Gulf Coast Water Authority to perform annual flow accuracy verification and calibration of master import water meter; ○ Continue tracking and estimation methods for all unbilled, unmetered uses; ● Utilize “Gap” Analysis to design comprehensive NRW Management Program; ● Conduct regular meetings of internal staff to review data tracking, trends and intervention project status; ● Develop and maintain a monthly tracking mechanism to be consistent with M36 methodology; ● Develop a plan for internal/external communication of efforts and results; ● Develop unbilled, unmetered authorized consumption strategy to include awareness, estimate methods and tracking; ● Continue to implement data collection practices to conduct water balance on segments of the overall system;
Billing & Metering	● Customer Meter Testing ○ Develop a large meter testing program to utilize revenue-based testing frequencies and repair/replacement decision based on revenue impacts (for all meters) to include use of flow profiling for appropriate composite performance average; ○ Develop a small meter testing program to include random sampling of higher throughput users to begin to develop an optimized replacement strategy based on statistical analysis of test results; ○ Evaluate implementation of statistical sampling of flow profiling to inform small meter testing program. ○ Develop small meter replacement strategy based on results of testing program;
Leakage Management	● Develop and implement Proactive Leak Detection Program to include: ○ In-depth technology identification and applicability analysis ○ Capital vs. Operational cost development ○ Implementation schedule and budget ● Develop and implement plan for Condition Assessment/Leak Detection for critical infrastructure as the building block for the development of a system-wide Asset Management Program ● Develop District Metering Area Pilot program with a focus on Minimum Night Flow analysis for real loss management; ● Develop Pressure Optimization Pilot program for reduction in break frequencies and background leakage component;

Methodology

Central to the IWA/AWWA Water Audit Method and M36 Manual for Water Audits & Loss Control Programs is the Water Balance. The balance is developed based on the principle that water can neither be created nor destroyed. Thus, the balance begins with the finished water supplied into the system and then the water is allocated into Authorized Consumption and Water Losses. Each of these categories are broken down into sub-components to further describe the use of the water. Losses are segregated between Apparent and Real losses with each valued and addressed differently.

Apparent or "paper losses" represent losses whereby the finished water reaches an end user but the utility is not properly compensated for its use. Examples of this include unauthorized consumption, data handling errors and under-registering customer meters. Because these losses represent lost revenue, they are valued at the customer unit retail rate.

Real Losses represent losses whereby finished water escapes the distribution system through leakage. Because the water has not reached an end user, these losses are valued at the variable production rate or the cost the utility expends to make an additional unit of water.

The water balance is a top-down analysis, as the remainder after authorized consumption and apparent losses are subtracted from water supplied results in the water losses.

Secondary analysis can be completed on the real losses by conducting a real loss component analysis, working from the bottom up to estimate the volumes of each of the three sub-components of real loss. These sub-components are background leakage, reported leakage and unreported leakage. Background leakage is a function of the condition of the piping system. Reported leakage is estimated using reactive leak detection results and unreported leakage is estimated using any proactive leak detection results. The sum of these three sub-components can be compared to the water balance real loss value for confirmation.

The AWWA Free Water Audit Software was utilized to conduct a preliminary top-down water balance. All analysis provided herein was conducted in strict conformance with the methodologies described in the AWWA M36 Manual for Water Audits & Loss Control Programs. Standard terminology from this method is provided at the end of this report.

The software includes an assessment of the reliability of the data inputs using a scale of 1 to 10 based on a prescriptive set of criteria. A weighted total Data Validity score is then calculated by the software to provide guidance on overall accuracy of the results. The composite score is not meant to be a pass/fail evaluation but rather an accurate description of the current practices as it relates to the criteria. The potential investment by a Utility to achieve the next highest score must be carefully evaluated to assure it will result in an increased accuracy of the data input. The score should be used to benchmark a utility as it begins a water loss control program. For utilities with established resources and developed intervention methods, there is often less increase in the score year after year. A Level 1 Validation of the inputs and data grades was conducted on the resultant audit per the recently published WRF Manual on Level 1 Validation (WRF 4639).

Audit Boundary

One of the most important aspects of a water audit is the formalization of the audit boundary. Based on the concept of the water balance (mass balance) it is essential to fully understand the delivery point(s) into the system and then properly account for water from that point to the extents of the audit boundary at the delivery points to authorized users. For the Galveston system, all treated water is metered as delivered from the GCWA prior to entering the distribution system and made available for consumption. Thus, the audit boundary for this analysis was established starting at the master import water meter and ending at the customer meters.

Variable Production Cost

One of the primary inputs of the top-down audit process is the Variable Production Cost. This input is used to establish the value of Real Losses (leakage) in the system. For most utilities, the variable production cost is calculated as a replacement cost, including only the primary variable costs. This includes the power (treatment and distribution) and chemicals used in the treatment process and/or purchase costs. However, utilizing only the primary costs does not accurately represent the true cost of leakage as there are other secondary costs created by leakage in the long-term. These vary by utility but can include wear and tear on equipment, residuals management, impending supply expansion or other less tangible costs.

For the Galveston system, the primary costs consist of the purchase costs from GCWA, distribution power costs and limited chemicals that are used. It should be noted that the rate charged by GCWA is made up of three components, 1) Raw Water, 2) Capital and 3) Maintenance and Operation. Despite the names assigned to these, only the Maintenance and Operation is variable based on water purchased. Raw Water and Capital are based on the total water available to the City and are adjusted annually based on actual use.

Secondary costs were identified as the costs of repairs, wear and tear on equipment (increased maintenance and reduction of asset life), constrained supply, constrained demand and environmental/political implications of diverting a greater volume of water for the potable water system than required. A formula for defining each of the costs was developed for ongoing calculations in future years and is as follows:

Primary Costs		
Import - GCWA - Raw Water	$3,402,734	rate as proposed by GCWA - $685.11/MG
Power - Distribution	$353,077	
Chemicals	$29,742	
	$3,785,553	
	$762.19	Variable Production Cost (Primary)
Secondary Costs		
Wear & Tear on Equipment	$12,658	10% of Annual Maintenance Budget
Break Repairs	$733,500	Valued @ $1,500/repair
Pump Repairs	$15,000	10% of Total Replacement Costs
Constrained Supply	$65,514	Potential surcharges at Stages 2, 3 & 4 of GCWA Drought Plan (10% excess beyond planned average flow (12.75 MG/day) for 30 days)
Constrained Demand	$211,321	Potential reduced revenue associated with mandatory restrictions in drought condition (15% reduction for 1 month period, annualized)
Environmental/Political	$113,340	Valued at .5% of annual operating expenses
	$1,151,333	
	$231.81	Variable Production Cost (Secondary)
	$994.00	**Variable Production Cost (Combined)**

Summary of Findings - Metrics

Findings from the analysis on NRW metrics are presented in this section. All metrics presented are for the benchmark year (Calendar year 2017) unless otherwise noted. The metrics are presented in unit terms of volume and value, as these units provide the most meaningful indicators for benchmarking and target setting.

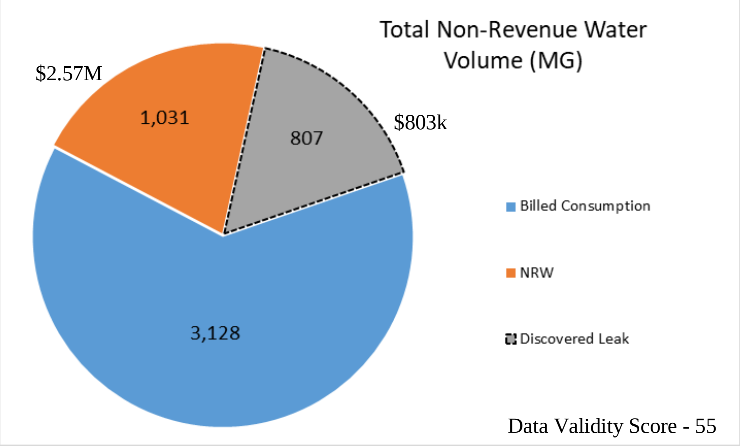


Figure 3 – Total NRW, Volume

Units of Non-Revenue Water as a percentage of system input volume, while reported in the audit software have been purposefully excluded from the analysis, as they are ineffective for both performance benchmarking and target setting. Use of the percentage metric is no longer recommended by AWWA.

NRW in the benchmark audit is 1,031 MG/year. Key metrics of NRW components by volume and value (cost) are presented below.

Understanding volumes and values at each of these levels is critical for developing a cost-effective, prioritized plan of action.

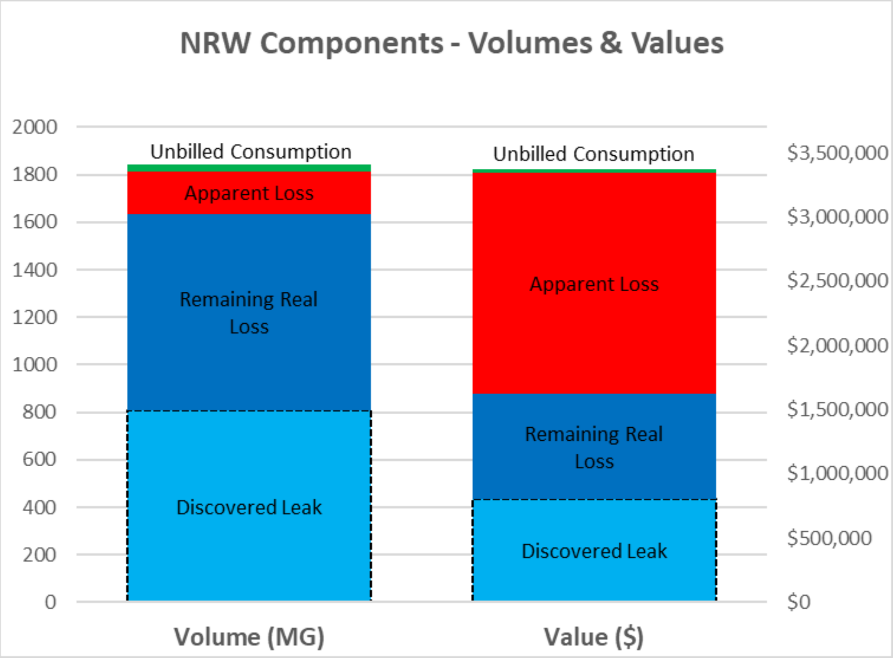


Figure 4 - NRW Volumes & Values by Primary Component

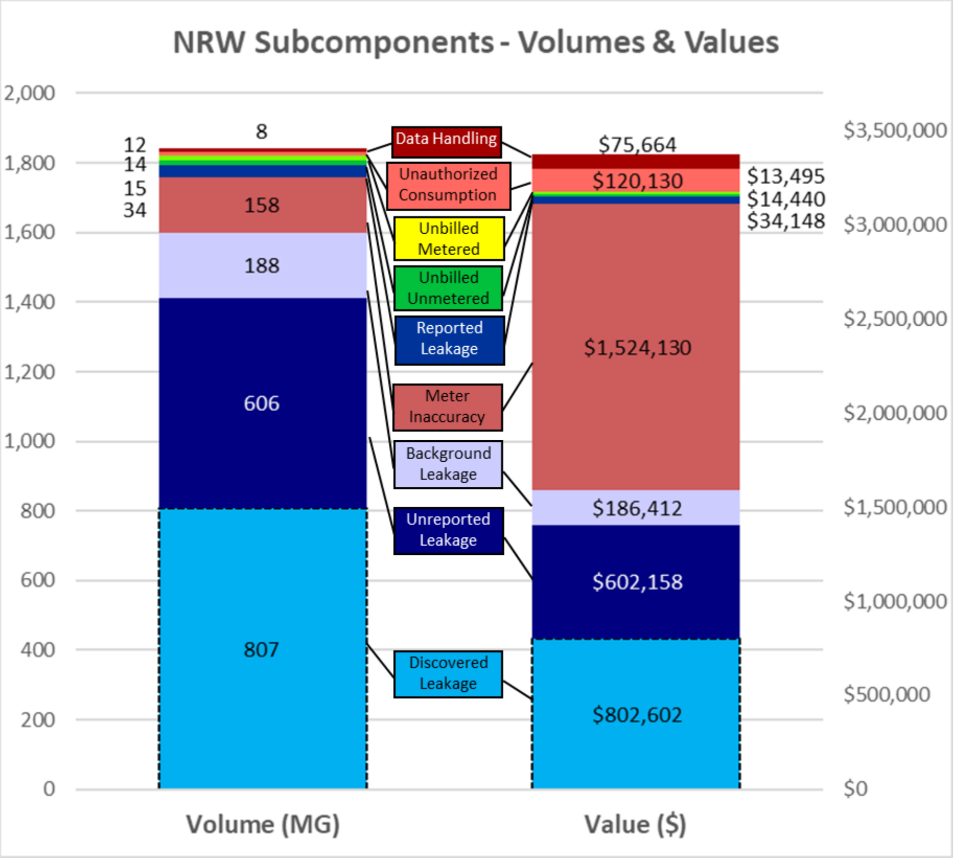


Figure 5 - NRW Volumes & Values by Subcomponent

Apparent Loss Component Analysis

For the Galveston system, Unauthorized Consumption and Systematic Data Handling Errors were estimated utilizing the default values supplied by the water audit software.

Galveston recently conducted customer meter testing utilizing a third-party testing contractor. The results of those tests are summarized in the adjacent chart. Small meter testing was limited by the requirement that meters removed for testing would have to be replaced. Large meters were tested in situ.

As noted by the test results, small meter performance aligned with previous estimates of 1.5% under-registration. However, many of the large meters tested, specifically 6" sized meters, failed expected performance standards. These meters should be repaired or replaced immediately as 6" meters make up a significant portion of the total volume billed.

Meter Size	Number of Tests	Results	% of Volume	Weighting
5/8" - 3/4"	10	98.4%	41%	40.1%
1"	5	97.9%	5%	4.8%
1.5"	0	*97.9%*	4%	3.9%
2"	12	98.6%	13%	12.9%
3"	11	95.6%	5%	4.8%
4"	7	93.6%	2%	2.0%
6"	9	86.9%	25%	21.4%
8"	0	*98.3%*	4%	3.5%
10"	1	98.3%	2%	1.9%
			Composite Accuracy	**95.3%**
			Composite Inaccuracy	**4.7%**

Figure 6 – Customer Meter Testing Results

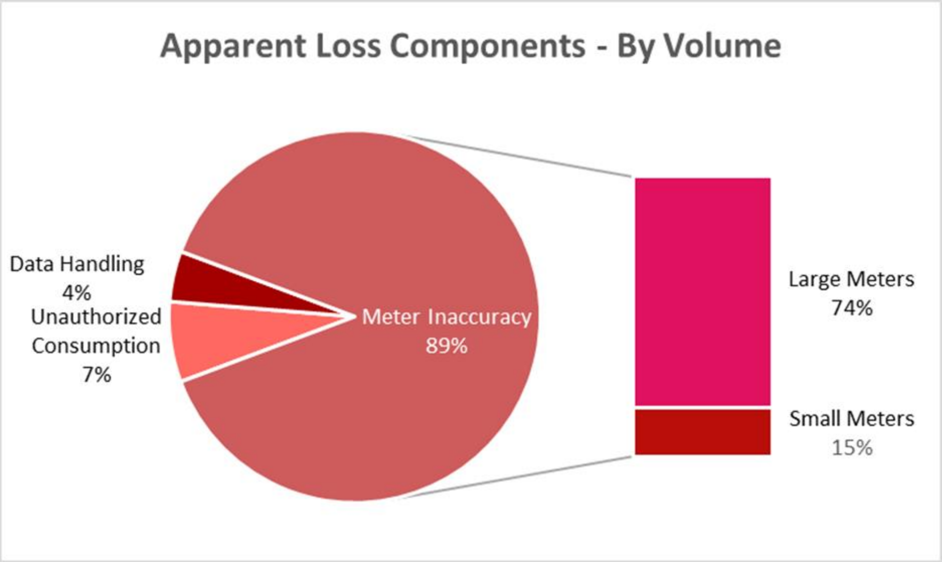


Figure 7 – Apparent Loss Component Analysis Breakdown

Real Loss Component Analysis

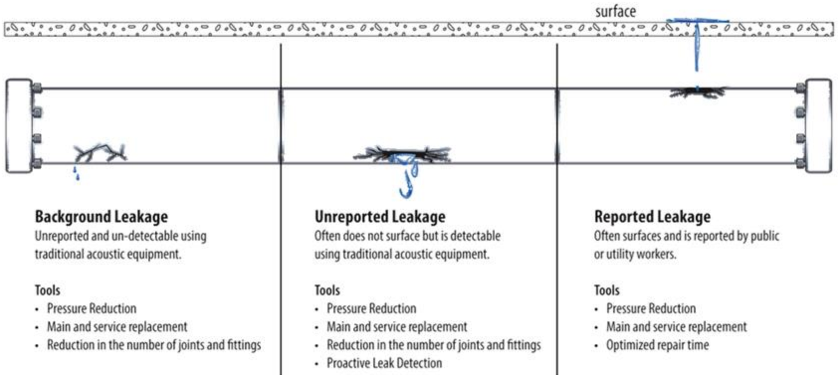


Figure 8 –Sub-Components of Real Loss (graphic credit WRF)

A bottom-up review of the Galveston system real losses was conducted utilizing a real loss component analysis. This process attempts to quantify the total real losses by summing each of the three sub-components together. As a part of ongoing practices, all reported breaks and leaks are tracked in a spreadsheet and used in this analysis.

The results of this component analysis are included below.

REAL LOSS COMPONENT ANALYSIS RESULTS				
System Component	Background Leakage	Reported Failures	Unreported Failures	Total
	(MG)	(MG)	(MG)	(MG)
Reservoirs	2.63	-	-	**2.63**
Mains and Appurtenances	49.84	25.98	807.45	**883.27**
Service Connections	135.07	8.37	-	**143.44**
Total Annual Real Loss	**187.54**	**34.35**	**807.45**	**1,029.34**
			Real Losses as Calculated by Water Audit	**1,635.13**
			Hidden Losses/Unreported Leakage Currently Running Undetected	**605.79**

Figure 9 –Real Loss Component Analysis Summary Table

Galveston is in the process of initiating a system-wide proactive leak detection program based on this NRW analysis, and thus only the discovered leak is included as unreported leakage. The difference in real losses calculated by the top-down water audit and the bottom up analysis was indicated as potentially recoverable unreported leakage. This is a broad analysis for the overall system. Because water systems have different infrastructure characteristics (age, material type, condition), it would be more advantageous to perform the component analysis for segments of the system rather than just the overall system. This would allow for more focused, effective analysis and intervention.

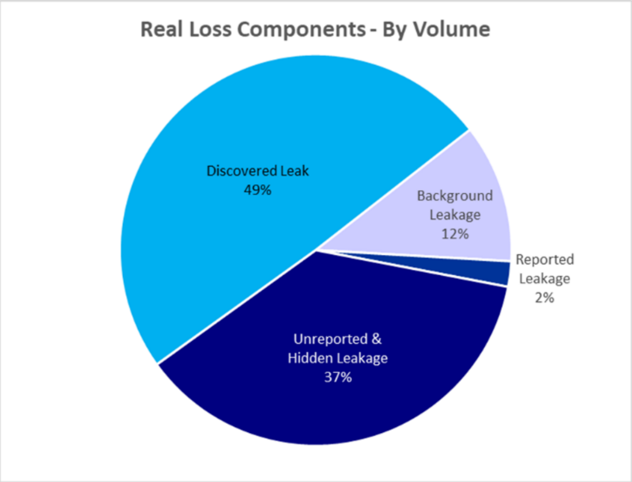
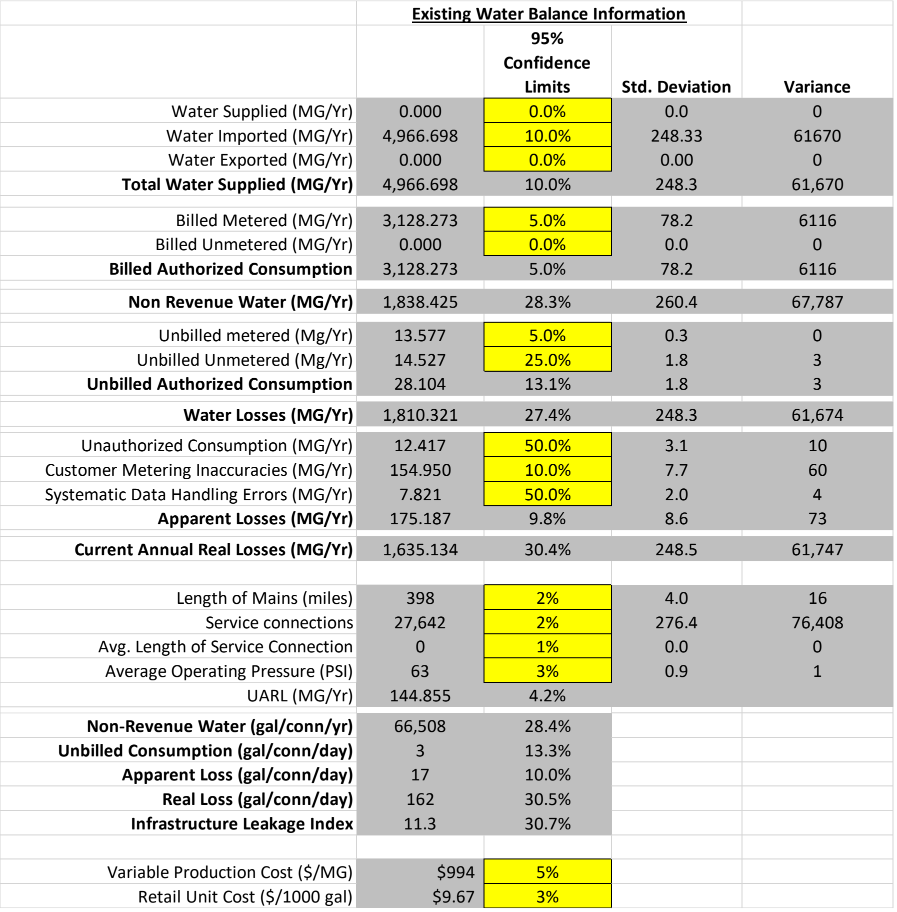


Figure 10 –Real Loss Components – By Volume

Economic Analysis

As presented earlier, the NRW levels revealed from the benchmark water audit are approximately 1,031 MG. The annual NRW cost is calculated as a composite of its three (3) primary components. The unbilled consumption and real losses (leakage) are valued at the variable production cost, $944/MG (primary and secondary costs). The value of those total non-revenue volumes is $2.57M annually. The apparent losses are valued at the customer retail unit cost, $7.22/ccf ($9,675/MG) and equate to $1.7M annually.



	Existing Water Balance Information			
		95% Confidence Limits	Std. Deviation	Variance
Water Supplied (MG/Yr)	0.000	0.0%	0.0	0
Water Imported (MG/Yr)	4,966.698	10.0%	248.33	61670
Water Exported (MG/Yr)	0.000	0.0%	0.00	0
Total Water Supplied (MG/Yr)	4,966.698	10.0%	248.3	61,670
Billed Metered (MG/Yr)	3,128.273	5.0%	78.2	6116
Billed Unmetered (MG/Yr)	0.000	0.0%	0.0	0
Billed Authorized Consumption	3,128.273	5.0%	78.2	6116
Non Revenue Water (MG/Yr)	1,838.425	28.3%	260.4	67,787
Unbilled metered (Mg/Yr)	13.577	5.0%	0.3	0
Unbilled Unmetered (Mg/Yr)	14.527	25.0%	1.8	3
Unbilled Authorized Consumption	28.104	13.1%	1.8	3
Water Losses (MG/Yr)	1,810.321	27.4%	248.3	61,674
Unauthorized Consumption (MG/Yr)	12.417	50.0%	3.1	10
Customer Metering Inaccuracies (MG/Yr)	154.950	10.0%	7.7	60
Systematic Data Handling Errors (MG/Yr)	7.821	50.0%	2.0	4
Apparent Losses (MG/Yr)	175.187	9.8%	8.6	73
Current Annual Real Losses (MG/Yr)	1,635.134	30.4%	248.5	61,747
Length of Mains (miles)	398	2%	4.0	16
Service connections	27,642	2%	276.4	76,408
Avg. Length of Service Connection	0	1%	0.0	0
Average Operating Pressure (PSI)	63	3%	0.9	1
UARL (MG/Yr)	144.855	4.2%		
Non-Revenue Water (gal/conn/yr)	66,508	28.4%		
Unbilled Consumption (gal/conn/day)	3	13.3%		
Apparent Loss (gal/conn/day)	17	10.0%		
Real Loss (gal/conn/day)	162	30.5%		
Infrastructure Leakage Index	11.3	30.7%		
Variable Production Cost ($/MG)	$994	5%		
Retail Unit Cost ($/1000 gal)	$9.67	3%		

Figure 11 – Water Balance Inputs with Confidence Ranges

Along with the metrics, we have applied a high level statistical confidence limits approach to each of the inputs and metrics. This allows us to calculate performance bands and determine if these ranges are acceptable for decision-making and continued investment. This process involved assigning a 95% confidence limit to each input of the water balance. These limits were chosen based on our experience and assessment of current data collection means and methods. For each of the performance indicators and audit outputs, the confidence limits are calculated based on the inputs included in the calculation of that specific metric. Based on the assigned confidence limit for each metric, the performance range (plus/minus) can be established. These performance ranges provide insight relative to the decision making associated with further action. Is the confidence band “tight” enough to invest in intervention implementation or should the focus be on improving the confidence in the data? For the Galveston system, the largest individual variance is from the Water Supplied input. An increased confidence in the data could be obtained from annual volumetric testing of the master import meter.

Preliminary economic analysis was performed to develop economic targets at the NRW subcomponent level. These economic targets were established at the subcomponent level and were assigned based on our experience and assessment of the current practices and intervention strategies. These subcomponent targets roll up to an aggregate preliminary economic NRW target of 316 MG, at an associated annual cost impact of $734k (primary and secondary costs). This yields a gap between current and optimal NRW of 715 MG, with a preliminary annual target NRW recovery of $1.84M.

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Infrastructure Leakage Index	5.7		5.7	5.7	0.0%
Data Validity Band (Level)	Band III (51-70)				

Figure 12 – Overall NRW Metrics with Confidence Ranges

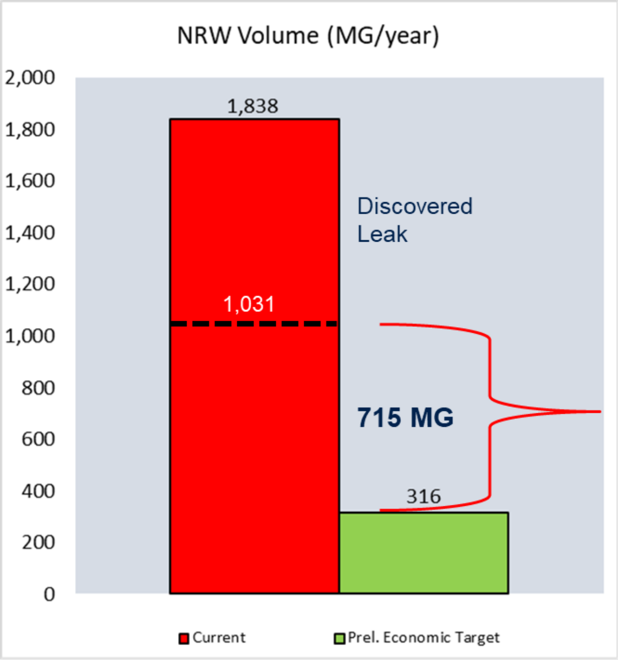

Figure 13a- Current vs optimal NRW volumes

Figure 13b - Current vs optimal NRW values

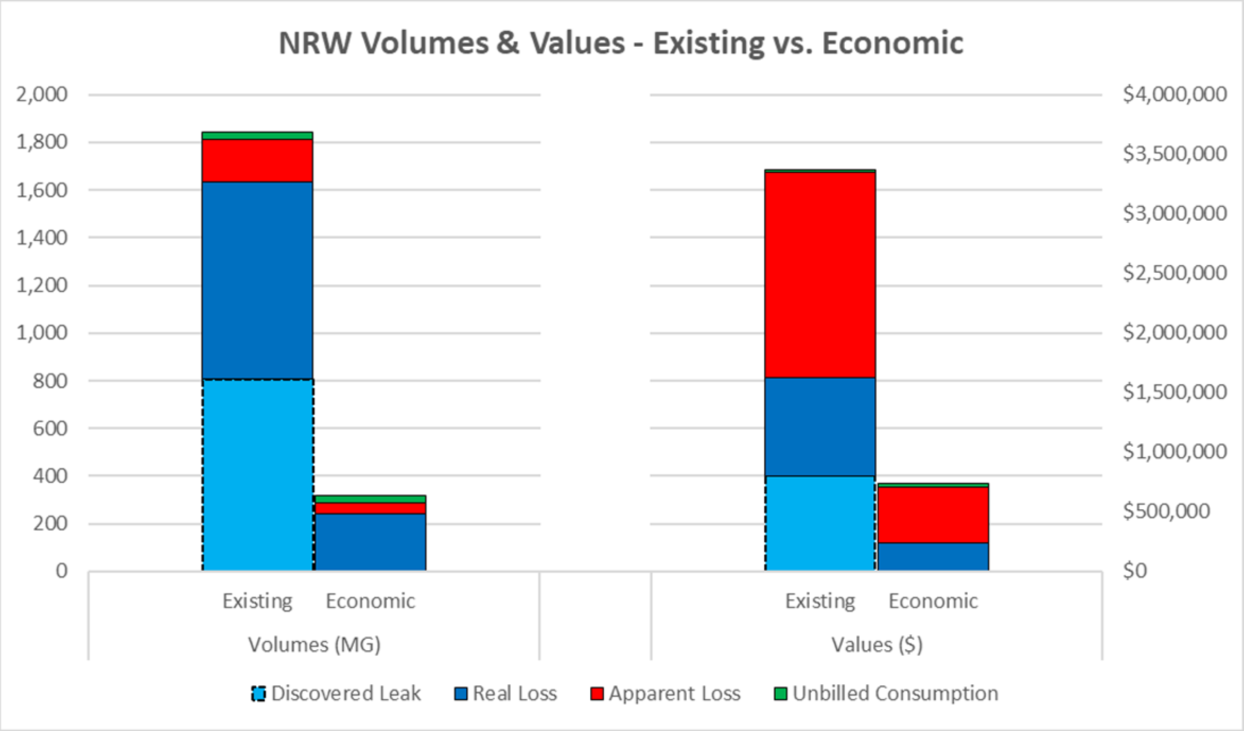

Figure 14 - Current vs optimal NRW Volumes and Values - Subcomponents

The economic analysis presented is strictly evaluating current and target levels of NRW and its components. The analysis does not factor in some other very real benefits from optimization of pressure in the network (beyond NRW) which can be significant, such as the overall reduction in energy and repair costs, and the deferment of capital such as pipe replacement costs from extending asset life. These benefits (beyond NRW) are typically developed as part of the planning and design of pressure optimization schemes for the network.

Simply said, the "gap" as shown currently, appears compelling for tangible future action. The value of every drop is significant in presenting a compelling business case for proactive management through strategic intervention.

Volumes (MG)	Existing	Economic
Unbilled Consumption	28	26
Apparent Loss	178	48
Real Loss	828	241
Discovered Leak	807	0

Values ($)	Existing	Economic
Unbilled Consumption	$28k	$26k
Apparent Loss	$1.72M	$468k
Real Loss	$823k	$240k
Discovered Leak	$803	$0

Figure 15 - Current vs optimal NRW Volumes and Values - Subcomponents

Recommendations for Improvement

The following are detailed descriptions of recommendations for improved management of NRW in the Galveston System through the continued development of a Comprehensive Water Loss Control Program. The recommendations are broken down by category.

Data Validity & Program Management

As noted earlier, the largest source of variance in the water balance is the confidence of the water supplied volume. To improve the confidence in this volume, Galveston should work with the Gulf Coast Water Authority to engage in annual volumetric testing and electronic calibration of the master import water meter. In our experience, the primary source of issues with the accuracy of master meters is irrespective of the meter itself, rather the in-situ location of the meter. The presence of bends, valves and other appurtenances can cause disturbances to the flow profile within the pipe. Additionally, flow rates outside of the designed flow range of the meter can lead to inaccurate results.

The unbilled authorized consumption usage in the Galveston system is required and justified for proper system operations. Internal metered Galveston facilities are not billed currently and are not evaluated on their usage patterns. Efforts should be made to provide awareness to City staff that could lead to small gains in efficiency. Galveston has estimates for many of its unbilled, unmetered uses within the system. These efforts should continue, and standard operating procedures updated as such. Through continued awareness and attention, optimization of these uses can be achieved.

Galveston has been quite proactive in their approach to NRW and staff seem to be aware and focused on NRW initiatives and a new program is expected to be developed subsequent to the finalization of this report and an updated Water Conservation Plan. To bring continued, consistent focus to these efforts, we recommend a regular meeting to review data tracking, trends and progress on initiatives. A new data tracker, consistent with M36 methodology should be set-up to assist in monthly data tracking. The tracker will also allow for ease in preparation of the volumetric inputs as required for the annual water audit.

The accuracy of the water balance can be increased as segments of the system are analyzed independent of the rest of the system. Some efforts have already been started and should be continued with the installation of any new infrastructure. The value of breaking a large system into smaller chunks is instrumental in providing insight to loss levels and appropriate intervention strategies.

Billing & Metering

As noted, Galveston recently conducted customer meter testing with a primary focus on large meters. The results of those test present an excellent opportunity for revenue recovery. In addition to addressing repairs or replacements of the meters recently tested, we would recommend that a large meter testing program be developed with meter testing frequencies based on revenue. This will provide a consistent evaluation of the system's largest customers and provide maximum revenue protection.

Additionally, flow profiling should be an integral part of the evaluation of the meter test results. Calculating the composite meter accuracy should be directly dependent on the flow rates the meter typically measures. A meter test that potentially "fails" at a low flow rate may not warrant repair or replacement if the customer never uses water at the low flow rate. One final aspect of the optimized large meter testing program is the decision matrix associated with evaluation of the results. Again, with flow profile results included, the potential lost revenue should be the driver for repair/replacement. Simply said, many of the highest revenue meters could provide a reasonable rate of return for repair/replacement at a meter accuracy that AWWA standards would deem to "pass", while lower revenue meters could potentially "fail" and not be candidates for repair/replacement.

For small meters, a testing program should also be developed. Meters should be tested at various volumes (throughput) and age for various manufacturers and types. The results of this program can help inform an optimized replacement strategy for these meters. Again, flow profiling (random sampling) should be included in this evaluation.

Leakage Management

Based on current metrics in the benchmark audit, real losses within the Galveston system could be classified as moderately high, with current levels approximately six times the unavoidable levels (Current Annual Real Losses = 828 MG vs. Unavoidable Annual Real Losses = 145 MG). Through our analysis of the real loss components, it was determined that of the current 828 MG of real losses, approximately 606 MG could be potentially recoverable leakage within the system. Based on the economic evaluation, approximately 25% of the system should be surveyed annually under a traditional leak survey approach. However, we would recommend that Galveston develop a proactive leakage management program. Initially, a detailed technical evaluation of current technologies and equipment should be conducted. This evaluation would also analyze whether third-party contractors should be utilized, or internal resources would be more effective. There are multiple options, but it is essential for Galveston to select the most appropriate approach for their system characteristics, funding availability, and utility implementation capacity (time available).

Included in this evaluation should be the review of creating District Metered Areas (DMAs) within the system. With DMAs, leaks can be detected days after they develop through continuous monitoring of Minimum Night Flows. In this process, the impacts of consumption can be minimized as flows are evaluated in the middle of the night at minimal consumption periods. After a baseline is established, any deviation from the minimum night flow can then be investigated. DMAs, while effective, can be capital intensive to establish especially at the size needed to provide maximum effectiveness. We would recommend beginning with a pilot area to set up as a DMA to establish the appropriate data measurement & analysis protocols. From that point, a master plan can be established such that the capital impacts are spread over a larger period, closely matching the potential return from leakage reduction. District Metered Area design is very system specific, but general guidance recommends that for maximum effectiveness, the areas should encompass less than 5,000 service connections. They can be designed as discrete, permanent zones or operated as "virtual" with multiple supply points metered. Other options include temporary zones where zonal valves are closed during a recurring evaluation period during late night hours. The use of step testing can also assist in the "narrowing" down of the possible leak location. These efforts can be very labor and/or capital intensive, but based on the current leakage levels, this investment is warranted.

Additionally, pressure optimization should be evaluated and piloted. The advantage of pressure optimization is that it can reduce all three components of leakage when most other intervention methods only target one component. Investment in pressure optimization should be engaged after other intervention methods have been installed to substantially reduce leakage levels.

Additionally, Galveston should continue in advancing a critical main condition assessment/leak detection program. This would be focused on the larger transmission mains and those that traverse under bodies of water. This program can establish the building blocks to a more comprehensive, system-wide asset management system.

A comprehensive Non-Revenue Water Management Program cannot be established overnight. Intervention projects and programs must be prioritized and only implemented with business case justification. Based on our experience, we would recommend a preliminary annual budget of approximately $250,000 annually to advance the NRW Program. This would include optimizing existing programs and the development of future initiatives.

AWWA M36 Standard Terminology

Data Validity
This is a measure of the reliability of the audit input data, and therefore the reliability of the audit output. Data Validity is quantified on a 1 – 100 scale.

Water Loss
This is simply the difference between water supplied and authorized consumption. Water loss consists of apparent loss plus real loss.

Apparent Loss
These are losses in customer consumption attributed to inaccuracies associated with customer metering, systematic data handling error and unauthorized consumption (theft). Apparent losses represent ‘paper losses’ or ‘commercial losses’ that result in uncaptured revenue for the water utility and distortion of customer consumption data. Apparent losses are valued at the retail rate.

Real Loss
These are the “physical” losses, largely leakage from the infrastructure: mains, valves, service lines, and tank overflows. Leakage occurrences are categorized as “reported” events, “unreported” events and background leakage. Real Losses are often valued at the variable production rate, but may also be valued at the customer retail rate if the source water resources are greatly constrained, such that any water saved in leakage control could be sold to an expanding customer base.

Unbilled Consumption
This represents any authorized consumption occurring in the water system for which no bill is issued and no revenue collected. This includes unbilled metered consumption, such as municipal buildings, and also includes unbilled unmetered consumption, such as flushing and fire-suppression.

Non-Revenue Water (NRW)
NRW equals real loss plus apparent loss plus authorized unbilled consumption.

Unavoidable Annual Real Loss (UARL)
UARL is the lowest real loss technically achievable in a water utility based on its key characteristics. The derivation of the UARL calculation is based on leakage data gathered from well-maintained and well-managed systems. Equations for calculating UARL for individual systems were developed and tested by the International Water Association’s Water Loss Task Force and published in 2000. The equations take into account measured frequencies, flow rates and durations of background losses, reported leaks and unreported leaks, as well as the pressure-leakage relationship (assumed to be linear for most large systems). Note: The UARL is strictly a reference value used in calculating performance indicators; it is not an actual component of leakage.

Infrastructure Leak Index (ILI)
The ratio of the Current Annual Real Losses (CARL) to the UARL. The ILI can be an effective performance indicator for comparing (benchmarking) the performance of utilities in operational management of real losses, once all justifiable pressure management measures have been undertaken. If rigorous leakage control existed such that the CARL was equal to the UARL, the ILI would then equal a value of “1”. However, such low leakage levels are rarely possible or economically justified for most water utilities. An ILI value less than “1” is highly unlikely and typically indicative of embedded data error(s) in the water audit.

AWWA Free Water Audit Software:
Reporting Worksheet

WAS v5.0
American Water Works Association.

? Click to access definition
\+ Click to add a comment

Water Audit Report for: Galveston
Reporting Year: 2017 | 1/2017 - 12/2017

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

All volumes to be entered as: MILLION GALLONS (US) PER YEAR

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.

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

WATER SUPPLIED

Master Meter and Supply Error Adjustments

								Pcnt:		Value:	
Volume from own sources:	+ ?	n/a	0.000	MG/Yr	+ ?				● ○		MG/Yr
Water imported:	+ ?	3	4,966.698	MG/Yr	+ ?	2		0.00%	● ○		MG/Yr
Water exported:	+ ?	n/a	0.000	MG/Yr	+ ?				● ○		MG/Yr

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

WATER SUPPLIED:	**4,966.698**	MG/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

					Pcnt:		Value:	
Billed metered:	+ ?	5	3,128.273	MG/Yr				
Billed unmetered:	+ ?	n/a	0.000	MG/Yr				
Unbilled metered:	+ ?	9	13.577	MG/Yr				
Unbilled unmetered:	+ ?	6	14.527	MG/Yr		○ ●	14.527	MG/Yr

Use buttons to select percentage of water supplied
OR
value

AUTHORIZED CONSUMPTION:	?	**3,156.377**	MG/Yr

WATER LOSSES (Water Supplied - Authorized Consumption) **1,810.321** MG/Yr

Apparent Losses

					Pcnt:		Value:	
Unauthorized consumption:	+ ?		12.417	MG/Yr	0.25%	● ○		MG/Yr

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

Customer metering inaccuracies:	+ ?	3	154.950	MG/Yr	4.70%	● ○		MG/Yr
Systematic data handling errors:	+ ?	5	7.821	MG/Yr	0.25%	● ○		MG/Yr

Default option selected for Systematic data handling errors - a grading of 5 is applied but not displayed

Apparent Losses:	?	**175.187**	MG/Yr

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses:	?	**1,635.134**	MG/Yr
WATER LOSSES:		**1,810.321**	MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER:	?	**1,838.425**	MG/Yr

= Water Losses + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

Length of mains:	+ ?	8	398.0	miles
Number of active AND inactive service connections:	+ ?	5	27,642	
Service connection density:	?		69	conn./mile main

Are customer meters typically located at the curbstop or property line? Yes

Average length of customer service line: + ? (length of service line, beyond the property boundary, that is the responsibility of the utility)

Average length of customer service line has been set to zero and a data grading score of 10 has been applied

Average operating pressure:	+ ?	3	63.0	psi

COST DATA

Total annual cost of operating water system:	+ ?	10	$12,609,832	$/Year
Customer retail unit cost (applied to Apparent Losses):	+ ?	10	$7.22	$/100 cubic feet (ccf)
Variable production cost (applied to Real Losses):	+ ?	8	$994.00	$/Million gallons

☐ Use Customer Retail Unit Cost to value real losses

WATER AUDIT DATA VALIDITY SCORE:

***** YOUR SCORE IS: 55 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: Water imported
2: Customer metering inaccuracies
3: Billed metered

AWWA Free Water Audit Software:
System Attributes and Performance Indicators

WAS v5.0

Water Audit Report for: Galveston
Reporting Year: 2017 1/2017 - 12/2017

***** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 55 out of 100 *****

System Attributes:

Apparent Losses:	175.187	MG/Yr
+ Real Losses:	1,635.134	MG/Yr
= **Water Losses:**	**1,810.321**	MG/Yr
? Unavoidable Annual Real Losses (UARL):	144.85	MG/Yr
Annual cost of Apparent Losses:	$1,690,859	
Annual cost of Real Losses:	$1,625,319	Valued at **Variable Production Cost**

Return to Reporting Worksheet to change this assumpiton

Performance Indicators:

Financial:

Non-revenue water as percent by volume of Water Supplied:	37.0%	
Non-revenue water as percent by cost of operating system:	26.5%	Real Losses valued at Variable Production Cost

Operational Efficiency:

Apparent Losses per service connection per day:	17.36	gallons/connection/day
Real Losses per service connection per day:	162.07	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	2.57	gallons/connection/day/psi

From Above, Real Losses = Current Annual Real Losses (CARL):	1,635.13	million gallons/year
? Infrastructure Leakage Index (ILI) [CARL/UARL]:	11.29	

* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline