2016 ANNUAL WATER AUDIT REPORT

BLACK & VEATCH PROJECT NO. 196020

PREPARED FOR

MIAMI-DADE COUNTY

Miami-Dade Water and Sewer Department

5 OCTOBER 2017

BUILDING A WORLD OF DIFFERENCE®

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Executive Summary

Miami Dade Water and Sewer Department (WASD) hired Black & Veatch (B&V) to complete the 2016 Water Audit following American Water Works Association (AWWA) methodology. The AWWA audit is a software tool that aids utilities with monitoring, calculating value, and validating water losses.

Project Background

B&V has prepared the past five annual water audit reports for WASD to fulfill the requirements of Miami Dade County's (County) water use permit issued by South Florida Water Management District (SFWMD).

Beginning in 2016, reporting requirements included in the water use permit were modified by SFWMD eliminating the annual water loss audit reduction plan. Though no longer required, WASD elected to complete an audit for calendar year 2016 (2016) using AWWA methodology as the report identifies key performance indicators (PI's) that assist with the prioritization of water loss interventions to reduce the WASD water losses in the most efficient manner possible.

Project Process

The B&V team evaluated data received from the WASD that enabled a desk top analysis to be conducted. The information evaluated included water supplied, authorized consumption, system data, and cost data. The information provided was validated using the AWWA grading matrix that is built into the AWWA water audit software. Validation grading is similar to a confidence factor and ranks data inputs from one to ten, with ten being the highest confidence. The audit data inputs enabled the WASD to identify the volume of water losses within the system, applied a cost to the water losses, and validated the accuracy of the data. Comments and recommendations were developed that will help the WASD reduce non-revenue water. Performance indicators were documented to help WASD measure the impact of current and future water loss interventions. These indicators aid in the development of strategic goal setting.

Project Findings

The overall validation grade for the 2016 water audit was 78 out of 100. This ranks the WASD solidly as a level IV (out of V) utility with regards to overall data accuracy. The overall validation grade has improved by five points since the initial audit conducted in 2011. This is a testament to the WASD making improvements in the way that they monitor and collect audit data.

WASD realized a slight increase in water loss from 2015 to 2016 though the 2016 audit value for water produced increased while the water billed through meters remained relatively consistent compared to 2015. The increase in water loss was minimal and could be a result of increased data accuracy. The Infrastructure Leakage Index (ILI), which is a reliable performance indicator with regards to water loss, improved from 11.16 to 10.96 from 2015 to 2016. Overall, the audit determined that there was minimal change in loss during 2016.

The WASD implemented substantial improvements during 2016 and 2017 that will reduce water loss. The implemented changes will reduce real (physical) loss by reducing water leakage through repair prioritization and increased data management. Additionally, the WASD has expanded the

large meter testing program which should reduce apparent (paper) loss as increased meter testing will identify and address problematic or inaccurate meters in a timely manner.

Conclusions

The WASD continues to improve the validation or accuracy of the data gathered for their annual water audits. During 2016 and 2017, the WASD has made and continues to make improvements that should reduce real and apparent loss for future audits.

The results herein are a result of data analysis and evaluations conducted on information provided for 2016.

Key Definitions

Water Supplied: Volume of water from the sources + Water Imported – Water Exported. Production, export, and import meter accuracy is factored when calculating the total water supplied component.

Real Losses: Physical Water losses from the pressurized system (water mains and customer service connections) and the WASD storage tanks, up to the point of customer consumption.

Apparent Losses = unauthorized consumption + customer metering inaccuracies + systematic data handling errors. Apparent Losses include all type of inaccuracies associated with customer metering (inaccurate meters as well as improperly sized meters or wrong types of meters for the water usage profile. This includes systematic data handling errors (errors in meter reading, billing, archiving, or reporting), plus unauthorized consumption (theft or illegal use).

Authorized Consumption = billed water exported + billed metered + billed unmetered + unbilled unmetered consumption. The volume of metered and/or unmetered water taken by registered customers, the WASD own uses, and uses of others who are implicitly or explicitly authorized to do so by the WASD for residential, commercial, industrial and public-minded purposes.

Non-Revenue Water = Apparent Losses + Real Losses + Unbilled Metered Consumption + Unbilled Unmetered Consumption. This is water which does not provide revenue potential to the utility

Infrastructure Leakage Index (ILI): The ILI is the ratio of real losses (physical losses) to the Unavoidable Annual Real Losses (UARL). The ILI is a highly effective performance indicator for benchmarking the performance of utilities in operational management of real losses.

Unavoidable Annual Real Losses (UARL): The UARL is the theoretical value that represents the technical low level of leakage achievable with optimal leak detection efforts using today's best technology.

1. Introduction

The project began by requesting data from various WASD staff to obtain all necessary information to complete the 2016 water audit. The data utilized for this audit was obtained from the production, billing, non-revenue, GIS, and financial sections of WASD. In addition to the initial data request, WASD personnel provided additional information on request as needed.

2. Audit Summary

Based on data reviewed, the performance indicators (PIs) reveal an increase in real and apparent losses while decreasing the infrastructure leak index (ILI). An increase in real and apparent losses was expected due to the high number of leaks identified in the 2015 audit which the repair crews were unable to fix in a timely manner. Contributing to the increase was the lack of prioritization of leak repairs which resulted in large leaks with long run times. As a result, the 2015 audit included a recommendation to classify leaks prioritizing repairs. WASD implemented this recommendation in 2017, ensuring that the largest leaks are repaired first and should substantially reduce real losses in the future. This overall trend of increasing losses mirrors that of the internal water accountability reports generated by WASD.

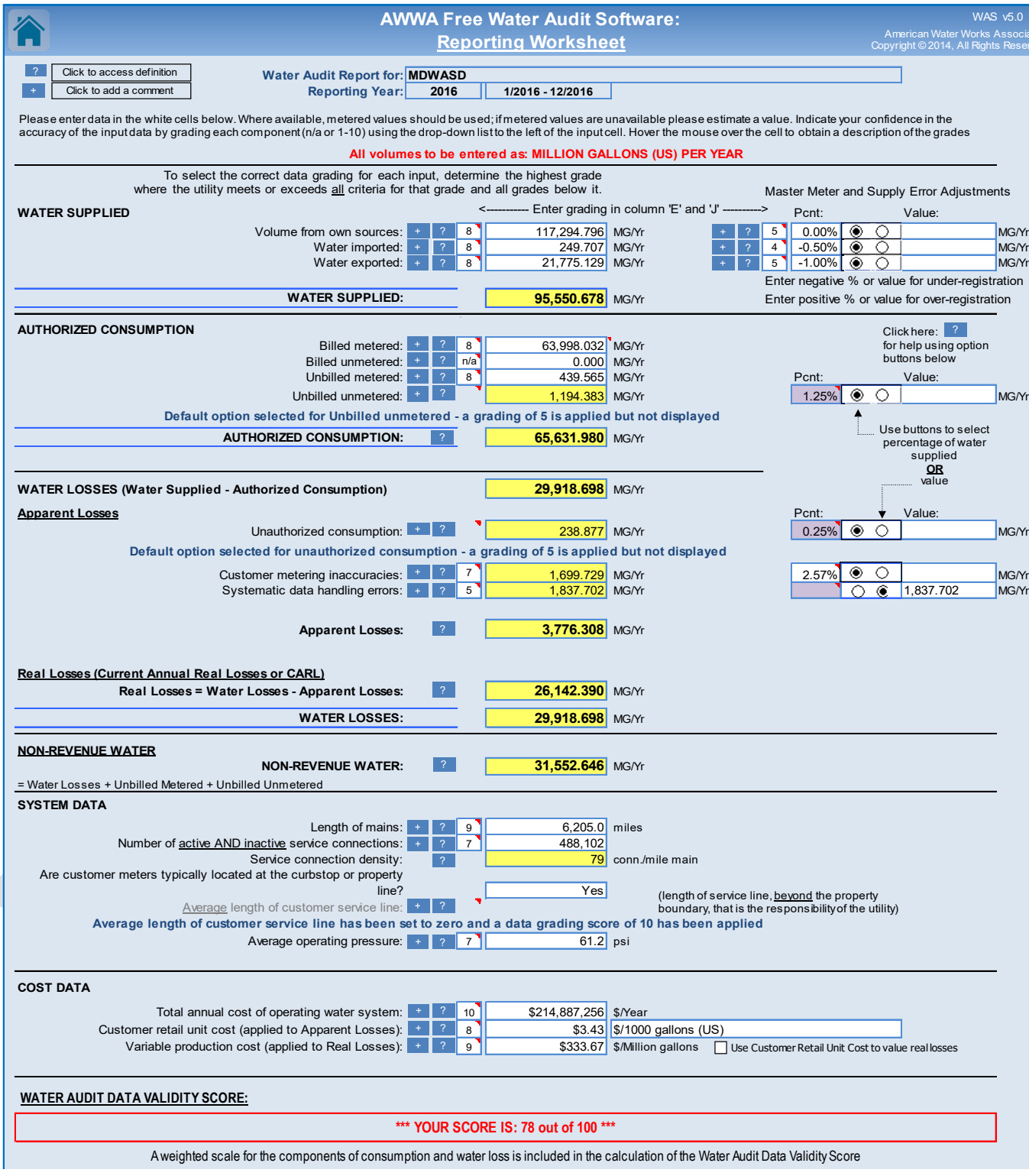
Several improvements have been implemented from late 2016 through mid-2017 that should reduce future water losses. These changes include: (1) the large customer meter testing program increased the number of meter test teams, from three to four, expanding the number of meter tests that can be completed each year; (2) implementation of a leak classification protocol to help prioritize water leak repairs; (3) employ a repair crew dedicated to repairing leaks identified by the leak detection program, (4) data management has increased throughout the leak detection process, and (5) a staff re-organization was implemented, allowing all facets of the program to fall under one umbrella. For additional details on these efforts, refer to the water loss section of this report.

2.1 AWWA/IWA Water Audit Pages

- Figure 2-1: 2016 AWWA/IWA (American Water Works/International Water Association) water audit worksheet. This worksheet lists the values of all components and validation grades.

- Figure 2-2: 2016 AWWA/IWA Water Balance

- Figure 2-3: 2016 AWWA/IWA Performance Indicator



AWWA Free Water Audit Software: Reporting Worksheet

WAS v5.0
American Water Works Associa
Copyright © 2014, All Rights Rese

? Click to access definition
+ Click to add a comment

Water Audit Report for: MDWASD
Reporting Year: 2016 | 1/2016 - 12/2016

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' ---------->

Master Meter and Supply Error Adjustments

WATER SUPPLIED			Pcnt:	Value:	
Volume from own sources:	8	117,294.796 MG/Yr	5	0.00%	MG/Yr
Water imported:	8	249.707 MG/Yr	4	-0.50%	MG/Yr
Water exported:	8	21,775.129 MG/Yr	5	-1.00%	MG/Yr

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

WATER SUPPLIED: 95,550.678 MG/Yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

			Pcnt:	Value:	
Billed metered:	8	63,998.032 MG/Yr			
Billed unmetered:	n/a	0.000 MG/Yr			
Unbilled metered:	8	439.565 MG/Yr			
Unbilled unmetered:		1,194.383 MG/Yr	1.25%		MG/Yr

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

AUTHORIZED CONSUMPTION: 65,631.980 MG/Yr

Use buttons to select percentage of water supplied OR value

WATER LOSSES (Water Supplied - Authorized Consumption) 29,918.698 MG/Yr

Apparent Losses

			Pcnt:	Value:	
Unauthorized consumption:		238.877 MG/Yr	0.25%		MG/Yr

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

Customer metering inaccuracies:	7	1,699.729 MG/Yr	2.57%		MG/Yr
Systematic data handling errors:	5	1,837.702 MG/Yr		1,837.702	MG/Yr

Apparent Losses: 3,776.308 MG/Yr

Real Losses (Current Annual Real Losses or CARL)

Real Losses = Water Losses - Apparent Losses: 26,142.390 MG/Yr

WATER LOSSES: 29,918.698 MG/Yr

NON-REVENUE WATER

NON-REVENUE WATER: 31,552.646 MG/Yr

= Water Losses + Unbilled Metered + Unbilled Unmetered

SYSTEM DATA

Length of mains:	9	6,205.0	miles
Number of active AND inactive service connections:	7	488,102	
Service connection density:		79	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:	7	61.2	psi

COST DATA

Total annual cost of operating water system:	10	$214,887,256	$/Year
Customer retail unit cost (applied to Apparent Losses):	8	$3.43	$/1000 gallons (US)
Variable production cost (applied to Real Losses):	9	$333.67	$/Million gallons ☐ Use Customer Retail Unit Cost to value real losses

WATER AUDIT DATA VALIDITY SCORE:

*** YOUR SCORE IS: 78 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

Figure 2-1 2016 AWWA/IWA Water Audit Worksheet

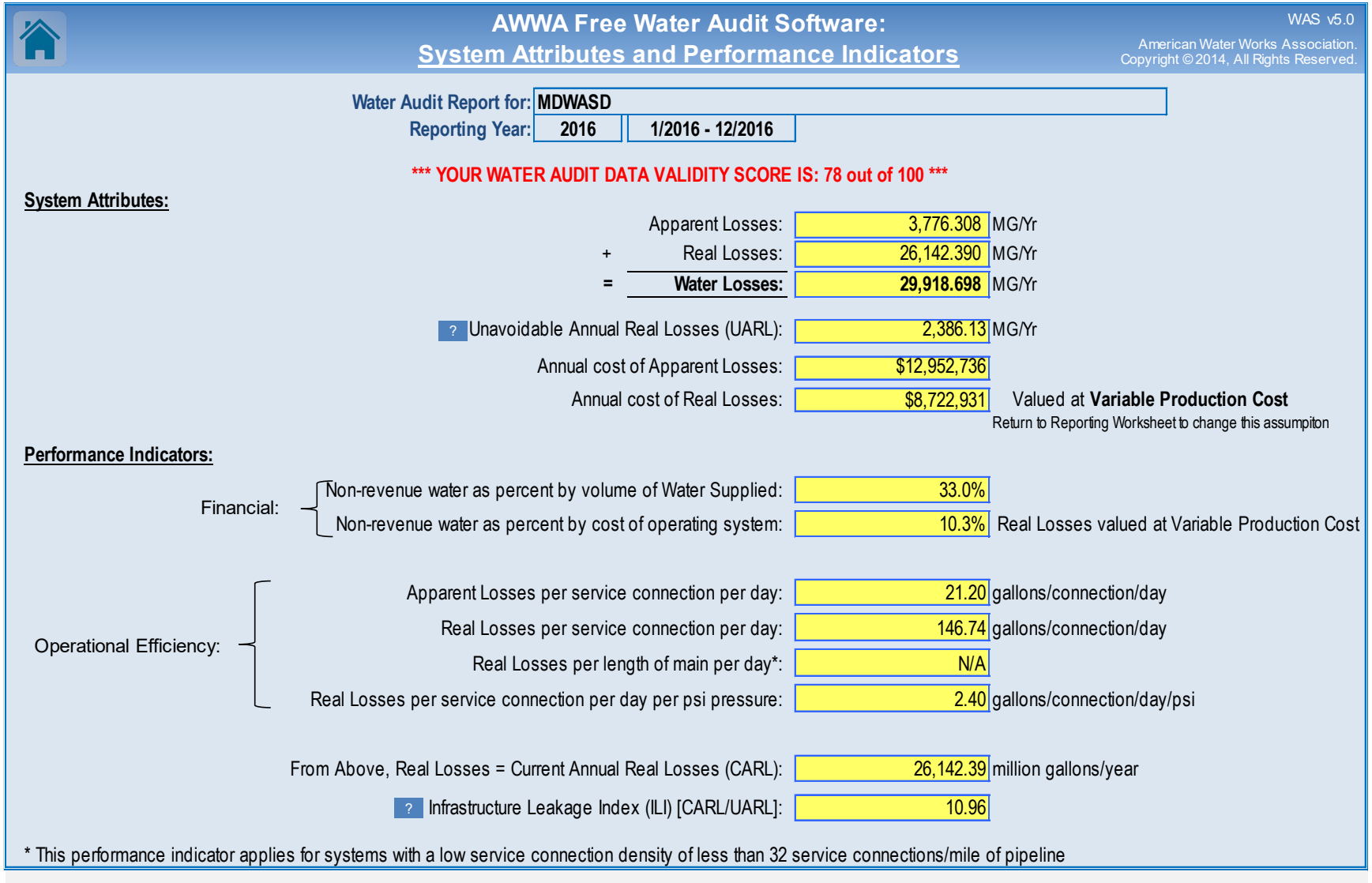
AWWA Free Water Audit Software: Water Balance

WAS v5.0

Water Audit Report for:	MDWASD	
Reporting Year:	2016	1/2016 - 12/2016
Data Validity Score:	78	

		Water Exported 21,995.080	Billed Water Exported			Revenue Water 21,995.080
Own Sources (Adjusted for known errors) 117,294.796	System Input 117,545.758	Water Supplied 95,550.678	Authorized Consumption 65,631.980	Billed Authorized Consumption 63,998.032	Billed Metered Consumption (water exported is removed) 63,998.032	Revenue Water 63,998.032
					Billed Unmetered Consumption 0.000	
				Unbilled Authorized Consumption 1,633.948	Unbilled Metered Consumption 439.565	Non-Revenue Water (NRW) 31,552.646
					Unbilled Unmetered Consumption 1,194.383	
			Water Losses 29,918.698	Apparent Losses 3,776.308	Unauthorized Consumption 238.877	
					Customer Metering Inaccuracies 1,699.729	
					Systematic Data Handling Errors 1,837.702	
Water Imported 250.962				Real Losses 26,142.390	Leakage on Transmission and/or Distribution Mains Not broken down	
					Leakage and Overflows at Utility's Storage Tanks Not broken down	
					Leakage on Service Connections Not broken down	

Figure 2-2 2016 AWWA/IWA Water Balance



AWWA Free Water Audit Software:
System Attributes and Performance Indicators

WAS v5.0

Water Audit Report for: MDWASD
Reporting Year: 2016 | 1/2016 - 12/2016

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 78 out of 100 ***

System Attributes:

	Apparent Losses:	3,776.308	MG/Yr
+	Real Losses:	26,142.390	MG/Yr
=	**Water Losses:**	**29,918.698**	MG/Yr
	? Unavoidable Annual Real Losses (UARL):	2,386.13	MG/Yr
	Annual cost of Apparent Losses:	$12,952,736	
	Annual cost of Real Losses:	$8,722,931	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:	33.0%	
	Non-revenue water as percent by cost of operating system:	10.3%	Real Losses valued at Variable Production Cost
Operational Efficiency:	Apparent Losses per service connection per day:	21.20	gallons/connection/day
	Real Losses per service connection per day:	146.74	gallons/connection/day
	Real Losses per length of main per day*:	N/A	
	Real Losses per service connection per day per psi pressure:	2.40	gallons/connection/day/psi
	From Above, Real Losses = Current Annual Real Losses (CARL):	26,142.39	million gallons/year
	? Infrastructure Leakage Index (ILI) [CARL/UARL]:	10.96	

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

Figure 2-3 2016 AWWA/IWA Performance Indicators

3. Water Supplied

[Calculation: Volume from Own Source + Imported Water – Exported (wholesale) water]

3.1 Volume From Own Sources

WASD provided water production data via internal documents titled "waterflows2016.xlsx", "Well 2016.xls", and "Water ProductionfromOrr-Hiah-Prestforyear2016.xlsx". The values calculated from these files may be different than those calculated for an internal water loss report as these values were calculated for the calendar year and not the fiscal year.

The 2016 input for the Volume from own Source component is 117,294.796 MG/year. This is an increase of 3,455.689 MG/year over 2015 values. WASD had a similar increase in production from 2014 to 2015. Table 3-1 lists the comparison in production for the past three calendar years.

Table 3-1 Annual Increase in Volume from Own Sources

PRODUCTION	2014	2015	2016
Volume from Own Sources	110,354.440	113,839.106	117,294.796
Increase (MG/Yr.)		**3,484.67 MG/Yr.**	**3,455.69 MG/Yr.**

Alexander Orr production appears to be the source of largest increase (+4.13%) in finished water produced. The difference registered at this plant is responsible for 2,741 MG/year of the 3,455.689 MG/year increase in 2016. Additionally, finished flow from the Hialeah Reverse Osmosis Plant increased 15% from the 2015 to 2016 audits. Table 3-2 lists the monthly finished flows listed on the "water flows" spreadsheet. Additionally, the table includes monthly produced volumes "water production spreadsheet" listed on the spreadsheet titled "Water Production from Orr-Hia-Prest for year 2016.xlsx".

There is a question about the accuracy of the Hialeah Reverse Osmosis (RO) plant finished flows. The RO plant is jointly owned by the County and the City of Hialeah (City). It is unclear if the finished water meters are read, since the City and County has an agreement to split (50/50) the water registered through the production meter. To calculate the finished water supplied from the Hialeah RO plant, WASD factors 50% of the water produced. WASD personnel are unsure if there are finished water meters from the RO WTP to the respective distribution systems.

The split of water between the City and County is based upon the actual SCADA totalizer information from the Monthly Operating Reports and then estimated to be 50%/50% through a SCADA graph of the year's split.

Table 3-2 2016 Finished Water Flows (*Source Plant Summary – water flows 2016*)

MONTH	HIALEAH	PRESTON	ORR	REX	RO HIALEAH (50%)	TOTAL PLANT SUMMARY (INTERNAL)	WATER PRODUCTION SPREADSHEET (INTERNAL)	WATER PRODUCTION SPREADSHEET + 50% RO
JAN	1,920.6	1,964.9	5,431.0	215.6	78.1	9,610.2	9,531.908	9,610.008
FEB	1,714.0	1,935.3	5,010.0	204.5	95.08	8,958.88	8,863.940	8,959.02
MAR	1,540.2	1,816.8	6,200.0	213.0	116.53	9,886.53	9,769.338	9,885.868
APR	1,584.1	2,392.2	5,608.0	212.8	112.74	9,909.84	9,797.038	9,909.778
MAY	1,621.9	2,552.9	5,548.0	230.3	116.50	10,069.6	9,953.017	10,069.517
JUN	1,560.0	2,367.3	5,328.0	221.4	112.21	9,588.91	9,476.556	9,588.766
JUL	1,874.0	2,501.7	5,511.0	228.8	116.41	10,231.91	10,095.805	10,212.215
AUG	1,692.1	2,445.6	5,562.0	213.9	116.51	10,030.11	9,912.920	10,029.43
SEP	1,638.2	2,369.4	5,378.0	210.5	113.15	9,709.25	9,595.864	9,709.014
OCT	1,547.4	2,444.4	5,472.0	220.1	116.44	9,793.95	9,683.760	9,800.20
NOV	1,532.3	2,039.4	5,624.0	214.4	112.9	9,517.3	9,409.928	9,522.828
DEC	1,715.2	2,288.8	5,657.0	221.2	116.36	9,992.8	9,881.792	9,998.152
Totals	**19,940**	**27,118.7**	**66,329**	**2,606.5**	**1322.93**	**117,317.13**	**115,971.866**	**117,294.796**

To better understand where production volumes increased during 2016, a review of 2015 production values was needed. The finished water from the RO treatment plant should be monitored to gain a better understanding of the Volume from Own Sources component. It is understood that the agreement calls for a 50/50 split, but from a water accountability standpoint, the most accurate method possible should be considered.

During the 2016 audit preparation, data received revealed a slight adjustment to the 2015 production data. These modifications resulted in very minimal overall changes to the 2015 Volume from Own Sources component. The value used for the 2015 water audit was 113,839.106 MG/year. After making adjustments to the 2015 production data, the value calculated to 113,817.812 MG/year. The changes resulted in a net reduction in production of 21.294 MG/yr. This adjustment was minimal and would have had very little impact on the 2015 water audit.

Table 3-3 lists the 2015 and 2016 monthly production totals from the Alexander Orr plant. The largest increases occurred during the first four months of the year, peaking in March. Further investigation is needed to identify possible reasons for the increases realized during this time. In addition to the increased production realized at the Alexander Orr plant, there was a 15% increase at the RO treatment plant during 2016.

Table 3-3 Alexander Orr Production Comparison (2015/16)

	2015 (MG/YR.)	2016 (MG/YR.)	INCREASE / DECREASE	
Month	**Orr**	**Orr**	**Volume**	**Percentage**
Jan	5,097.00	5,431.00	334.00	6.15%
Feb	4,524.00	5,010.00	486.00	9.70%
Mar	**5,329.00**	**6,200.00**	**871.00**	**14.05%**
Apr	5,248.00	5,608.00	360.00	6.42%
May	5,410.00	5,548.00	138.00	2.49%
Jun	5,362.00	5,328.00	-34.00	-0.64%
Jul	5,580.00	5,511.00	-69.00	-1.25%
Aug	5,449.00	5,562.00	113.00	2.03%
Sep	5,198.00	5,378.00	180.00	3.35%
Oct	5,388.00	5,472.00	84.00	1.54%
Nov	5,307.00	5,624.00	317.00	5.64%
Dec	5,697.00	5,657.00	-40.00	-0.71%
Total	**63,589**	**66,329**	**2,740**	**4.13%**

The largest increase occurred at the Alexander Orr WTP. Table 3-4 lists the increased production at each water treatment plant.

Table 3-4 Increased production volumes from 2015 to 2016

	HIALEAH	PRESTON	ORR	REX	50% RO HIALEAH	TOTALS
Increase MG/Yr.	261	264	2,741	14	200.62	3,480.62
Percent Increase	**1.31%**	**.97%**	**4.13%**	**.52%**	**15%**	**2.96%**

Values input for the Volume from own sources component are as follows:

2014 – Volume from own sources: 110,354.440 MG/Year

2015 – Volume from own sources: 113,839.107 MG/Year

2016 - Volume from own sources: 117,294.796 MG/ Year

To determine if weather may have contributed to the increase in production numbers, B&V evaluated the monthly weather for the past 3 years. It is not uncommon to see decreases in irrigation use during times of substantial precipitation. It is common to see production and consumption increase during summer months when the weather is generally hot and dry. Table 3-5 lists the average high temperature, monthly precipitation, average monthly temperature, and production volumes for 2015 and 2016. The highlighted cells indicate months with less than 1" of rain / precipitation. While the precipitation in March, April, and November 2016 was less than the norm, it seems unlikely that the weather played a large role in the production meter increases. The cells highlighted in light blue represent the 3 months of the year that recorded less than .5" of precipitation. The average temperature and precipitation remained relatively consistent for 2015 and 2016. The 2016 monthly production volumes increase each month (compared to 2015) regardless of precipitation or temperature variance. Several of the largest increases in production occurred during months when the precipitation increased. For this reason, it appears that weather had little to no impact on the water production requirements.

Table 3-5 Monthly Weather (Avg. High Temp | Precipitation | Avg. Temp) vs Production Volumes

	2015				2016			
Month	Avg. High Degrees	Precip (Inches)	Avg. Temp Degrees	Production MG/Yr.	Avg. High Degrees	Precip (Inches)	Avg. Temp Degrees	Production (MG/Yr.)
Jan	76.4	1.34	70.25	9,474.92	73.6	7.35	73.6	9,610.008
Feb	73.3	1.64	66.45	8,577.36	73.5	3.4	67.05	8,959.02
Mar	79.8	2.15	74.65	9,769.52	79.1	0.1	74.25	9,885.868
Apr	82.7	3.7	78.25	9,620.41	80.5	0.4	76	9,909.778
May	83.3	1.1	78.95	9,701.39	83	7.8	78.05	10,069.517
Jun	85.9	1.2		9,441	86.7	6.92	82	9,588.766
Jul	88.7	5.05	83.35	9,744.805	88.4	3.4	83.95	10,212.215
Aug	88.6	6.75	83.35	9,630.419	88.2	9.81	83.3	10,029.43
Sep	88.2	12.85	82.7	9,174.719	87.4	4	87.4	9,709.014
Oct	85.5	4.37	85.5	9,657.819	84.2	11.2	79.7	9,800.20
Nov	82.3	8.75	78.45	9,316	79.3	0.5	74.6	9,522.828
Dec	80.8	8.4	77.05	9,709.45	80	3.2	75.6	9,998.152
Total	83.0	57.3	78.1	113,817.812	82.0	58.1	78.0	117,294.796

3.2 Master Meter Accuracy – Production Meters

WASD conducts electronic calibration on their large production meters. Test certificates were provided and all meters were found to be within allowable limits. Most calibrations resulted in

100% accuracy. Because of this, there is no master meter error adjustment recorded for 2016. Data received lists that 34 calibrations occurred on 26 meters during the audit period.

3.3 Water Imported

WASD purchases water from the cities of Homestead and North Miami Beach. The volume purchased from the City of Homestead increased from 34,901,000 gallons to 163,300,000, an additional 128,399,000 gallons, an increase of 368%. Overall, the volume of water purchased in 2016 doubled compared to 2015. This included an approximate 3.8% reduction in water purchased from the City of North Miami Beach. Table 3-6 lists the monthly total gallons purchased during 2015 and 2016. Because the data received is in 1,000 gallons, the accuracy could be increased if rounding had not occurred.

Table 3-6 2015 & 2016 Water Imported (MR/Yr.)

WATER PURCHASED / IMPORTED (MG/YR.)						
Month	Homestead 2015	Homestead 2016	North Miami Beach 2015	North Miami Beach 2016	Total 2015	Total 2016
January	410	10,495	12,474	6,529	12,884	17,024
February	3,032	7,713	5,188	4,572	8,220	12,285
March	2,460	9,291	6,305	7,335	8,765	16,626
April	2,840	10,907	7,750	6,099	10,590	17,006
May	3,030	8,902	8,201 (estimate)	6,326	11,231	15,228
June	10	7,256	8,387	8,516	8,397	15,772
July	1,183	1,209	11,414	7,850	12,597	9,059
August	3,632	16,852	10,894	14,916	14,526	31,768
September	1,037	19,038	4,697	6,815	5,734	25,853
October	4,922	11,023	4,290	5,416	9,212	16,439
November	6,472	30,999	5,335	6,940	11,807	37,939
December	5,873	29,615	4,898	5,093	10,771	34,708
Total	**34,901 MG**	**163,300 MG**	**89,833 MG**	**86,407 MG**	**124,734 MG**	**249,707 MG**

The water purchased input of 249,707 was consistent between the data received and the internal "Unaccounted for Water Report".

3.4 Master Meter Accuracy – Import Meters

There is no test result data available for import water meters. The utility providing the water for purchase is generally responsible for the testing and maintenance of import meters. Because there were no changes to the way that this component is managed, the input of -0.50 % under-registration of total throughput was used. This percentage was used for the 2015 water audit.

3.5 Water Exported

WASD continues to sell or export water to 15 wholesale customers through 81 wholesale meters (Table 3-7). The volume exported represents the monthly totals supplied to wholesale customers. These customers fall under the water supplied section of the water audit and are not counted as billed metered or retail customers. Wholesale customers have their own regulatory reporting requirements and manage their own water losses. The volume input for 2016 water exported component was derived from each monthly invoice for all wholesale meters.

Table 3-7 2014-2016 wholesale customer volume totals

WHOLESALE CUSTOMERS	2014 (GALLONS)	2015 (GALLONS)	2016 (GALLONS)	VARIANCE 2015 / 2016 (GALLONS)
Miami Beach	7,581,004,000	8,451,039,000	8,465,076,000	14,037,000
Hialeah	7,105,359,000	6,713,718,000	6,718,276,340	4,558,340
North Miami	1,823,132,000	1,836,723,000	1,692,182,448	-144,540,552
Opa-Locka	916,486,000	960,675,000	969,285,328	8,610,328
Hialeah Gardens	591,156,000	742,288,000	766,175,652	23,887,652
Medley	481,176,000	357,569,000	346,327,600	-11,241,400
North Bay Village	408,685,000	428,449,000	422,561,656	-5,887,344
Bal Harbour	398,741,000	514,266,000	498,072,256	-16,193,744
Surfside	314,790,000	322,934,000	327,061,504	4,127,504
Bay Harbor Islands	305,653,000	319,073,000	295,066,352	-24,006,648
West Miami	270,650,000	254,527,000	334,300,648	79,773,648
Homestead	216,829,000	649,068,000	660,325,132	11,257,132
Indian Creek Village	118,073,000	126,456,000	124,088,712	-2,367,288
Virginia Gardens	87,931,000	82,074,000	83,237,440	1,163,440
North Miami Beach	806,000	3,080,000	73,090,072	70,010,072
Wholesale Water Sold (Gallons)	**20,620,471,000**	**21,761,939,000**	**21,775,127,140**	**13,188,140**
Retail (Gallons)	63,470,026,000	63,794,433,000	63,998,032,000	203,599,000
Total Water Sold (Gallons)	**84,090,497,000**	**85,556,372,000**	**85,773,159,140**	**216,787,140**

Water sold to wholesale customers increased by 13,188,140 gallons in 2016 compared to 2015. This variance included an increase in volume from 3,080,000 gallons to 73,090,072 gallons for North Miami Beach and a 144,540,522 gallon reduction from North Miami. Of note, the 10" meter (ID#947401) located at NE 161st St & NE 18th Ct. (Sunny Isles), in the City of North Miami Beach, registered 59,959,680 of the 73,010,072 gallon variance. While there were several substantial increases like Hialeah Gardens, West Miami, and North Miami Beach, there were also several substantial decreases as seen with North Miami, Medley, Bal Harbour, and Bay Harbor Islands. Overall, the total water exported remained relatively consistent over the past 3 years.

3.6 Master Meter Accuracy – Export Meters

With the available test data, it is not possible to determine the "as found" accuracy of the export (wholesale) meters. The data suggested that several large meters were tested and it is assumed that many were wholesale meters. The test data received shows the "as left" test result, so it is not possible to calculate a weighted average by type. Of the over 280 large meters tested, very few meters needed to be replaced. The export/wholesale meter inaccuracy input for 2016 is – 1.0% (under-registration of throughput) accuracy (no change from previous audit).

The Water Supplied component was calculated by taking the Volume from Own Source component (117,294.796 MG/year) plus the water imported component (249.707 MG/year) less the Wholesale Water exported component (21,775.129 MG/year) as per Equation 1:

Equation 1: Supplied Water

$$Water\ Supplied = Volume\ from\ own\ Source + Imported\ Water - Exported\ Water$$

By using this formula, the initial water supplied value calculates to 95,769.374 million gallons (prior to calculating meter error).

To increase the accuracy of this component, adjustments were made based on the estimated accuracy of the production, import, and export meters. Electronic calibrations were conducted and revealed that the production meters, based on electronic calibration of the transmitters (Venturi Meters), appear to be highly accurate. The import meter accuracy was estimated to under-register by an average of -0.5% and the export meters were calculated using an average under-registration of -1%. The total adjustment made to the water supplied section based on under-registration of meters resulted in a decrease of 218.696 million gallons and corresponding net water supplied of 95,550.678 MG/Yr. Table 3-8 lists yearly supplied water from 2013 to 2016 and the variance between years.

Table 3-8 Yearly comparison of the Water Supplied component

COMPONENT	2013 (MG/YR.)	2014 (MG/YR)	2015 (MG/YR.)	2016 (MG/YR.)
Water Supplied	86,887.594	89,582.983	91,982.709	95,550.678
Supplied Diff		2,695.39 MG/Yr.	2,399.73 MG/Yr.	3,567.969 MG/Yr.

Values input for the Water Supplied components are as follows:

2015 Water Supplied: 91,982.709 MG/year

2016 Water Supplied: 95,550.678 MG/year

3.7 Water Supplied Validation Grades

As part of the AWWA/IWA methodology, a grading matrix has been developed to assign a grade for each component of the water audit. The grading matrix is based on a scale from one to ten, ten

being the highest level of confidence in the accuracy of the data. See the comments and recommendations section of this report to identify the steps necessary to increase the validation grade for each component. See the grading matrix tab of the water audit software to gain an understanding of what is required for each grade. The grading matrix is customized for each individual component.

Table 3-9 lists the audit validation grade comparison between the 2015 and 2016 water audits. During 2016, there were no changes to the way production, export, or import meter data was managed. For this reason, the validation grade remained the same for both years. To understand the needs to improve the validation grade for the 2017 audit, see the data validation summary along with the comments and recommendations sections of this report.

Table 3-9 Water Supplied Validation Grading

GRADED VARIABLE	2015 GRADING	2016 GRADING	REASONING
Volume from Own Sources	8	8	Calibration conducted annually, occasional flow testing
Master Meter Error	5	5	Meter calibrations conducted, continuously evaluated
Water imported	8	8	Calibrations conducted annually by wholesale entities. Results not known.
Water Exported	8	8	Meters tested bi-annually. Not all configurations allow for flow testing

4. Authorized Consumption

Authorized consumption is calculated by taking the volume of water sold through registered customers (not wholesale) as well at other usage authorized and tracked by WASD as part of their Non-Revenue Water programs.

Equation 2 Authorized Consumption

$$Authorized\ Consumption = billed\ metered + Billed\ unmetered + Unbilled\ metered + Unbilled\ unmetered$$

For example, fire-fighting and training, sewer line flushing, flushing of water mains, street cleaning, water use at WASD facilities, etc.

4.1 Metering Systems

During 2016, nearly 100 Automatic Meter Reading (AMR) meters were installed for difficult to read customers as requested by the Customer Service Division. Data from these meters can be collected automatically without having to physically access the meter. WASD continues on-going maintenance of the Miami Springs Automatic Metering Infrastructure (AMI) meters. AMI is an integrated system of smart meters that allow for two way communication. This enables utilities to read meters quickly and as often as desired.

4.1.1 Meter Change-outs

WASD continues to replace meters that are 14 years and older as part of their standard protocol. They intend to abandon the meter replacements as they get closer to installing AMI meters county-wide. In-situ comparative flow testing of all 3" through 10" turbine meters will continue as part of standard operating procedures. WASD's meter test goals have not changed and there are no plans to change testing frequencies.

4.2 Billed Metered Summary

WASD system is reportedly 100% metered. The Billed Metered component includes residential, commercial, industrial, and institutional customers within WASDs service area and make up the majority of authorized consumption. As noted in previous sections, wholesale or water exported is calculated as part of the water supplied section and is not factored into the billed metered component. WASD continues to maintain the same meter testing goals as in previous years, but personnel issues prevented them from reaching their test goals. With two of three meter test technicians being promoted, the test crew is training new technicians which could impact the meter test program in the future. Ninety percent of the meters in the system are classified as residential which account for approximately 70% of the billed metered consumption. Table 4-1 compares the value of water billed in 2015 and 2016.

Table 4-1 Monthly billed retail meter usage 2015 vs. 2016 (MG)

MONTH	2015 (MG)	2016 (MG)	DIFFERENCE (MG)
Jan	5,565.112	4,867.709	-697.403
Feb	4,994.525	5,102.534	108.009
Mar	5,510.724	5,472.621	-38.103
Apr	5,152.996	4,929.799	-223.197
May	5,056.945	5,432.401	375.456
Jun	5,562.511	5,832.822	270.311
Jul	6,292.895	5,217.284	-1,075.611
Aug	4,402.881	5,729.887	1,327.006
Sep	5,331.118	5,291.367	-39.751
Oct	5,606.248	5,687.800	81.552
Nov	5,013.703	5,248.671	234.968
Dec	5,304.775	5,185137	-119.638
Total	**63,794.433 (MG)**	**63,998.032 (MG)**	**203.599 (MG)**

The Billed metered values input for 2016 showed an increase of 203,599 MG vs. 2015.
Values input for the Billed Metered component are as follows:

2015 – Billed Metered: 63,794.433 MG/Year

2016 – Billed Metered: 63,998.032 MG/Year

4.3 Billed Unmetered Summary

There is reportedly no billed unmetered consumption. The input for the Billed Unmetered component was 0 MG for the 2016 audit.

4.4 Unbilled Metered

There is usually a small amount of water in the unbilled metered component. The unbilled metered value includes WASD facilities that are not charged for water use. The data for this input was derived from the PDF entitled "Data 2016.pdf". The report is called the "Unaccounted Water Report" as named in the subject line. This report lists quarterly water produced and purchased as well as water sold to retail and wholesale customers. Under the water sold section, the report includes WASD Facilities.

WASD included in the project data the file "WASD-2016-UDSLs.pdf". This file contains the "Estimated Accounted for Water" report. This internal report lists values from January 2012 through December 2016 and includes water produced, purchased, and sold; non-revenue water, adjustments that include flushing, leak detection, gravity main cleaning and under-registration of meters. Furthermore, it includes a column for WASD Facilities and provides a column of "unaccounted for" distribution losses.

Table 4-2 lists the unbilled metered volume by quarter. For the 2016 water audit, the volume of water supplied to WASD facilities was derived from the Unaccounted-for Water report which is generated from billing. The increase in 2016 is likely due to improved tracking of WASD facility usage that is billed as zero.

Table 4-2 Unbilled Metered Volume by Quarter for 2016

UNBILLED METERED (MG)	1ST QUARTER	2ND QUARTER	3RD QUARTER	4TH QUARTER	TOTAL
WASD Facilities ("Unaccounted Water" Report")	104.687	112.137	131.877	90.294	438.995
Cleaning gravity / sewer lines	0.139	0.140	0.144	0.147	0.570
2016 Totals	**104.826**	**112.277**	**132.021**	**90.441**	**439.565**

Values input for the Unbilled Metered component are as follows:

2015 Unbilled Metered: 11.475 MG/Year

2016 Unbilled Metered: 439.565 MG/Year

4.5 Unbilled Unmetered

The unbilled unmetered component is difficult to accurately calculate. This component is made up of the sum of the various flushing exercises that occur throughout the year. This flushing includes fire-fighting and training; distribution line flushing (including auto flushers), and all other water consumption that is not metered. Table's 4-3, 4-4, and 4-5 list the estimated water used for flushing during 2015 and 2016. Water used for Vactor (sewer cleaning) trucks has not been estimated since January 2015.

For WASD's past audits, the estimates provided by WASD have appeared to be low for a system of this size so the audit default of 1.25% of water supplied was input for all previous audits. While the volume of unbilled unmetered water documented by WASD increased from 232 MG in 2015 to 468 MG in 2016, the value still appears to be quite low for a system of this size. See the comments and recommendations section of this report for ways to improve the validation of the unbilled unmetered component.

Table 4-3 lists the summary of unbilled unmetered estimates for 2015 and 2016. This information was derived from the internal "Non-Revenue Water Audit Report" supplied by WASD. The table lists five flushing categories currently estimated by WASD personnel.

Table 4-3 Annual comparison of Flushing Estimates (internal Non-Revenue Water Audit Report)

YEAR	INSPECTION	DISTRIBUTION	AUTOMATIC DEVICES	FIRE WASD-CORAL GABLE/CITY OF MIAMI/MIAMI DADE COUNTY	HYDRANT SECTION	TOTAL (GALLONS)
2015	41,819,000	157,817,695	25,367,140	5,603,955	1,461,890	232,069,680
2016	202,194,370	237,999,880	25,205,628	189,996	2,541,729	468,131,603

Due to the increased flushing estimates realized in 2016, the 2015 and 2016 quarterly estimates (Table 4-4 and Table 4-5) are included for comparison.

Table 4-4 2015 Flushing Estimates (internal Estimated Non-Revenue Water Audit Report)

FLUSHING WATER ACCOUNTED – ESTIMATED FOR QUARTERLY INTERNAL NRW REPORT							
Month/Qtr.	Inspection	Distribution	Automatic Devices	Fire WASD-Coral Gable/City of Miami/Miami Dade County	Hydrant Section	Vactor Trucks Usage	Total (Gallons)
Jan	2,831,311	10,409,565	2,111,400	1,198,287	155,641	202	16,706,406
Feb	4,080,541	7,834,731	1,958,400	1,271,791	142,811	0	15,288,274
Mar	169,130	17,673,430	2,142,000	1,312,816	191,685	0	21,489,061
Qtr. 1	**7,080,982**	**35,917,726**	**6,211,800**	**3,782,894**	**490,137**	**202**	**53,483,741**

Apr	344,172	11,747,486	2,050,200	1,285,466	125,238	0	15,552,562
May	5,315,237	7,625,382	2,111,140	440,597	197,880	0	15,690,236
Jun	5,327,896	6,859,175	2,111,400	0	145,070	0	14,443,541
Qtr. 2	**10,987,305**	**26,232,043**	**6,272,740**	**1,726,063**	**468,188**	**0**	**45,686,339**
Jul	3,529,352	11,185,662	2,264,400	15,833	0	0	16,995,247
Aug	5,073,431	7,071,124	2,111,400	15,833	0	0	14,271,788
Sep	4,208,311	10,773,404	2,111,400	15,833	0	0	17,108,948
Qtr. 3	12,811,094	29,030,190	6,487,200	47,499	0	0	48,375,983
Oct	3,990,727	6,589,129	2,111,400	15,833	159,695	n/a	12,866,784
Nov	4,996,107	54,537,397	2,142,000	15,833	126,238	n/a	61,817,575
Dec	1,952,785	5,511,210	2,142,000	15,833	217,632	n/a	9,839,460
Qtr. 4	10,939,619	66,637,736	6,395,400	47,499	503,565	n/a	84,523,819
Total	**41,819,000**	**157,817,695**	**25,367,140**	**5,603,955**	**1,461,890**	**202**	**232,069,882**

During 2016, flushing estimates increased dramatically in the categories of inspection, distribution, automatic devices and the hydrant section (Table 4-5). A reduction in flushing occurred in the category of fire use at the City of Coral Gables, City of Miami and Miami Dade County. This shows that increased tracking will provide WASD with a more accurate account of apparent and real loss.

Table 4-5 2016 Program Estimates (internal Estimated Non-Revenue Water Audit Report)

MONTH/QTR	INSPECTION	DISTRIBUTION	AUTOMATIC DEVICES	FIRE WASD-CORAL GABLE/CITY OF MIAMI/MIAMI DADE COUNTY	HYDRANT SECTION	TOTAL (GALLONS)
Jan	169,130	12,897,765	2,142,000	15,833	148,211	15,372,939
Feb	5,686,414	17,110,369	2,080,800	15,833	99,920	24,993,336
Mar	11,220,546	17,821,204	2,111,140	15,833	203,491	31,516,670
Qtr. 1	**17,220,546**	**47,829,338**	**6,333,940**	**47,499**	**451,622**	**71,882,945**
Apr	30,085,366	10,740,460	2,111,400	15,833	151,236	43,104,295
May	12,266,624	8,166,810	2,142,000	15,833	93,301	22,684,568
Jun	7,159,845	9,116,171	2,111,400	15,833	193,781	18,597,030
Qtr. 2	**49,511,835**	**28,023,441**	**6,364,800**	**47,499**	**438,318**	**84,385,893**
Jul	4,135,370	9,783,213	2,111,400	15,833	101,889	16,147,705
Aug	3,282,040	16,425,253	2,111,400	15,833	195,968	22,030,494

Sep	4,780,370	6,319,281	2,111,400	15,833	745,448	13,972,332
Qtr. 3	12,197,780	32,527,747	6,334,200	47,499	**1,043,305**	**52,150,531**
Oct	16,448,491	8,705,790	1,949,888	15,833	209,113	27,329,115
Nov	29,135,766	36,185,507	2,111,400	15,833	300,654	67,749,160
Dec	77,679,952	84,728,057	2,111,400	15,833	98,717	164,633,959
Qtr. 4	123,264,209	129,619,354	6,172,688	47,499	608,484	259,712,234
Total	**202,194,370**	**237,999,880**	**25,205,628**	**189,996**	**2,541,729**	**468,131,603**

As WASD develops accounting protocols for the unbilled unmetered component, they will be able to move away from software defaults as accuracy continues to increase. The unbilled unmetered values that have been calculated and inputs are listed below:

2015: Estimated Unbilled Unmetered calculated by WASD: 232.069 MG/Year

2015: Audit Input calculated at 1.25% of Water Supplied: 1,149.784 MG/Year

2016: Estimated Unbilled Unmetered calculated by WASD: 468.132 MG/Year

2016: Audit Input calculated at 1.25% of Water Supplied: 1,194.383 MG/Year

2015: Total Authorized Consumption – 64,611,518 MG/Year

2016: Total Authorized Consumption – 65,631.980 MG/Year

4.6 Authorized Consumption Validation grading

Table 4-6 lists the audit validation grades for the Authorized Consumption component for 2015 and 2016. The validation grading for the Authorized Consumption sub-components remained unchanged from 2015 and 2016. See the Data Validations Improvements Summary section of this report to identify changes that will increase the validation grading for future audits.

Table 4-6 Authorized Consumption Validation Grading

GRADED VARIABLE	2015 GRADING	2016 GRADING	REASONING
Billed Metered	8	8	Good billing systems. Slight reduction in meter testing occurred due to man power. Now employ 4 technicians dedicated to testing water meters. Continued regular replacement of oldest meters.
Billed Unmetered	n/a	n/a	No billed unmetered consumption reported
Unbilled	8	8	Unbilled meter are read and maintained in the same manner as retail

GRADED VARIABLE	2015 GRADING	2016 GRADING	REASONING
Metered			meters. Still need to evaluate testing and billing procedures for unbilled properties
Unbilled Unmetered	5	5	The default was used for this variable

5. Water Losses

Water loss within a system is equal to total water supplied less total authorized consumption. Total water loss is the sum of real losses (water loss through leakage plus tank overflows and leaks) plus apparent losses (paper loss attributed to inaccurate meters and data handling/billing errors).

5.1 Internal Water Loss Reporting

In addition to the annual IWA/AWWA water audit, WASD prepares internal quarterly accountability/non-revenue related reports. As a comparison, the internal reports are discussed in this section to enable WASD personnel to easily identify the differences between all internal water loss reporting methodologies and the AWWA audit. The three internal reports are as follows:

1. The first internal report is referred to as the Water Accountability Section's "Estimated Non-Revenue Water Audit Report". This report lists the quarterly estimated leakage within the water distribution and transmission systems for 2016 and breaks down real losses by estimating gallons lost by types of leakage and estimated gallons of leakage by pipe size. This report contains leak estimate (real loss) information only. This data was derived from the file "Worksheet with 4 Quarters together.xls" provided as part of the AWWA water audit data request.

   Table 5-1 lists the quarterly water loss estimates due to leakage for the past 3 years. This data was derived from the Water Accountability Section "Estimated Non-Revenue Water Audit Report" and can be located in the file "Worksheet with 4 Quarters together.xls". This report estimates the water recovered by leak repair, but is not tied to the repairs. The values are as if all leaks were repaired. The AWWA audit does not have a leak component and does not account for water leaks as authorized consumption.

Table 5-1 Estimated Water Recovery due to leakage (Estimated Non-Revenue Water Audit Report)

QUARTER	FY 2014 (GALLONS)	FY 2015 (GALLONS)	2016 (GALLONS)
1st	3,322,980,054	3,623,975,593	4,277,941,108
2nd	2,859,769,742	3,022,506,607	4,225,502,499
3rd	3,308,826,838	3,413,153,030	3,642,660,042
4th	2,519,987,788	2,608,312,677	2,501,152,927
Estimated Total	**12,011,564,422**	**12,667,947,907**	**14,647,256,576**

2. WASD's report titled "Distribution System Water Accounting" is used to determine the "estimated accounted for water". This is a term used internally by WASD to calculate their non-revenue water. It is the total value of water supplied less authorized consumption (including leak estimates). It includes quarterly data from January of 2012 through December 2016 on water produced, purchased, distributed and sold. These components are used to calculate percentage of loss. Adjustments are then made by deducting authorized consumption. The authorized water consumption tracked on this report includes uses for fire, flushing, estimated leak recovery, cleaning of gravity mains and under-registration of meters (factored at -4.5%). This value was calculated as a "conservative" accuracy figure in 1995 when a study suggested that older meters in the system were under-registering by 6%. Due to substantial changes in the meter testing program, WASD should consider updating this value for future internal water loss reports.

   Water used by WASD facilities is then deducted and an annual percentage of non-revenue water is calculated. Figure 5-1 shows estimated annual "unaccounted for distribution losses". Because this report uses non-revenue water as a percentage of total water supplied as the key PI, the percentage varies from quarter to quarter (doubled in some cases). The overall trend of this report indicates that the overall estimated percentage has continued to increase over time. This report was provided as part of the AWWA water audit data request. The file is titled "WASD-2016-UDSLs.pdf".

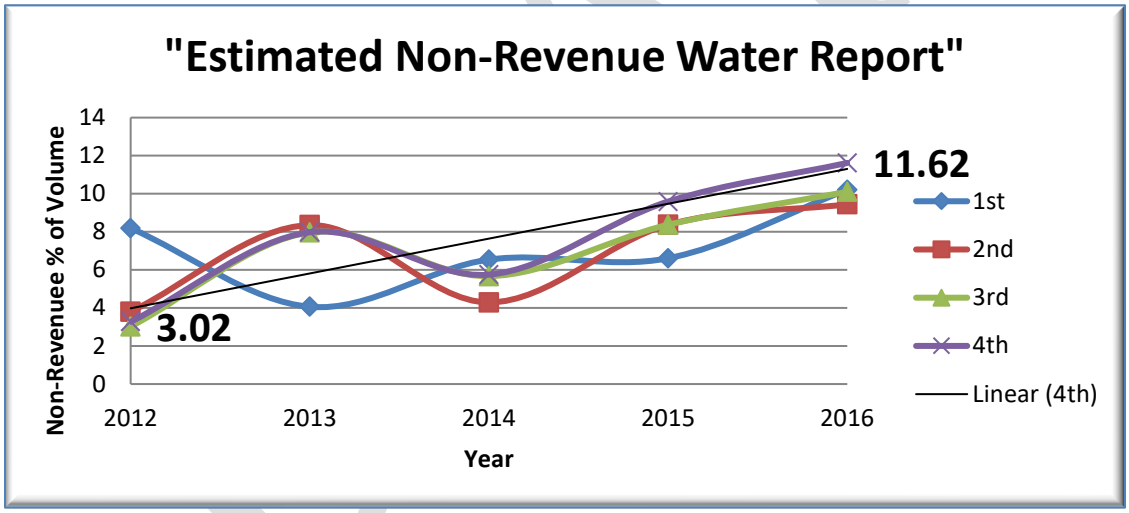


Figure 5-1 Internal estimated Non-Revenue Water Report

Figure 5-2 shows the average annual percentage of non-revenue water based on water produce less water sold. This does not account for authorized or unauthorized consumption other than water sold.

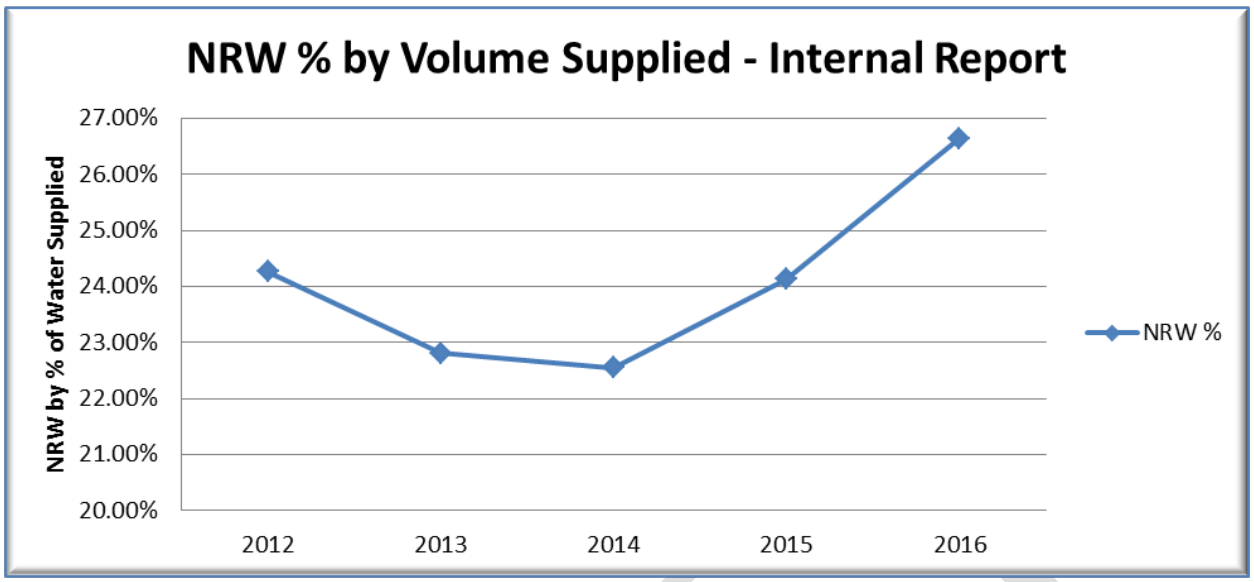


Figure 5-2 Internal Non-Revenue Water Report

Table 5-2 lists the quarterly data used to calculate the estimated accounted for water in 2016. The PI of percentage of volume increased 2.18% from the 2nd quarter to the end of the 4th quarter. The 4th quarter flushing is highlighted to show the somewhat dramatic increase in flushing conducted during the 4th quarter. The internal audit methodology identifies "Unaccounted for Water" and factors the estimated losses due to leakage as authorized consumption. The AWWA methodology identifies non-revenue water and identifies apparent losses. The real loss (leakage) is not estimated as authorized consumption.

Table 5-2 Quarterly Data from Internal Report for 2016

DATA FROM INTERNAL "ESTIMATED ACCOUNTED FOR WATER" REPORT					
2016	**1st Qtr.**	**2nd Qtr.**	**3rd Qtr.**	**4th Qtr.**	**1000/Gallons**
Produced + Purchased	28,552,671	29,587,243	30,036,686	29,410,289	117,586,889
Water Sold = Retail |Wholesale | WASD Facilities	20,699,434	21,960,425	21,995,506	21,598,021	86,253,386
Non-Revenue Water	7,853,237	7,626,817	8,041,179	7,812,268	31,333,502
AVG % UFW	27.50%	25.78%	26.77%	26.56%	
ADJUSTMENTS					
Fire Dept.	47	47	47	47	188
Flushing	71,835	84,338	52,103	259,665	467,941

Leak Estimates	139	140	144	147	570
Under-Registration of Meters	931,475	988,219	989,798	971,911	3,881,403
WAASD Facilities – Not Retail	925	1,110	1,175	842	4,052
DISTRIBUTION LOSSES					
Total After Adjustments	2,570,875	2,327,462	3,355,253	4,078,503	12,332,093
Annual Percentage	10.21%	9.44%	10.10%	11.62%	10.34%

Figures 5-3 and 5-4 display the volume of water supplied and sold per year as documented in the estimated accounted for water report. Slight variations in totals compared to the AWWA water audits are likely due to rounding numbers or data received for the calendar year instead of a fiscal year.

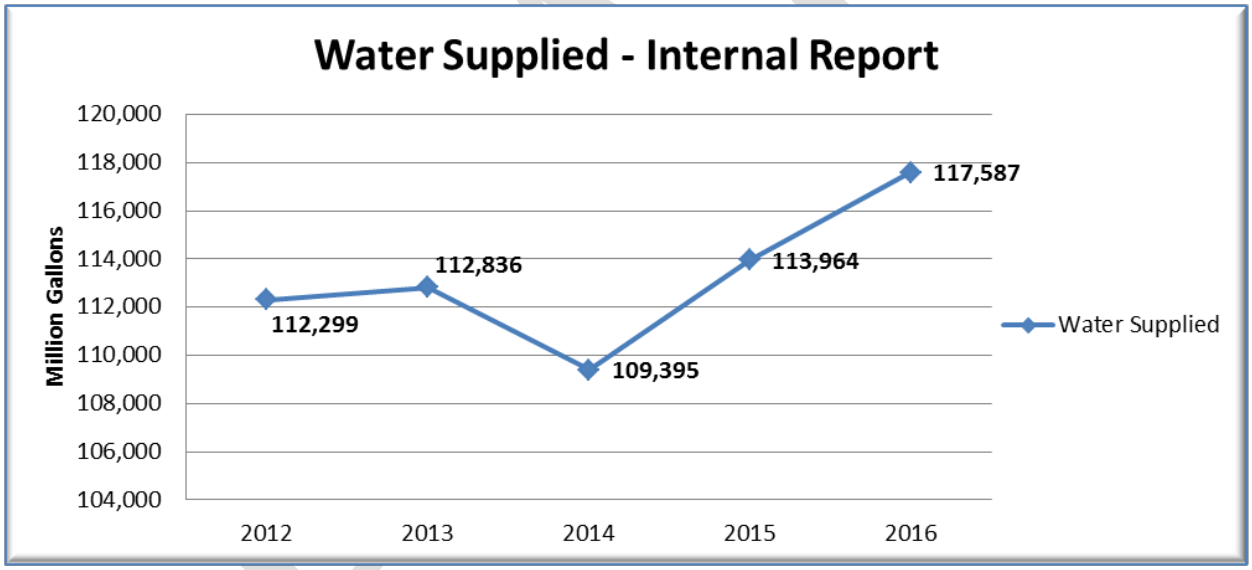


Figure 5-3 Shows that the water supplied over the past five years

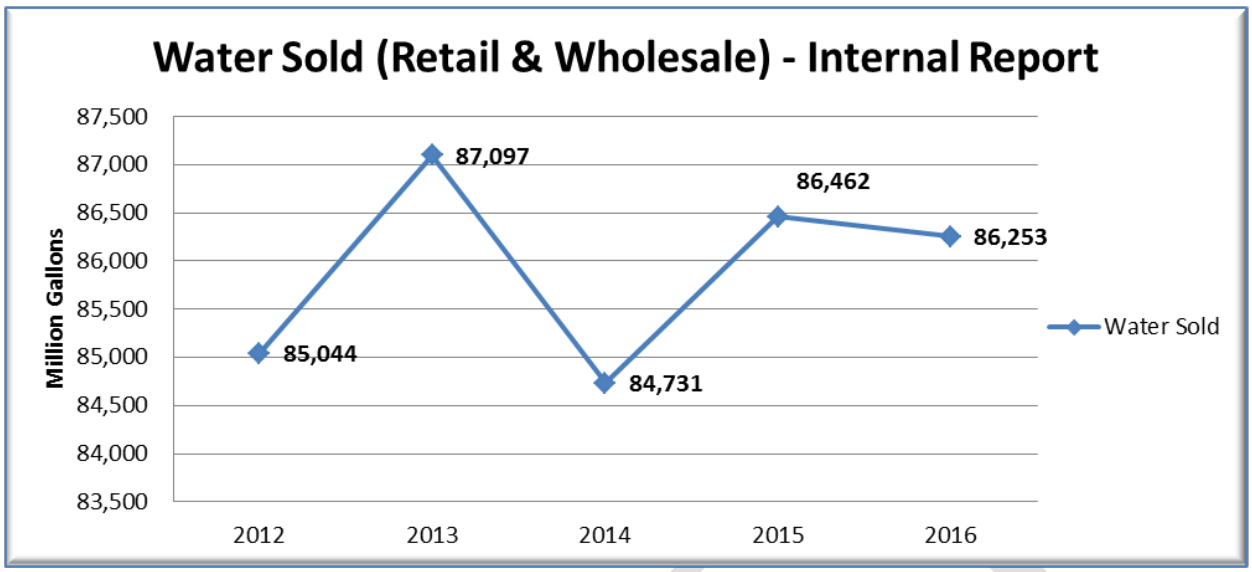


Figure 5-4 Shows that the water sold over the past five years

3. The internal Distribution System Accounting report includes water produced, purchased, retail water sold, wholesale water sold, and total usage at WASD facilities. The report calculates the "unaccounted for water" percentage (quarterly) by deducting water sold from water produced and purchased. This report differs from the internal unaccounted for water report as it does not factor estimated leakage or adjustments made for unbilled unmetered components (flushing etc.). Data for this report was received as part of the 2016 AWWA water audit data request; the name of the file is "Data 2016.pdf".

5.2 Apparent Water Losses

Apparent water loss is made up of unauthorized consumption, customer meter inaccuracies, and systematic data handling errors. Based on the 2016 audit, the apparent loss component was calculated as 3,776.308 MG/year. The value of this loss, as it applies to the customer retail unit cost of $3.43 per 1000 gallons is approximately $12,952,736.

2015 Apparent Losses: 3,585.199 MG/year

2016 Apparent Losses: 3,776.308 MG/year

5.3 Unauthorized Consumption

Unauthorized consumption includes illegal use of hydrants, bypasses, and reversed or tampered with meters. It includes all water usage that has not been authorized by WASD. This component is difficult to track accurately therefore the default of 0.25% of water supplied was used for the 2016 water audit.

2015 Unauthorized Consumption: 229.957 MG/Year

2016 Unauthorized Consumption: 238.877 MG/Year

5.4 Customer Meter Inaccuracies

WASD has an active meter testing program and continues to make changes that will help reach their annual test goals. The meter test program is well run with highly trained personnel.

The current meter team is made up of four Senior Meter Technicians whose primary responsibility is to test large meters. The three new technicians were hired in November of 2016, so it is anticipated there will be an increase in the number of meters tested during 2017.

The large meter test goal is annual testing of meters 3" and larger and semi-annual testing of wholesale meters. While the meter test program is very good compared to its peers, WASD is willing to change protocols to improve the process and have included additional measures to make testing more efficient. One such change is switching the low flow testing quantity for small meters from 100 CF to 10 CF. This change reduces the low flow test time on applicable meters (4") by approximately 50 minutes. In addition, WASD continues to replace meters in service 14 years and older, however, due to a pending future county-wide AMI project, meter replacement activities may cease in the future.

Table 5-3 lists the number of large meter tests conducted during 2016. The information received lists all 288 large meter tests as "passed" with an average high flow accuracy (over-registration) of 100.05% and the average low flow accuracy of 99.81%. It is very unlikely that all meters test at nearly 100%, so the meter inaccuracy component for the 2016 audit was estimated. To better understand the meter accuracy, it is recommended that the initial test results ("as found") are tracked closely.

Table 5-3 Large Meter Tests During 2016

SIZE	# OF TESTS	PASSED	AVG. HIGH FLOW	AVG. LOW FLOW
3"	7	7	100.27%	100.10%
4"	187	187	99.80%	99.83%
6"	56	56	99.75%	98.12%
8"	22	22	100.18%	100.28%
10"	16	16	100.26%	100.73%
Totals	**288**	**288**	**100.05%**	**99.81%**

To estimate residential meter (5/8") population accuracy, B&V once again turned to the 2015 program that tested 1,241 5/8" meters. Figure 5-5 diagrams the results of the program. Of the 1,241 tests conducted, 828 meters failed to meet AWWA specified accuracy limits. The average accuracy for the 1,241 - 5/8" meters was 91.7% for the low flow tests, 97.89% for the mid-range flow tests, and 98.31% for the high flow tests. Using the standard AWWA weighted average of 15 for low flow and 70 for mid-range flow and 15 for high flow, the weighted average for the 1,241 residential meters tested during the 2015 program calculates to an under-registration of 2.74%.

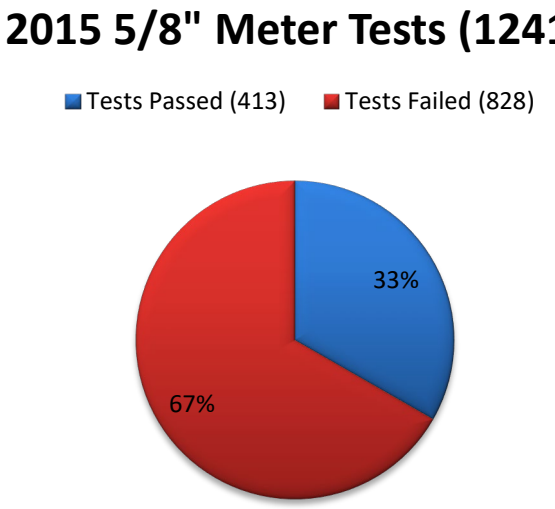


Figure 5-5 Test Results for 2015 meter test project (5/8")

The under-registration for large meters was reduced from 2.4% in 2015 to 2.2% for the 2016 water audit. This is an estimate as several large meters have been changed out since the initial value was calculated during previous audits. Residential and non-residential meters make up 69.4% and 30.6% of overall consumption, respectively. Table 5-4 shows how the retail meter accuracy was calculated for the 2016 audit. Of the 63,998.032 million gallons billed to retail customers, 69.4% (44,414.634 million gallons) was attributed to residential customers. The average accuracy for residential meters was estimated at -2.74%. 19,583.398 million gallons or 30.6% of the billed metered water was attributed to non-residential customers. The average accuracy estimated for the non-residential customers is -2.20%. By calculating the weighted average for residential and non-residential customers, a weighted average of -2.57% was input for the 2016 meter accuracy component.

Table 5-4 2016 Retail Meter Accuracy

CATEGORY	% OF BILLED METERED	BILLED METERED	METER ACCURACY
Residential	69.4%	44,414,634	-2.74%
Non-Residential	30.6%	19,583,398	-2.20%
	100.00%	63,998,032	
Weighted Average			-2.57%

The pending AMI project should result in increased meter accuracy for future audits.

During the 2016 audit period, the meter test program attempted to improve data management protocols by using WASDs asset management system (EAMS) to manage the turbine meter testing. After a few months of review by all parties, it was determined that the benefit of using EAMS would

not justify the effort to implement and maintain the system. It is recommended that WASD consider managing their test data electronically which should increase program efficiency.

5.5 Systematic Data Handling Errors

WASD utilizes several automated and human error checking processes for their billing practices. Although billing system reports are sizeable, automatic triggers to track potential data handling errors are built-in to the billing software and forwarded on to staff specifically assigned for addressing potential data errors in the billing process. To the best of our knowledge, there are no systems with zero systematic data handling errors therefore an estimated value of 2.8% of billed authorized consumption (1,837.702 MG) has been calculated for this input variable.

2015: Systematic Data Handling Error – 1,786.244 MG/Year

2016: Systematic Data Handling Error – 1,837.702 MG/Year

Table 5-5 lists the validation grading for the apparent water loss section of the audit.

Table 5-5 Apparent Water Losses Validation Grading for 2016

GRADED VARIABLE	2015 GRADING	2016 GRADING	REASONING
Unauthorized Consumption	5	5	The default was used for this variable
Meter Inaccuracies	7	7	This component will likely increase for next year's audit due to continued meter change outs and increased meter testing
Data Handling Errors	5	6	This is an estimate assuming a complex billing system

5.6 Real Losses

Real losses, also known as Current Annual Real Losses (CARL) is 26,161.862 MG/Yr. This calculates to an annual cost of $8,722,931.

The AWWA audit methodology does not allow an input for real losses. Instead, the methodology accounts for all components in the water supplied, authorized consumption, and apparent loss areas. When authorized consumption and apparent loss figures are subtracted from the water supplied, the remaining water is classified as real loss. Real loss (physical loss) is attributed to system leakage and leaking or over-flowing water storage.

CY 2015: Real Losses - 23,441.819 MG/Year

2016: Real Losses - 26,142.390 MG/Year

5.7 Leak Reduction Program

WASD continues to employ an aggressive leak detection program. This team continually strives to improve and expand the program which is recognized as an industry leader in the field. The team remains flexible and continually looks for ways to improve the overall efficiency of the program.

WASD personnel are not tied to any one manufacturer, so they are continually conducting pilot projects in an effort to identify equipment and/or techniques that may increase the effectiveness of the program. Management continues to be open to new ideas and remain flexible in their methodologies.

This group welcomes third party evaluation to identify any and all gaps where improvement can be made to field protocols, repairs and data management. This willingness to change ensures the long-term sustainability of the program and keeps the utility on the cutting edge of leak detection technology and techniques. This is contrary to most U.S. municipalities that generally continue utilizing the same protocols developed and passed down from previous personnel.

The automated leakage detection pilot program discussed in the 2014 and 2015 audit reports are no longer in the pilot program phase. WASD now manages an automated fixed network system which identified 57 water leaks during 2016 of which 32 were repaired in the same year. It was estimated that the leakage identified by fixed networks accounted for over 215 million gallons of water saved worth approximately $102,000 (per internal conversation with Hector Marcos).

WASD commenced utilization of a Mobile Network System in 2016. This entails deploying leak loggers on a temporary basis (lift & shift technique) to survey South Dixie Highway (US 1). Table 5-6 lists the 2016 water leaks pinpointed by leak type and month located.

Table 5-6 2016 Water Leakage Summary

MONTH	TYPES OF LEAKS			TOTAL
	Service Line	Main	Valve	
January	37	46	3	86
February	54	42	5	101
March	60	62	12	134
April	43	34	9	86
May	91	32	8	131
June	45	39	9	93
July	34	34	5	73
August	51	15	4	70
September	58	40	10	108
October	45	27	4	76

November	28	31	11	70
December	49	49	9	107
Total	**595**	**451**	**89**	**1,135**

Figure 5-6 Number of leaks identified by month

Figure 5-7 shows the number of leaks located in 2016, sorted by leak type with service line leaks accounting for over 50% of the leaks located. Main line and valve leaks made up the remaining leaks located. WASD did not document hydrant leaks.

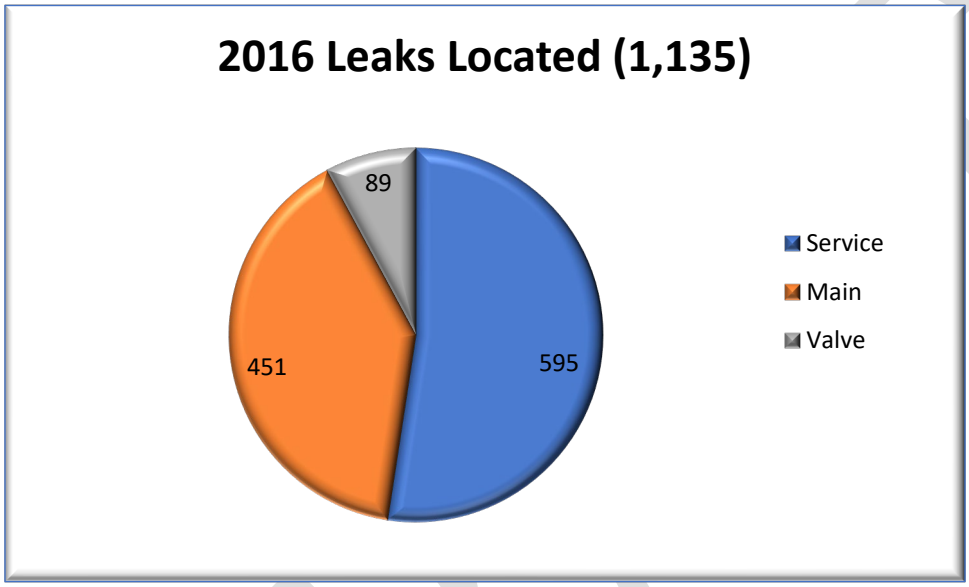


Figure 5-7 Number of leaks by type

While the leak detection program has been successful in identifying leakage throughout the years, real losses have remained relatively consistent from year to year. In an effort to identify gaps and increase program efficiency, the utility recently completed a restructuring and reorganization of staff to ensure that leak detection efforts will provide maximum savings in the future.

These changes made in 2017 combined resources and enable two teams - leak location and leak repair, to fall under one umbrella. Additionally, as part of standard protocols, technicians are classifying leaks to ensure the larger ones have a higher priority than smaller ones.

With a backlog of approximately 452 leaks (2015-Present), the leak detection program has added a crew dedicated to making repairs on unreported non-breaking ground leaks. In the past, leak repairs were requested to a repair crew in another section and not prioritized. Adding a repair crew to the program ensures a quicker turnaround time reducing leak run times.

These changes will be more effective because of data management changes that are and continue to be made. By monitoring leak run times and prioritizing repairs by size, these efforts should have a significant impact on the real loss component of future audits and will allow management to dispatch staff to repair large leaks with the highest impact.

A brief evaluation of historic leakage reveals there is little change in the number of leaks running at any one time. As leaks are repaired, other leaks occur. This is likely the reason why there has not been a significant drop in real loss over the years. Reducing leak run times (especially prioritizing large leaks) should dramatically decrease the volume of water lost that results from non-surfacing leaks.

It is unlikely that these changes will have an immediate impact in 2017, but with the current backlog of 452 unclassified leaks, a dramatic impact should be recognized in future years. Table 5-7 lists leak run times and the number of leaks repaired in 2016. This does not include leaks that were located previous to 2016 that have not been repaired or leaks that are still running in 2017.

Table 5-7 2016 Leak Run Time Evaluation

LEAK RUN-TIMES (DAYS)	# OF LEAKS REPAIRED	%
0 to 20 Days	92	28%
21 to 40 Days	52	16%
41 to 60 Days	44	13%
61 to 80 Days	26	8%
81 to 100 Days	21	6%
101 to 200 Days	45	14%
201 to 300 Days	5	0.02%
301 to 365 Days	44	13%
Total	**329**	

Table 5-8 lists the estimated water saved by leakage located in 2016. This data was derived from estimated non-revenue water audit report provided by WASD personnel. This information can be viewed in file "Worksheet with 4 Quarters together.xls". These volumes are estimates based on standard leakage estimates for each type of leak, pressure, and a set time estimate of 180 days (leaking for 180 days).

The program uses these values as estimated savings for their non-revenue report. These totals list the estimated recovery due to leakage located. Unlike the AWWA water audit, WASD calculates estimated leakage as authorized consumption. This is the primary reason why the key PIs of percentage of water supplied varies between the two types of audits methodology.

Because of the high number of leaks identified on an annual basis, the estimated volume of leakage is substantial. If this leakage estimate is not accurate, it can have a dramatic impact on the accuracy of the non-revenue water report. With planned changes to data management, the data produced by the leak program will increase in accuracy. The largest benefit of these program changes will be a reduction in real loss as WASD will be able to "get ahead" of the leakage through reduced run times of impactful leaks.

The audit methodology does not factor the number of leaks or the estimated loss of leakage. B&V was provided with 2 reports that estimated non-revenue water that resulted from leaks located (not repaired). Table 5-9 lists the data provided in the "Estimated Non-Revenue Water Audit Report" (File: "Worksheet with 4 Quarters together.xls") and lists the estimated water saved due to leakage types by quarter and leak type.

Table 5-8 2016 Estimated Non-Revenue Water Due to Leakage (internal report)

QTR	MAINS	SERVICES	VALVES	HYDRANTS	TRANSMISSION	TOTAL(GALLONS)
1st	2,137,737,834	2,008,893,067	119,037,311	3,813,904	8,458,992	4,277,941,108
2nd	1,849,874,545	1,961,787,456	300,814,891	220,320	112,805,287	4,225,502,499
3rd	2,044,721,278	1,250,032,345	201,713,728	130,512,387	15,680,304	3,642,660,042
4th	1,124,495,509	1,004,658,980	79,763,646	281,786,693	10,448,099	2,501,152,927
Est.	**7,156,829,166**	**6,225,371,848**	**701,329,576**	**416,333,304**	**147,392,682**	**14,647,256,576**

Table 5-9 reflects the data from the "Estimated non-revenue calendar Year 2016 audit report (2).xls" that was provided by WASD and lists the estimated leakage water recovery used in the internal non-revenue water report. This report accounts for estimated leakage as authorized usage. If these estimates are incorrect, or if the leakage run times are different than what the estimate is based on, the accuracy of the report could be easily compromised. Because it is extremely difficult to estimate leakage volume and impossible to accurately estimate the length of time a leak has ran prior to repair, these estimates are not used for the AWWA audit.

Table 5-9 Estimated leakage recovery by quarter due to leaks located (not repaired) in 2016

LEAKAGE WATER RECOVERY (GALLONS)				
Month	**Water Accountability 2015**	**Trouble – Section 2015**	**Water Accountability 2016**	**Trouble – Section 2016**
Jan	675,533,472	372,165,708	565,955,169	418,458,786
Feb	643,642,756	623,665,996	855,191,820	279,944,355
Mar	968,279,428	287,204,492	1,894,183,994	264,206,984
Qtr. 1	**2,287,455,656**	**1,283,036,196**	**3,315,330,983**	**962,610,125**
Apr	802,956,249	274,241,658	1,303,439,260	302,636,550
May	523,610,032	510,687,058	855,638,732	188,938,962
Jun	660,091,013	205,234,258	1,313,719,152	261,129,843
Qtr. 2	**1,986,657,294**	**990,162,974**	**3,472,797,144**	**752,705,355**
Jul	1,046,446,435	140,555,671	951,136,592	168,707,445

Aug	646,475,329	538,629,331	861,134,528	644,392,222
Sep	703,803,507	288,866,774	787,343,164	229,946,091
Qtr. 3	**2,396,725,271**	**968,051,776**	**2,599,614,284**	**1,043,045,758**
Oct	467,255,161	259,961,615	362,808,914	134,856,893
Nov	791,631,944	162,213,858	683,592,402	269,177,330
Dec	520,378,122	322,348,158	717,945,784	332,771,330
Qtr. 4	**1,779,265,227**	**744,523,631**	**1,764,347,100**	**736,805,553**
Total	**8,450,103,448**	**3,985,774,577**	**11,152,089,511**	**3,495,166,791**
Monthly AVG.	**704,175,287**	**332,147,881**	**929,340,793**	**291,263,899**

Table 5-10 lists the number of unreported leaks detected through survey efforts (does not include reported surfacing leakage (leaks that are called in as they are visible). The program is working with GIS to increase data management efforts which will enable the leak detection crew to complete a more strategic survey and further increase program efficiency. If WASD identifies leaks that are prevalent but do not surface readily, they will be able to increase the survey regularity while decreasing the survey frequencies in areas where non-surfacing leaks are unlikely. This, along with prioritizing leaks for repair should have a significant impact on real loss reduction ensuring that large leaks take priority which would reduce run times for impactful leaks. The decrease in real loss will occur when the number of active leaks at any one time is dramatically reduced. In 2017, WASD made protocol and data management changes to the program to monitor and track the results.

Table 5-10 Annual Unreported Leak Count by Comparison

ANNUAL LEAKS PINPOINTED	2014	2015	2016
Total non-surfacing leaks	1,240	1,491	1,135

The non-revenue program did not install district metered areas or perform any pressure management activities during the audit period.

To increase efficiency, WASD performs preventative maintenance and makes repairs to their leak detection equipment. This skill set allows WASD to keep more equipment in the field as delays are reduced due to equipment being sent out for repairs. As is the case with all proactive leak detection programs, WASD surveys for leakage throughout their system. With the current personnel, equipment, and procedures, the entire system is surveyed in 10 months.

WASD employs multiple survey techniques as deemed appropriate for each area. They manage permanently mounted survey loggers in areas deemed dangerous, i.e. high traffic areas. They conduct standard manual surveys in locations where logger access is too far apart to conduct a comprehensive survey. Most of their surveying is conducted by utilizing a lift and shift technique using loggers that are programmed, deployed, and retrieved on a daily basis. The loggers are

brought back to the shop to be analyzed by staff experienced in sound characteristics of the equipment. Recently, the program has added a mobile network program that involves deploying leak loggers, using cellular technology, strategic locations throughout the system. When leaks are detected, a highly trained technician is deployed to accurately pinpoint the leak. Tables 5-11 through 5-14 list the leak detection equipment utilized by the WASD.

Table 5-11 Survey Equipment

LEAK SURVEY LOGGERS (2015)	LEAK SURVEY LOGGERS (2016)
Fixed Network System • ZoneScan • SEBA N-3	Fixed Network System • ZoneScan • SEBA N-3
Sewerin Sepem Loggers	Sewerin Sepem Loggers
Permanet+ Mobile Network	Mobile Network System • Permanet +

Table 5-12 Listening Devices

LEAK LISTENING DEVICES (2015)	LEAK LISTENING DEVICES (2016)
AquaScope Ground Microphone	Aquascope
Geophone	Geophone
Fuji LD10 Ground Microphone	FCS X-Mic
	Hykron

Table 5-13 Locators

LOCATORS (2015)	LOCATORS (2016)
Sure-Lock	Sure-Lock
	Metrotech
	Valve Locator
	Pipehorn
	Sewerin M130

Table 5-14 Leak Correlators

LEAK CORRELATORS (2015)	LEAK CORRELATORS (2016)
Primayer Enigma	Primayer Enigma
Aqua 3600 Correlator	LC 2500
FCS Tri-Corr	FCS Tri-Corr

Sewerin Correlator	Primayer Eureka 3
	Secorr 08

The program is open to utilizing new equipment and will continue to look for ways to improve efficiency through equipment advancements.

6. System Data

6.1 Length of Mains

WASD tracks miles of main line with GIS software. The report provided by audit request lists miles of line for each diameter of main. The inventory, which includes distribution and transmission main lines, is 6,205 miles of water line as of February 7, 2017 which is an increase from 6,035 miles of main input for the 2015 water audit. The 2015 and 2016 data was provided by the GIS section with inventory listed by pipe type. See Appendix B for a list of pipe inventory sorted by main size. The system experienced an increase of 170 miles of main line from 2/11/2016 to 2/7/2017. A review of the pipe size reveals a couple of anomalies that should be field verified if possible. The anomalies are isolated to unique pipe diameters (i.e. short segments of water line listed as 5", 7", 26", 45", and 51"). These should be verified to ensure data accuracy.

2015: Length of Mains – 6,035 miles

2016: Length of Mains – 6,205 miles

6.2 Number of Active & Inactive Service Connections

The number of active and inactive connections was calculated by summing the number of customers billed during the 4th quarter of 2016. This information was obtained from the file titled "Wtr-WP 24th.xlsx" and the number of non-residential customers (including multi-family dwellings) was provided by the billing section as part of an email in response to a data request. Over the past two audit years, approximately 2,500 accounts receive their final bill per month. It is assumed that when most of these accounts are closed, new accounts are opened for new occupants. For this reason, accounts receiving final bills were not factored as inactive service connections. The increase in service connections and miles of water main suggests growth is occurring in WASD's service area (Table 6-1). The increase in billed meters aligns with the increasing service connections. WASD does not track inactive service connections so the estimated average of .5% was used for the 2016 audit.

Table 6-1 Number of Active and Inactive Service Connections

CONNECTION TYPE	2015	FY 2016
Residential Connections	429,445	442,073
Non-Residential Connections	47,953	43,601
Inactive Connections (.5%)	2,387	2,428

Total Active and Inactive Service Connections	479,785	488,102

6.3 System Pressure Data

Table 6-2 lists the locations of all pressure monitors throughout the system as well as the average monthly pressures for the past three years. The average operating pressure component was calculated by averaging the daily reads at each pressure monitoring location. When pressure monitors were not working correctly, the read was removed so it would not impact the average pressure calculations. The average PSI for 2016 was 61.22 PSI. This is an increase of 3.17 compared to 2015. Previous audit reports continued to use 55 psi for consistency purposes. Because there has been a slight increase every year, the calculated average was used and recommendations will be made to use 60-61 psi for water loss calculations. The change in pressure was discussed with leak detection personnel and 61 PSI will be used for future leak estimate calculations. If WASD is able to identify the flow or percentage of the system of each pressure monitor location, they will be able to conduct a weighted average. The variances between pressure monitor locations are minimal throughout the system (56.14 to 66.02).

Table 6-2 Average Operating Pressures

PRESSURE MONITOR LOCATION	12 MONTH AVG PSI (2013)	12 MONTH AVG (PSI) 2015	12 MONTH AVG (PSI) 2016
112 St	50.79	43.93	66.02
186 St	66.86	47.76	61.03
199 St	58.54	57.42	56.14
209 St	57.47	55.40	63.43
PS0682	63.65	63.00	65.29
Airport	60	61.58	62.87
Aventura	57.5	55.90	59.89
Bal Harbour	60.04	59.55	62.65
Broad Cswy	65.61	64.81	67.57
Byron Ave		59.77	60.96
Downtown	62.5	62.67	63.67
Key Biscayne	59.79	59.82	61.23
NE 161 St	58.56	55.58	58.52
Normandy	60.68	58.56	60.10
Norwood	61.89	62.13	63.33
PS 0698	56.78	56.06	56.38
San Marco	61.1	56.37	57.14

SDWWTP	46.69		
SW 152nd St	57.26	57.31	58.85
W 60 St	49.08	61.03	57.73
Watson Is.	60.39	62.27	61.64
12 Month Average	**58.759**	**58.046**	**61.22**

6.4 System Data Validation

Table 6-3 is a comparison of validation grades for the system data section of the water audit. There were minimal changes in the way this data is tracked over the past year. This section did see increases in the miles of water line, number of service connections and system pressure. The validation grades input for the system data section of the audit are relatively high, but changes can be made to improve the scores of each sub-component (other than service line length). To determine the changes needed to increase the validation grades, see the Data Validation Improvement Summary section of this report. The validation grades remain high, but there were no increases for this audit year.

Table 6-3 2015/16 System Data Section Validation Grading

GRADED VARIABLE	2015	2016	REASONING
Length of Mains	9	9	Developed through GIS, uncertain protocols for transfer of new data
Number of Services	7	7	Good billing records, uncertain policies and procedures regarding inactive service lines
Customer Service Line	10	10	All services at property boundaries (therefore zero (0) value)
Average Operating Pressure	7	7	Utilized operations average which was near 2013, 2014, and 2015 averages.

7. Cost Data

7.1 Total Annual Cost of Operating Water System

The total annual cost of operating the water system includes operations, maintenance and any incurred costs for long-term upkeep of the system such as repayment of capital bonds for infrastructure expansion or improvement. Typically costs include salaries, benefits, materials, equipment, insurance, fees, administrative and any other costs necessary to sustain the drinking water supply system. WASD provided quarterly financial statements to allow for a thorough investigation for this audit.

The 2015 and 2016 value was derived from WASD's financial statements and data inputs were based on calendar year data. The 2016 data was derived from the following components:

- Operations and maintenance incurred cost
- Depreciation Costs

Table 7-1 shows the cost of operating the system (water only) comparison inputs over the past three audits.

Table 7-1 Operating Cost Details 2014-2016

TOTAL COST	2014	2015	2016
O&M	$152,873,192	$173,501,657	$142,713,682
Depreciation	$65,846,584	$91,237,698	$72,443,628
Total Annual Cost	**$218,719,776**	**$264,739,355**	**$214,887,256**

The annual cost of operating the water system is the expense to produce, treat, and distribute water. The component input was derived by calculating the "water only" accounts located in the quarterly financial statements received and a percentage of accounts that included water and sewer.

The water accounts that were calculated at 100% were:

- Water Source of Supply (100%)
- Water Pumping (100%)
- Water Treatment and Purification (100%)
- Water Transmission and Distribution (100%)

For future audits, a line item budget review should be conducted to verify the accuracy of the "water only" costs. This will enable WASD to determine the actual water costs for the customer accounting; customer service, and general and administrative accounts. To calculate 2016 costs for customer accounting, customer service, and general and administrative accounts, the value input was calculated at 58% of the cost for each account (per previous communications with WASD). There was a reduction of $30,787,975 in O&M costs from 2015 to 2016. For future audits, a line item budget for all labor etc. should be reviewed to increase the accuracy of this component.

Table 7-2 shows a breakdown of operating costs. These values were added to depreciation to calculate the total annual cost of operating the system component.

Table 7-2 Yearly Operating Costs Comparison

OPERATING COSTS COMPARISON	2014	2015	2016
Water Source of Supply	$11,122,989	$10,403,632	$14,819,700
Water Pumping	$2,068,830	$1,941,661	$1,987,822
Water Treatment & Purification	$59,975,202	$66,492,123	$64,822,528

Water Transmission & Distribution	$29,904,232	$30,075,522	$30,878,323
Customer Accounting	$3,173,101	$3,264,812	$2,590,383
Customer Service	$10,038,132	$12,873,432	$7,585,725
General & Administrative	$36,590,706	$48,450,475	$20,029,201
Total Annual Cost	**$152,873,192**	**$173,501,657**	**$142,713,682**

Table 7-3 lists the quarterly operating and maintenance costs input for the 2015 audit. This data was derived from quarterly financial reports. Highlighted is the $48,450,475 General & Administrative expense in 2015. This value reduced to $20,029,201 for 2016 (see Table 7-4).

Table 7-3 2015 Quarterly Expenses

O & M EXPENSES	1ST QUARTER	2ND QUARTER	3RD QUARTER	4TH QUARTER	TOTAL
Water Source of Supply	$2,276,756	$2,461,269	$3,969,387	$1,696,220	$10,403,632
Water Pumping	$664,496	$217,783	$634,749	$424,633	$1,941,661
Water Treatment & Purification	$15,983,803	$15,848,930	$16,994,713	$17,664,677	$66,492,123
Water Transmission & Distribution	$7,244,323	$7,300,617	$8,421,299	$7,109,283	$30,075,522
58% of Customer Accounting	$807,105	$838,152	$787,507	$832,048	$3,264,812
58% of Customer Service	$3,762,174	$2,438,683	$3,547,336	$3,125,239	$12,873,432
58% of General & Administrative	$12,946,633	$13,675,102	$11,348,196	$10,480,544	$48,450,475
Quarterly O & M Expenses	**$43,685,290**	**$42,780,536**	**$45,703,187**	**$41,332,644**	**$173,501,657**

Table 7-4 lists the quarterly operating and maintenance costs input for the 2016 audit. This data was derived from quarterly financial reports. The general & administrative costs are highlighted as the largest reduction to these inputs.

Table 7-4 2016 Quarterly O&M Expenses ($142,713,682)

O & M EXPENSES	1ST QUARTER	2ND QUARTER	3RD QUARTER	4TH QUARTER	TOTAL
Water Source of Supply	$2,622,254	$2,574,833	$7,390,804	$2,231,809	$14,819,700
Water Pumping	$343,355	$590,413	$623,995	$430,059	$1,987,822
Water Treatment & Purification	$16,719,964	$18,730,594	$15,156,796	$14,215,174	$64,822,528
Water Transmission & Distribution	$7,519,955	$7,461,603	$8,463,222	$7,433,543	$30,878,323
58% of Customer Accounting	$458,627	$567,070	$955,064	$609,622	$2,590,383
58% of Customer Service	$2,247,440	$1,545,615	$1,861,222	$1,931,448	$7,585,725
58% of General & Administrative	$4,217,731	$5,916,675	$5,661,659	$4,233,136	$20,029,201
Quarterly O & M Expenses	**$34,129,326**	**$37,386,803**	**$40,112,762**	**$31,084,791**	**$142,713,682**

Table 7-5 breaks out the depreciation cost from the quarterly financial statement. The depreciation input received from WASD was $72,431,414. After a review of the quarterly depreciation costs from income statements, the input calculated to $72,443,628. It is uncertain what is causing the $12,214 discrepancy, but the difference is minimal and has no real impact on the audit

Table 7-5 Quarterly Depreciation

DEPRECIATION	1ST QTR	2ND QTR	3RD QTR	4TH QTR	TOTAL
Deprec – Pump Station Structures	6,177,386	3,386,327	3,527,351	3,457,423	16,548,487
Deprec – Water Transmis & Distri	10,462,726	10,525,662	11,183,117	10,798,859	42,970,364
Derec - OFFSET -Common Fund	1,335,373	1,290,946	1,746,109	1,520,314	5,892,742
Deprec – Pump Station Equipment	0	0	0	20,813	20,813
Deprec – Treatment & Plant Oper Equ	365,707	1,219,286	1,460,356	1,339,877	4,385,226
SCADA Equipment	365,707	155,101	155,101	155,101	831,010
Deprec - Wtr Mtrs, Bckflw Prev Eq	705,212	405,142	490,201	447,672	0
Deprec – Personal Prop-Non-Auto	259,167	321,928	335,906	334,476	1,251,447
Deprec – Utility Plant Acq Adj	-349,205	0	0	0	-349,205
Deprec – Automotive Equipment	209,376	215,282	240,396	227,690	892,744
Depreciation Per Qtr.	**$19,531,449**	**$17,519,674**	**$19,138,537**	**$18,302,225**	**$72,443,628**

7.2 Customer Retail Unit Cost

Customer retail unit cost is the charge that customers pay for water service (consumption) and is applied to apparent losses. This generally puts a higher value on apparent loss reduction than real loss reduction. Table 7-6 lists the quarterly retail water sales for the 2015 calendar year, sorted by meter type.

Table 7-6 2015 Quarterly Retail Water Sales

RETAIL UNIT COSTS	1ST QUARTER	2ND QUARTER	3RD QUARTER	4TH QUARTER	2015
Residential	$14,453,599	$18,682,056	$15,149,298	$16,177,591	$64,462,546
Multi-Family	$9,754,965	$5,573,521	$7,470,160	$8,411,568	$31,210,216
Res - Sprinkler	$1,632,416	$1,165,558	$1,641,646	$1,278,739	$5,718,360
Commercial	$19,622,982	$23,974,445	$23,327,217	$26,326,379	$93,251,025
WASD Wtr Facility	$105,945	$105,096	$93,986	$131,292	$436,320

Non-ResSrink-Wtr	$2,877,235	$2,452,278	$2,926,126	$2,675,551	$10,931,192
Marina - Water	$24,923	$32,272	$29,292	$17,303	$103,792
Firelines	$54,700	$20,189	$-25,356	$117,075	$166,608
SFWMD Wtr Rest Surcharge	$-335,473	$-8,878	$-8,789	$-473	$-353,615
Total					$205,926,447

Table 7-7 lists the 2016 quarterly retail water sales sorted by customer classification. WASD realized an increase in retail water sales from 2015 to 2016 of $13,531,158. This aligns with the growth recognized in the system data section (increased connections and miles of pipe).

Table 7-7 2016 Quarterly Retail Water Sales

RETAIL UNIT COSTS	1ST QUARTER	2ND QUARTER	3RD QUARTER	4TH QUARTER	2016
Residential	$15,995,450	$17,078,800	$17,338,105	$17,981,983	$68,394,338
Multi-Family	$8,239,549	$7,502,817	$8,718,578	$8,989,567	$33,450,511
Res - Sprinkler	$1,200,740	$1,529,414	$1,599,218	$1,757,527	$6,086,899
Commercial	$22,536,518	$25,529,489	$25,173,123	$26,378,108	$99,617,238
WASD Wtr Facility	$81,099	$86,851	$102,090	$69,985	$340,025
Non-ResSrink-Wtr	$2,155,955	$2,999,327	$3,085,338	$3,090,825	$11,331,445
Marina - Water	$14,012	$13,141	$27,243	$14,789	$69,185
Firelines	$-5,784	$53,046	$171,849	$-47,724	$171,387
SFWMD Wtr Rest Surcharge	$-425	$-32	$-2,050	$84	$-2423
Total	$50,217,114	$54,792,853	$56,213,494	$58,235,144	$219,458,605

Table 7-8 lists the annual comparison of retail unit costs. The initial data received for water revenue provided was $296,885,579. WASD then provided financial statements that revealed that this value includes wholesale water and wastewater revenues as well as $7,380,458 revenue resulting from meter base charges for retail water.

Table 7-8 2014-2016 Retail Unit Cost

RETAIL UNIT COST	2014	2015	2016
Metered Sales – Residential-WTR	$62,126,908	$64,462,546	$68,394,338
Metered Sales – Multi Family-WTR	$27,735,528	$31,210,216	$33,450,511
Metered Sales – Res Sprink-WTR	$5,124,614	$5,718,360	$6,086,899

Metered Sales – Commercial-WTR	$90,231,118	$93,251,025	$99,617,238
Metered Sales – WASD WTR Facility	$432,555	$436,320	$340,025
Metered Sales – NonResSprink-WTR	$9,115,692	$10,931,192	$11,331,445
Metered Sales – Marina-WTR	$112,485	$103,792	$69,185
Metered Sales – Firelines	$267,937	$166,608	$171,387
Wtr Conservation Surcharge/Excess Water Usage	$108,101	-$353,615	$-2423
Total Retail Water Sales	$195,254,939	$205,926,447	$219,458,605
Billed Water (x 1000 gallons)	63,470,026	63,794,433	63,998,032
Retail Unit Cost of Water Sold (per 1000 gallons)	**$3.08**	**$3.23**	**3.43**

2015: Billed Water (x 10000) - 63,794,433
2016: Billed Water (x 10000) - 63,998,032

2015: Retail Unit Cost of Water Sold (per 1000 gallons) - $3.23
2016: Retail Unit Cost of Water Sold (per 1000 gallons) - $3.43

Table 7-9 through Table 7-11 list the consumption rate comparison for each customer type. A rate block or tier is a specific price per CCF based on consumption. The costs escalate as consumption thresholds are reached. For example, Table 9 shows that a residential customer pays $0.3740 per CCF for consumption in tier 1 (0 to 5 CCF). For consumption over 5 CCF, the customer pays $3.0057 per CCF.

Table 7-9 2015 & 2016 Residential Usage Rates / Blocks

RESIDENTIAL USAGE RATES	2015 (EFFECTIVE 10/1/2015)	2016 (EFFECTIVE 10/1/2016)
0 to 5 ccf	$0.3740	$0.3740
6 to 9 ccf	$3.0057	$3.0057
10 to 17 ccf	$3.5579	$3.5579
18 ccf and over	$5.8808	$5.8808

Table 7-10 2015 & 2016 Multi-Family Usage Rates / Blocks

MULTI-FAMILY USAGE RATES	2015 (EFFECTIVE 10/1/2015)	2016 (EFFECTIVE 10/1/2016)
0 to 4 CCF	$0.3740	$0.3740
5 to 7 CCF	$3.0057	$3.3469
8 to 14 CCF	$3.5579	$3.8568
15 CCF and Over	$5.8808	$6.3748

Table 7-11 2015 & 2016 Non-Residential Usage Rates / Blocks

METER SIZE	NON-RESIDENTIAL USAGE RATES	2015 (EFFECTIVE 10/1/2015)	2016 (EFFECTIVE 2016)
5/8”	0 to 5 CCF	$0.3740	$0.3740
	6 to 9 CCF	$3.0057	$3.3469
	10 to 17 CCF	$3.5579	$3.8568
	18 CCF and over	$5.8808	$6.3748
1”	0 to 13 CCF	$0.3740	$0.3740
	14 to 23 CCF	$3.0057	$3.3469
	24 to 43 CCF	$3.5579	$3.8568
	44 CCF and over	$5.8808	$6.3748
1.5”	0 to 25 ccf	$0.3740	$0.3740
	26 to 45 ccf	$3.0057	$3.3469
	46 to 85 ccf	$3.5579	$3.8568
	86 ccf and over	$5.8808	$6.3748
2”	0 to 40 CCF	$0.3740	$0.3740
	41 to 72 CCF	$3.0057	$3.3469
	73 to 136 CCF	$3.5579	$3.8568
	137 CCF and over	$5.8808	$6.3748
3”	0 to 80 CCF	$0.3740	$0.3740
	81 to 144 CCF	$3.0057	$3.3469
	145 to 272 CCF	$3.5579	$3.8568
	273 CCF and over	$5.8808	$6.3748
4”	0 to 125 CCF	$0.3740	$0.3740
	126 to 226 CCF	$3.0057	$3.3469
	227 to 425 CCF	$3.5579	$3.8568
	426 CCF and over	$5.8808	$6.3748
6”	0 to 250 CCF	$0.3740	$0.3740
	251 to 451 CCF	$3.0057	$3.3469
	452 to 850 CCF	$3.5579	$3.8568
	851 CCF and over	$5.8808	$6.3748
8”	0 to 400 CCF	$0.3740	$0.3740
	401 to 722 CCF	$3.0057	$3.3469
	723 to 1,360 CCF	$3.5579	$3.8568
	1,361 CCF and over	$5.8808	$6.3748
10”	0 to 575 CCF	$0.3740	$0.3740
	576 to 1,038 CCF	$3.0057	$3.3469
	1,039 to 1,955 CCF	$3.5579	$3.8568

	1,956 CCF and over	$5.8808	$6.3748
12”	0 to 1,075 CCF	$0.3740	$0.3740
	1,076 to 1,940 CCF	$3.0057	$3.3469
	1,941 to 3,655 CCF	$3.5579	$3.8568
	3,656 CCF and over	$5.8808	$6.3748
14”	0 to 2,000 CCF	$0.3740	$0.3740
	2,001 to 3,610 CCF	$3.0057	$3.3469
	3,611 to 6,800 CCF	$3.5579	$3.8568
	6,801 CCF and over	$5.8808	$6.3748

Table 7-12 lists the percentage of retails sales in each of the 4 retail blocks/tiers. The residential block was responsible for nearly half (46.43%) of the water consumption.

Table 7-12 Water billed for each retail block (4 blocks)

2016 BILLED METERED BY RETAIL BLOCKS				
	Residential	**Multi-Family**	**Non-Residential**	**Total**
Block 1 (44.8%)	15,876,203	8,894,864	3,420,594	28,191,661
Block2 (20.62%)	7,102,312	4,016,726	1,860,491	12,979,529
Block 3 (13.55%)	4,111,082	1,784,149	2,631,268	8,526,499
Block 4 (21.03%)	2,126,866	404,715	10,703,882	13,235,463
Totals	29,216,463	15,100,454	18,616,235	62,933,152
% by Category	46.43%	23.99%	29.58%	100%
Data Adjustment made to reflect financial adjustment to high bills in January 2016				1,064,880
				63,988,032

7.3 Variable Production Cost

Variable production cost is the cost to produce and supply the next unit of water which for WASD is 1 million gallons. This cost is determined by calculating the summed unit costs for treatment and power used for pumping from the source to the customer. Pump and plant equipment depreciation is also factored into this calculation. This cost is generally applied to real loss (physical loss). Table 7-13 provides a comparison of variable costs for three years; 2014, 2015 and 2016.

Table 7-13 Annual Variable Cost Comparison

LINE	VARIABLE COST	2014	2015	2016
1	Water Source of Supply	$4,251,986	$2,096,967	$2,286,853
2	Water Pumping	$1,418,675	$1,270,755	$1,151,518
3	Water Treatment and Purification	$28,481,936	$32,688,807	$30,468,615
4	Water Transmission and Distribution	$1,827,615	$1,042,854	$914,954

5	Pump / Treatment Plant Equip. Depreciation			$4,406,039
5	**Total Variable Cost**	**$35,980,212**	**$37,099,383**	**$39,227,979**
6	Finished Water (MG)	110,364	113,839	**117,295**
7	Purchased Water (MG)	152	124	269
8	**Total Water Supplied**	**110,516**	**113,963**	**117,564**
9	**Cost to Produce 1 Million Gallons of Water**	**$325.56**	**$325.54**	**$333.67**

The depreciation input for the variable cost component included pump equipment and treatment and plant equipment only. Refer to Table 7-14 for pump depreciation used for variable production costs for 2015 and 2016.

Table 7-14 Highlighted pump depreciation factored into variable production cost ($4,406,039)

DEPRECIATION	2014	2015	2016
Deprec – Pump Station Structures	$12,790.334	$24,789,785	16,548,487
Deprec – Water Transmis & Distri	$39,740,979	$41,663,193	42,970,364
Deprec - OFFSET -Common Fund	$2,918,795	0	5,892,742
Deprec – Pump Station Equipment			20,813
Deprec – Treatment & Plant Oper Equ	$5,531,411	0	4,385,226
SCADA Equipment	$37,264	$5,866,694	831,010
Deprec - Wtr Mtrs, Bckflw Prev Eq	$652,763	$3,185,213	0
Deprec – Personal Prop-Non-Auto	$1,689,691	$1,833,508	1,251,447
Deprec – Utility Plant Acq Adj	$1,685,977	$10,895,355	-349,205
Deprec – Automotive Equipment	$799,370	$3,003,946	892,744
Depreciation Per Year	**$65,846,584**	**$91,237,698**	**72,443,628**

7.4 Cost Data Validation Grading

WASD realized a slight increase in grading for cost data validation in 2016. This increased validation / accuracy appropriate given that the data received has been audited and compiled for the past 6 years. Table 7-15 lists the update validation grading for the 2016.

Table 7-15 2015/2016 Cost Data Validation Comparison

GRADED VARIABLE	2015 GRADING	2016 GRADING	REASONING
Total Cost of Operation	9	10	All costs developed and Third party CPA audited. Quarterly data received to allow for CY calculations
Customer Retail Unit Cost	8	8	Used the calculation of metered sales against the total billed metered.

Variable Production Cost	8	9	An evaluation of the financial reports calculating only variable costs and depreciation

8. Audit Values

Table 8-1 summarizes the inputs for 2015 and 2016 water audits. As discussed in this report, there were increases in real and apparent loss per connection, and a decrease in the ILI.

Table 8-1 2015/2016 Audit Values Comparison

COMPONENT	2015 AND 2016 REPORTS	
	2015	2016
Volume from own sources (MG/Yr.)	113,839.106	117,294.796
Master meter error adjustment (MG/Yr.)	0%	0%
Water imported (MG/Yr.)	124.734	249.707
Water exported (MG/Yr.)	21,761.940	21,775.129
Water Exported MMEA	-1.00%	-1.00%
WATER SUPPLIED (MG/Yr.)	**91,982.709**	**95,550.678**
Authorized Consumption		
Billed Metered (MG/Yr.)	63,794.433	63,998.032
Billed Unmetered (MG/Yr.)	N/A	N/A
Unbilled Metered (MG/Yr.)	11.475	439.564
Unbilled Unmetered (MG/Yr.)	1,149.784	1,194.631
AUTHORIZED CONSUMPTION (MG/Yr.)	**64,955.692**	**65,631.980**
Water Losses		
Unauthorized Consumption (MG/Yr.)	229.957	238.877
Customer meter inaccuracies (MG/Yr.) – 2.4%	1,568.998	1,699.729
Systematic data handling (MG/Yr.)	1,786.244	1,837.702
Water Losses (MG/Yr.)	**27,027.017**	**29,918.698**
System Data		
Length of mains (miles)	6,035	6,205
Number of active & inactive service connections	479.785	488,102
Average length of customer service line (feet)	0	0
Average operating pressure (psi)	55.0	61.2
Cost Data		
Total annual cost of operating water system	$264,739,355	$214,887,256

Customer retail unit (water) cost (per 1000 gallons)	$3.23	$3.43
Variable production cost ($/MG)	$325.54	$333.67

9. Performance Indicators

The overall validation grading for the 2016 audit increased from 77 to 78. The increase in water loss may be a by-product of increased overall audit data accuracy. This is a normal occurrence for utilities that have conducted multiple audits. Table 9-1 summarizes PIs for the past two water audits completed.

The data suggests that there was a minimal increase in apparent losses. The increase in real loss is more obvious, but the ILI score has improved. The ILI is the ratio of real losses to unavoidable annual real loss. This PI is used as an effective indicator for benchmarking the performance of utilities in the operational management of real losses. WASD will likely see improvements in real loss reductions with the modifications now being employed i.e. assigning a repair crew to the leak detection team to reduce leak run times, improved data management using GIS, and classifying leaks to prioritize repairs. See section 5.7 "Leak Reduction Program" for a more detailed review of loss reduction modifications that the WASD is implementing.

Table 9-1 2015/2016 Performance Indicators Comparison

PERFORMANCE INDICATOR	2015 VALUE	2016 VALUE	UNITS
Validation Grading	77	78	out of 100
Non-revenue water as percent by volume of Water Supplied:	30.6%	33%	%
Apparent Losses per service connection per day:	20.47	21.2	Gallons per connection per day
Real Losses per service connection per day:	133.86	146.74	Gallons per connection per day
Infrastructure Leakage Index	11.16	10.96	Dimensionless
Annual Cost of Apparent losses	$11,580,191	$12,918,698	$
Annual Cost of Real Losses	$7,631,250	$8,722,931	$

Table 9-2 shows historic PIs. The number of leaks identified in 2015 increased from 2014. The volume of leakage was such that repair crews were unable to make repairs in a timely manner. While the internal water accountability reports account for leakage pinpointed, the audit reveals the real loss after all other components are accounted for. The increase in leaks tracked in 2015 may very well have had an impact on the real loss component for the 2016 audit. This may have occurred as WASD was unable to repair all leaks and the leaks identified at that time were not prioritized by size.

Table 9-2 Historic Performance Indicator Variances

PERFORMANCE INDICATOR (PI)	UNITS	2011	2012	2013	2014	2015	2016

Total NRW (% by volume)	%	30.2%	27.9%	26.7%	29.1%	30.6%	33%
Apparent Loss	Gallons/conn/day	44	22	22	22	20	21
Real Loss	Gallons/conn/day	126	120	113	127	134	147
AWWA grading	(1-100)	73	78	77	75	77	78

10. Apparent Loss Management

WASD is taking several steps that should reduce apparent loss values. The pending AMI project should not only increase meter accuracy, it will also allow WASD to more closely monitor water system efficiency.

Large customer meter testing has been somewhat short handed over the past few years as meter test technicians were called away from their duties to work on other pressing projects. WASD has increased the test vehicles and teams from 3 to 4 (November 2016). Additionally, the new technicians are dedicated to meter testing and should not be pulled away for other projects. These changes should enable WASD to meet its goal of testing all large meters on an annual basis and all wholesale meters twice per year.

To further increase the efficiency of the meter test program and thereby reduce apparent loss, it is recommended that meters selected for testing are based on consumption. Meters with high consumption should be considered for flow testing on a regular basis while meters with limited throughput should be tested less frequently. However, all large meters should be tested.

While WASD attempted to improve data management, it elected to discontinue as it was not worth the effort or time. It is recommended that WASD manage their historic and current meter test data electronically and track meter failures to help prioritize and plan meter tests. It is important that the tracking system used increases program efficiency and provides the meter technicians with information to identify problematic meters and allow for an overall customer meter accuracy calculation.

11. Real Loss Control Management

As discussed in this report, the non-revenue water division is making several changes that should have a dramatic impact on real loss reduction in the future. By conducting strategic surveys, reducing leak run times, implementing a robust data management system, and managing all facets under one heading, WASD should see significant improvements in real loss reduction.

12. Comments and Recommendations

WASD has started to implement changes to their current Non-Revenue Water programs that should provide a significant impact in losses due to leakage. Most of the changes made have occurred in 2017, so the impact may not be fully realized until 2018 or 2019. One large change that should have an impact in 2017 is the implementation of leak classification. This method of reporting prioritizes leak repairs and insures that large leaks take repair priority over small leaks. The restructuring of the department, which includes a dedicated repair crew, should further reduce water loss as leak run-times should decrease. The evolution of data management should increase the number of leaks located as areas of greatest concern will be identified and prioritized for additional leak surveys. By

running the entire leak program from survey to repair through one location, WASD will not only reduce water losses that are a result of water leaks, they will be able to monitor the effectiveness of each intervention in an efficient manner.

The following are a list of recommendations for consideration:

1. It is recommended that the WASD review the 2016 production values at the Alexander Orr Plant. The largest increases occurred in March. The increase in production appears to have started in February, peaked in March, and reduced in April. At the time of this report, it was not clear if any event occurred that caused this spike in production.

2. WASD should consider a review of wholesale meter consumption, meter test reports, and billing data. The objective of the review is to identify the reasons why consumption variances are prevalent. A billing and flow evaluation may identify meter accuracy issues or size and configuration anomalies that may result in apparent losses.

3. It is recommended that if WASD does not review the entire wholesale population, it should consider reviewing the billing, testing, and meter configuration details for high priority wholesales customers that may have a significant financial impact.

4. To reduce apparent loss, it's recommended that WASD implement a data management system that can be installed and used efficiently. Increased data management would increase the understanding of the overall meter accuracy by tracking "as found" results. Increased data management will allow meters with the highest throughput or problematic meters to be selected for testing more frequently. Historic data will aid the field personnel in testing each meter in the most efficient and effective way. The meter test program attempted to use their CMMS as a data management tool for their program but made the decision to stop using the software as the benefit did not justify the inefficiency. The data management program selected should increase the overall efficiency of the large customer metering program.

5. To increase the validity grade of import meter accuracy, WASD should ask for copies of the meter test reports for all import meters.

6. To improve WASD's Volume From Own Source grade of 8 received from this audit, the utility should do the following:

- Continuous production meter data logged automatically and reviewed each business day
- Adjusted data to correct errors from instrumentation or accuracy testing
- Automate the Tank/Storage facility elevation changes used in VFOS tabulations

7. For future audits, a line item budget for customer accounting, customer service, and general & administrative accounts should be reviewed to increase the accuracy of the overall water costs. This may allow the WASD to break out water only costs like labor from the accounts that include water and sewer. The objective is to insure that no sewer costs are factored into the Total Annual Cost of Operating the Water System component.

8. The WASD 2016 overall audit validation grade of 78 solidifies the WASD water loss ranking as a Level 4 (71-90) of 5. The AWWA Water Audit Software Recommends the following for all Level 4 utilities.

- Audit Data Collection: Refine data collection practices and establish as routine business process
- Short-term loss control: Refine, enhance or expand ongoing programs based upon economic justification
- Long-term loss control: Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management
- Target-setting: Establish mid-range (5 year horizon) apparent and real loss reduction goals
- Benchmarking: Performance Benchmarking ILI is meaningful in comparing real loss standing.

9. It is recommended that WASD review the following data validation improvements. The list identifies what is needed to increase each components validation grade by one point from this year's audit grading:

A. ***Volume From own Sources (Table 3-9):*** To improve the current grade from 8 to 9, 100% of the water production meters must be metered, meter accuracy testing ***and*** electronic calibration testing should be conducted annually and less than 10% of the meters are outside of +/- 4% to 5% accuracy.

B. ***Master Meter Error Adjustment (Table 3-9):*** To improve the current grade from 5 to 6, WASD should formalize annual meter accuracy testing for all source meters, complete installation of meters on unmetered water production sources and complete replacement of all obsolete/defective meters.

C. ***Water Imported (Table 3-9):*** To improve the current grade from 8 to 9, 100% of import water sources shall be metered, and meter accuracy testing and/or electronic calibration should be conducted annually and less than 10% of meters are outside of +/- 4% to 5%.

D. ***Water Exported (Table 3-9):*** To improve the current grade from 8 to 9, 100% of export water sources should be metered, meter accuracy testing and/or electronic calibration should be conducted annually and less than 10% of meters are outside of +/- 4% to 5%.

E. ***Billed Metered (Table 4-6):*** To improve the current grade from 8 to 9, at least 98% of WASD customers exist with volume based billing from meter reads. At least a 90% customer meter read success rate, or minimum 80% read success rate with planning and budgeting for trial of Automatic Meter Reading (AMR) in one or more pilot areas. Good customer meter records, regular meter accuracy testing guides replacement of statistically significant number of meters each year. Routine auditing of the computerized billing records for global and detailed statistics verified periodically by 3rd party.

F. ***Billed Unmetered:*** Not Applicable

G. ***Unbilled Metered (Table 4-6):*** To improve the current grade from 8 to 9, written policies should identify the types of accounts granted a billing exemption. Customer meter management and meter reading should be considered secondary priorities, but meter reading is conducted at least annually to obtain consumption volumes for the annual water audit. High level auditing of billing records ensures that a reliable census of such accounts exists.

H. ***Unbilled Unmetered (Table 4-6):*** To improve the current grade from 5 to 6, coherent policies should exist for some forms of unbilled, unmetered consumption but others await closer evaluation. Reasonable recordkeeping for the managed uses exists and allows for annual volumes to be quantified by inference, but unsupervised uses are guesstimated.

I. ***Customer Meter Inaccuracies (Table 5-5):*** To improve the current grade from 7 to 8, there should be ongoing water replacement and accuracy testing result in highly accurate customer meter population. Testing should be conducted on samples of meters at varying lifespans to determine optimum replacement time for various types of meters

J. ***Systematic Data Handling Errors (Table 5-5):*** To maintain the current grade of 6, policy for permitting and billing should be adequate and reviewed periodically. Computerized billing system is in use with basic reporting available. Any effect of billing adjustments on measured consumption volumes is well understood. Internal checks of billing data error conducted annually. Reasonably accurate quantification of consumption volume lost to billing lapses is obtained.

K. ***Length of Mains (Table 6-3):*** To improve the current grade from 9 to 10, sound policy should exist for managing water main extensions and replacement. Geographic Information System (GIS) data and asset management database agree and random field validation proves truth of databases.

L. ***Number of active AND inactive service connections:*** To qualify for a grade of 8, permitting policy and procedures reviewed at least biannually. Well managed, computerized information management system and routine, periodic field checks and internal system audits allow counts of connections that are no more than 2% in error.

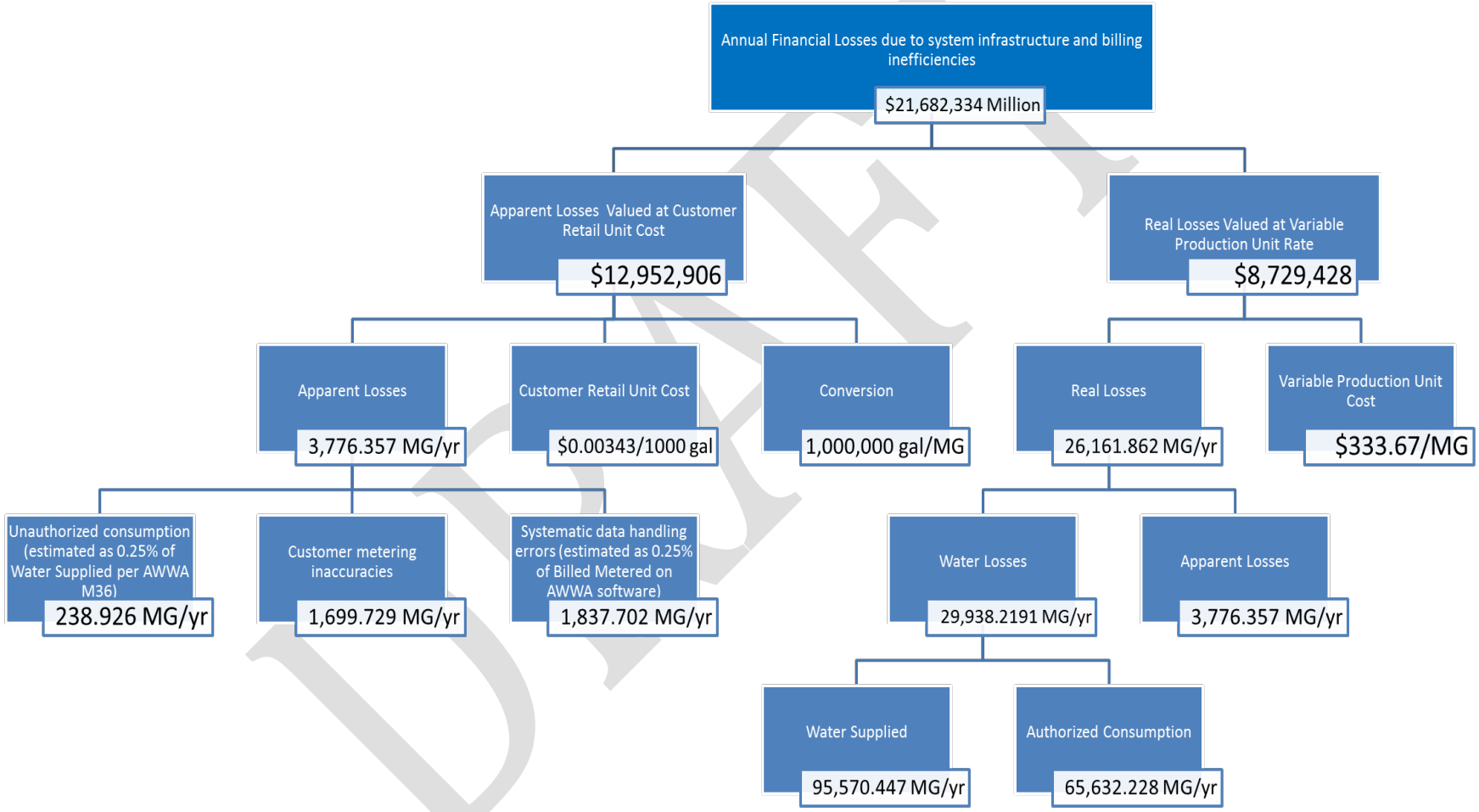
M. ***Average operating pressure (Table 6-3):*** To improve the current grade from 7 to 8, well managed, discrete pressure zones should exist with generally predictable pressure fluctuations. A current full-time SCADA system exists to monitor the water distribution system and collect data, including real time pressure readings at representative sites across the system. The average system pressure is determined from reliable SCADA System data.

N. ***Total annual cost of operating water system (Table 7-15):*** To remain at a grade of 10, reliable electronic, industry-standard cost accounting system in place, with all pertinent water system operating costs tracked. Data audited annually by utility personnel and by third-party CPA.

O. ***Customer retail unit cost (Table 7-15):*** To improve the current grade from 8 to 9, effective water rate structures are in force and are applied reliably to billing operations. Composite customer rate is determined using a weighted average composite consumption rate, including residential, commercial, industrial, and any other classes within the water rate structure.

P. ***Variable production rate (Table 7-15):*** To improve the current grade from 9 to 10, third party CPA audit of all primary and secondary cost components should occur on an annual basis.

Appendix A – Financial Loss Calculated Breakdown from 2016 Audit



Appendix B – Length of Water Main

SIZE	LINIAL FEET	MILES
0	42,105.35	7.97
1	55,940.49	10.59
2	2,936,185.95	556.10
3	179,714.95	34.04
4	2,289,008.33	433.52
5	165.29	.03
6	6,188,294.64	1,172.03
7	36.27	.01
8	11,497,595.94	2,177.57
10	306,326.25	58.02
12	5,314,685.71	1,006.57
14	4,371.02	.83
16	1,678,407.35	317.88
18	17,601.31	3.33
20	454,387.17	86.06
24	525,493.58	99.53
26	84.28	.02
30	248,886.80	47.14
36	320,476.36	60.70
42	68,474.02	12.97
45	876.88	.17
48	360,312.99	68.24
51	906.76	.17
54	96,344.86	18.25
60	57,492.80	10.89
66	2,247.04	0.43

72	11,507.77	2.18
80	26.12	0.00
84	8,559.70	1.62
96	93,084.13	17.63
120	202.20	0.04

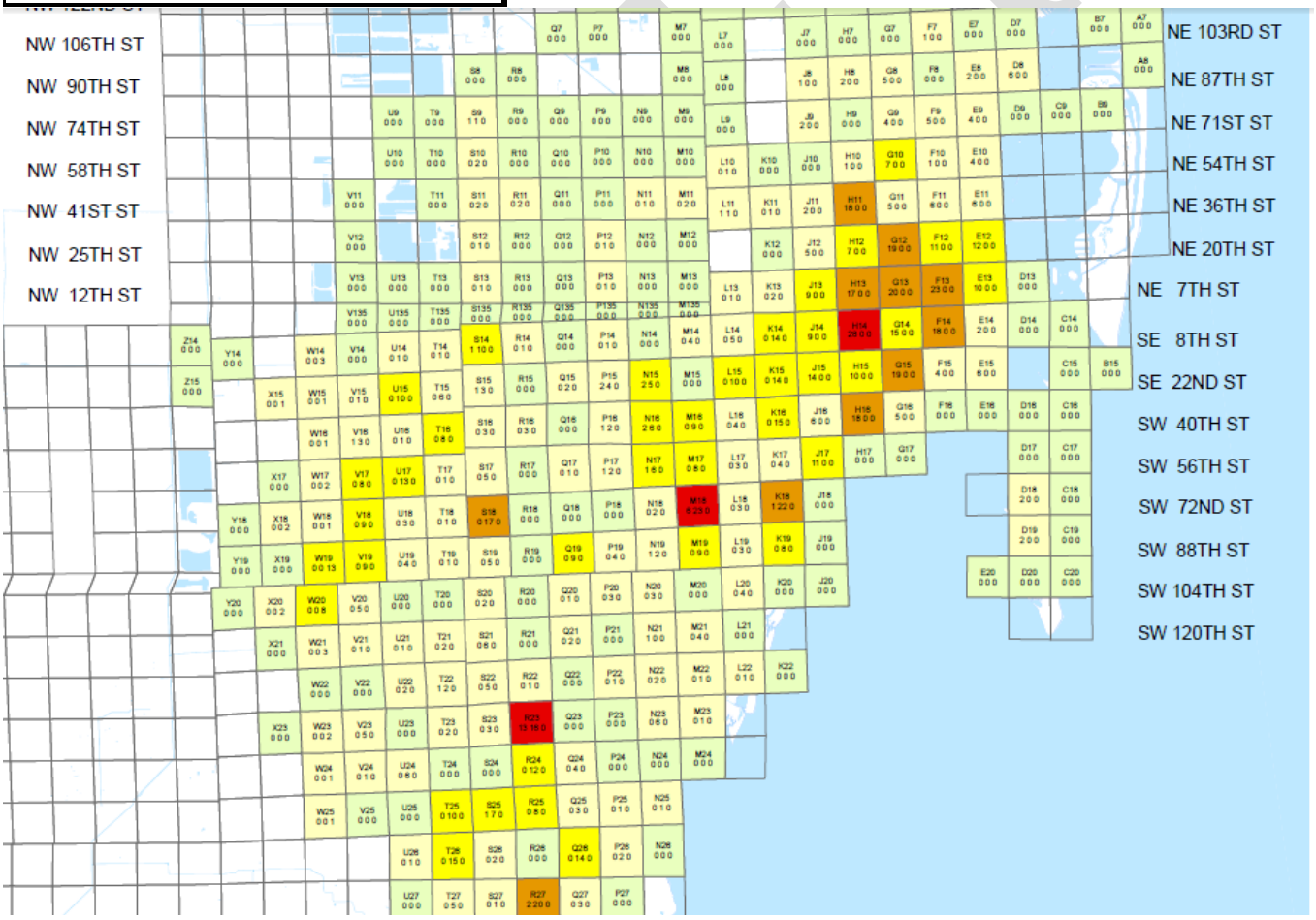
Appendix C – GIS 2016 Water Leaks

LEGEND		
Total Leaks (#Pages)		
	0	(225)
	1-6	(157)
	7-15	(41)
	16-24	(12)
	24>	(3)
	Atlas Index	

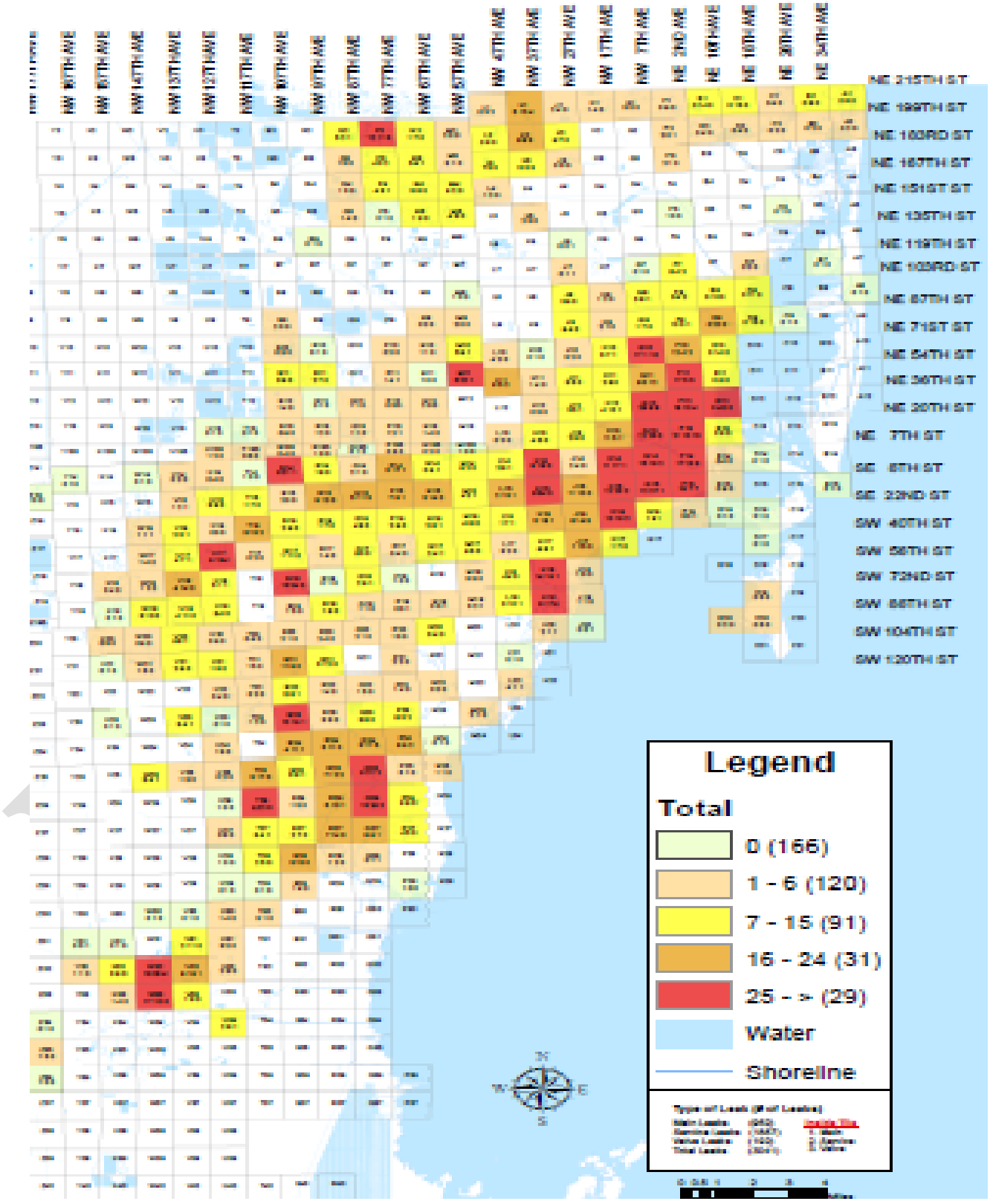
Type of Leak (# of Leaks)	
Main Leaks	451
Service Leaks	595
Valve Leaks	89
Total Leaks	1,135

This GIS map was developed with GIS and highlights the grid maps with the highest concentration of leaks during 2016. The total number of leaks tracked with GIS in 2015 was 3,041.

The total number of leaks tracked with GIS in 2016 was 1,135. Of note, the Department does not appear to track hydrant leaks.



Appendix D – CY 2015 GIS Water Leaks



Appendix E - Variable Production Cost Breakdown

Water Source of Supply

ACCOUNT	ACCOUNT NAME	2014	2015	2016
722010	Electrical Services	1,477,684	1,421,171	1,366,139
722020	Natural Gas	23,714	37,444	206,763
722110	Water & Sewer Service	35,960	36,055	35,858
722114	Purchased Water	460,338	309,322	283,052
722115	Prchsd Water-City of Homestead	41,901	46,853	199,149
722118	Calcium Carbonate Disposal	1,726,892	0	0
722130	Swm Charges Waste Disposal	0	0	0
726060	Fm Lt Eq Fuel	294,273	190,911	140,747
726131	It 800 Mhz Maintenance	191,223	55,211	55,145
Total	***Water Source of Supply***	***4,251,986***	***2,096,967***	***2,286,853***

Water Pumping

ACCOUNT	ACCOUNT NAME	2014	2015	2016
722010	Electrical Services	1,222,135	1,212,814	1,088,721
722020	Natural Gas	5,292	2,706	7,612
722110	Water & Sewer Service	25	24	32
726131	It 800 Mhz Maintenance	191,223	55,211	55,153
741020	Compressed Natural Gas (Cng)	0	0	0
Total	***Water Pumping***	***1,418,675***	***1,270,755***	***1,151,518***

Water Treatment and Purification

ACCOUNT	ACCOUNT NAME	2014	2015	2016
722010	Electrical Services	6,720,310	6,309,178	5,797,676
722020	Natural Gas	3,319,933	1,538,231	2,110,745
722110	Water & Sewer Service	0	0	0
722118	Calcium Carbonate Disposal	928,697	4,694,216	6,757,028
722123	Hazardous Waste Disposal	24,302	31,224	30,888
722130	Swm Charges Waste Disposal	10,851	9,333	18,200
726060	Fm Lt Eq Fuel	273,646	226,462	150,610
726131	It 800 Mhz Maintenance	191,223	55,211	57,926
741015	Diesel Fuel	2,748,867	0	0
749014	Miscellaneous Chemicals	23,678	14,901	16,755

749016	Chlorine	954,137	1,020,173	722,323
749018	Ammonia	342,299	578,277	689,679
749019	Liquid Caustic Soda	1,360,382	1,351,275	1,263,673
749023	Lime	7,476,308	11,922,743	8,004,629
749024	Sodium Hypochlorite	1,560,211	1,633,636	1,995,539
749025	Silicate	277,819	373,485	108,891
749027	Sodium Polyphosphate	489,564	661,366	373,028
749029	Potassium Permanganate	169,264	310,644	290,041
749031	Polymers	141,509	199,649	297,767
749032	Polymeric Flocculant	0	0	0
749035	Liquid Carbon Dioxide	664,240	835,166	736,724
749037	Maint & Repair - Lab Instrument	4,300	175,140	159,445
749038	Chemical Inventory Adjustment	346,833	262,313	118,155
749039	Fluorosilicic Acid	298,103	296,724	586,268
749219	Laboratory Supplies	155,460	169,461	182,625
Total	***Water Treatment & Purification***	***28,481,936***	***32,668,807***	***30,468,615***

Water Transmission & Distribution

ACCOUNT	ACCOUNT NAME	2014	2015	2016
722010	Electrical Services	2,163	1,846	2,030
722020	Natural Gas	1,952	834	828
722110	Water & Sewer Service	74,944	40,739	0
722123	Hazardous Waste Disposal	587,050	280,761	361,448
722130	Swm Charges Waste Disposal	5,962	9,105	13,302
726060	Fm Lt Eq Fuel	964,322	654,359	482,201
726131	It 800 Mhz Maintenance	191,223	55,211	55,145
Total	***Water Transmission & Distribution***	***1,827,615***	***1,042,854***	***914,954***