GUAM WATERWORKS AUTHORITY

Water Audit Program
&
Water Loss Control
Plan

Approved by the CCU on August 23, 2011

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TABLE OF CONTENTS

Part I. Introduction

The Guam Waterworks Authority (GWA) has long recognized opportunities to decrease water loss in the potable water system, provide additional water, and recover lost revenues. GWA has demonstrated a commitment to efficiently reduce water loss through the meter replacement program, leak detection program, and leak repairs. Managing customer meter inaccuracies through meter replacement programs is recognized as one of the fundamental steps in a water loss program. The utility's meter replacement program is currently implementing and replacing the existing meters with new meters. The 2011 bond funds will be utilized to complete this project. The program has already demonstrated an increase in revenues by reducing customer meter inaccuracies. Reducing leakage on distribution mains is also a fundamental step in a water loss program. GWA has demonstrated a commitment to reduce water loss by implementing an aggressive leak detection program and leak repair program. The utility is beginning the second year of the leak detection contract with GWA crews repairing the identified leaks. This contract is also a knowledge transfer program in which GWA's crews are trained in leak detection. Clearly, GWA has begun to address the reduction in water loss. This plan will demonstrate GWA's substantial progress in water loss reduction from both the operational and planning perspective.

The next step in the water loss program is implementing a detailed water audit program and aggressive loss control plan to manage and better understand the water loss. In 2008, the American Water Works Association (AWWA) updated the standards for Water Audits and Loss Control Program or AWWA M36 which establishes consistent reporting throughout the United States. This is important because GWA's water loss is higher compared to other utilities. Other utilities loss rate is considered high if loss rate is over 20%, but GWA uses a vastly different reporting method. Through GWA's implementation of the AWWA M36, the perception of the utility's water loss will greatly improve. More importantly by implementing AWWA M36, GWA will begin measuring, evaluating, and reporting water losses in a more consistent manner. Therefore, GWA will have the established performance management tools to make the informed decisions where to relocate resources and reduce water losses in the most economical way.

Problem Statement

In 2009, GWA reported a water loss rate at 58%. The current method GWA uses to report water loss is the "unaccounted-for water percentage", which is the water loss percentage equaling the amount of water produced to the amount of water sold. GWA loss rate is calculated by using the previous AWWA water loss standards without reducing the later losses by accounting for acceptable losses. Examples of acceptable losses include fire hydrant flows and system flush-out. Additionally, zero values for many other inputs the AWWA M36 would reflect a lower rate than 58% water loss rate. This method GWA employs is not how other jurisdictions report water loss percentage. GWA's current leak detection program identifies the quantity of individual leaks at about 5 MGD (million gallons per day) throughout the whole distribution system. After the

reduction of this 5 MGD due to water leaks, GWA remains at a water loss rate of 45%. Table 1 provides the calculations for the existing water loss and a conversion for the 5 MGD to 1,826,000 (1,000 gallons) kgallons per year.

Table 1: Existing Water Loss Calculation

2009	kgallons per year	
GWA Production	14,058,629	100%
GWA Sales & Usage	6,488,577	42%
Water Loss	8,873,635	58%
Water Loss	8,873,635	58%
Leaks detected	1,826,000	13%
Unknown		45%

The problem is twofold: first, GWA's loss rate is very high, and second, GWA's understanding of water loss is limited. Before the leak detection program, a prevailing view in GWA was due to water leaks. The first year of the Leak Detection Program clearly demonstrated that the water loss issues in GWA are more dimensional than water leaks. If we review the historic water loss data with the new information gained from the Leak Detection Program, one would ask the question, "Where is the 45% of water loss coming from?" A general understanding of the AWWA M36 method answers this question specifically by understanding the inputs defined in Table 2 of this Plan.

Summary of Plan:

The primary goal of this Plan is to develop a method and instructions manual for GWA to perform a water audit using the AWWA M36 method. Part I is an introduction which includes the problem statement. Part II, Water Audit Program defines the AWWA M36 water audit and provides a desktop audit as a starting point for the utility's initial water audit. The instruction or training manual customized for GWA to complete the AWWA M36 water audit is introduced in Part II and included in the appendices.

Part III, Water Loss Control Planning, defines a standard water loss control program and reviews GWA's existing water loss control plans, programs, and efforts with respect to this standard plan. For example, the 2011-2015 Capital Improvement Plan and GWA's Priorities are reviewed in detail. The Water System Monitoring Plan is introduced in Part III and provides integrated water system planning and information technology into the water loss control. Part IV, Implementation of the Plan, sets a road map for the implementation of a water loss control plan that will substantially improve water audits. Part IV establishes an action plan for the implementation of GWA's Water Loss Control Plan and combines all the elements reviewed in Part III of the plan.

Part II. Water Audit Program

AWWA M36 Water Audits Program

Past practices of defining and calculating "unaccounted-for" and the "unaccounted-for percentage" varied so widely in utilities around the world that these terms had no consistent meaning. Additionally, the "unaccounted-for percentage" indicator is mathematically misleading and reveals nothing about the two most important factors in water efficiency assessments: water volume and costs. For instance, some definitions allow a certain volume of leakage – deemed "unavoidable" leakage – to be included as "accounted-for" water. Similarly, utility personnel have sometimes classified leaks that are known to exist in inaccessible locations such as pipelines under streams or rivers as "accounted-for" water.

The old method of calculating a loss percentage is sensitive to water sales, and does not focus on economic value of the leakage. The AWWA M36 recommended against the use of the water loss percentage or "unaccounted-for water percentage." Instead, water utilities should employ the term "non-revenue" water. The AWWA M36 also establishes the performance measures of apparent loss indicators and real loss indicators. These new indicators help water utilities gain a firm understanding of fiscal health and operational efficiency.

The two terms "Apparent Losses" and "Real Losses" are important to understand. Apparent losses are the non-physical losses that occur in utility operations due to master meter and customer meter inaccuracies, systematic data handling errors in customer billing systems and unauthorized consumption. In other words, this is water consumed, but is not properly measured, accounted for, or billed. These losses cost utilities revenue and distort data on customer consumption patterns. Real losses are the physical losses of water from the distribution system, including leakage and storage overflows. These losses inflate the water utility's production costs and stress water resources since they represent water that is extracted and treated, yet never reaches beneficial use. "Apparent Losses" and "Real Losses" are listed in Column 3 of Table 2.

Table 2 defines the terms used in the AWWA M36 and their perspective relationships. For example, the "Water Supplied" (Column 1) is defined in the Authorized Consumption in addition to the "Water Losses" (Column 2) or the water supplied is the "Revenue Water" plus the "Non-Revenue" water (Column 5). In Appendix B, Section 2 Audit Worksheet Instruction for Quantity of Water provides the definitions of terms listed in Table 2.

Table 2: AWWA M36 Summary Table

Column 1	Column 2	Column 3	Column 4, INPUTS	Column 5
Water Supplied	Authorized Consumption	Billed Consu ption	Billed Metered	Revenue Water
			Billed Unmetered	
		Unbilled Consumption	Unbilled Metered	Non-Revenue Water
			Unbilled Unmetered	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Systematic Data Handling Errors	
		Real Losses	Leakage on Mains	
			Leakage and Overflows at Tanks	
			Leakage on Service Connections	

Additionally, the AWWA M36 includes a grading system to rate the data utilized to calculate the loss, therefore providing a level of assurance with the values.

In summary the advantages of using AWWA M36 reporting method are threefold: 1) the AWWA M36 is an established standard method, 2) it provides a set of standard performance indicators based on economic values, and 3) it calculates a grading system for the quality of data.

The GWA Water Audit

One of the goals of this Plan is to serve as a customized manual to train GWA's employees to perform the water audit on the utilities system. This detailed manual includes standard definitions, the GWA Water Audit Worksheets, and standard instructions for completing the Worksheet. The GWA Water Audit Manual is provided in Appendix B of this Plan.

This Plan includes a customized process for a GWA water audit, but does not include performance measures established under the AWWA M36. The "top-down" approach is the AWWA M36 manual's recommended starting point for utility water audit. The "top-down" approach provides a desktop audit, but also provides the basic understanding of the data used in the AWWA M36 method. The Water Audit Program (WAP) plan includes the tools GWA will need to perform the basic water audit including the GWA Water Audit Worksheet, reference Appendix B, Section 1. Additionally, step by step instruction will be provided in order for GWA staff to fill out the Water Audit water quantity information and data quality in the form of a Water Audit Worksheet. Instructions for Quantity of Water are provided in Appendix B, Section 2, and instructions for Quality of Data are provided in Appendix B, Section 3. With the GWA Water Audit Worksheet and instruction for completing the GWA Water Audit Work sheet, the WAP is the first step in improving the water loss reporting.

Part III. Water Loss Control Planning

Guam Waterworks Authority's distribution system is very complex, and combined with the ageing condition of GWA's water system, means that a holistic approach must be initiated to plan and develop a water loss control program. GWA's Water Loss Control Program Planning will include: 1) a review of the Standard Water Loss Control Program; 2) the establishment of a Water System Monitoring Plan and an aggressive Capital Improvement Program (CIP); 3) an evaluation of GWA's Priorities; and finally, 4) an Action Plan for the Implementation of the Water Loss Control Plan.

The Action Plan will be accomplished by a series of steps. First, a framework will be developed for the Standard Water Loss Control Program using the AWWA M36 Standard Water Loss Control Matrix or the AWWA M36 Planning Matrix. The AWWA M36 Planning Matrix will be presented as the starting point; GWA's current programs will be reviewed with respect to the AWWA M36 Planning Matrix. Second, GWA's existing plan such as the Water System Monitoring Plan, the GWA 2011-2015 CIP, and the GWA Priority list will be reviewed with respect to the AWWA M36 Planning Matrix. With the addition of priorities based on GWA's existing plans the AWWA M36 Planning Matrix will be modified into an Action Plan for the Implementation of the Water Loss Control Plan.

The Standard Water Loss Control Program

The AWWA M36 Planning Matrix presents the Standard Water Loss Control Program for the purpose of planning; this matrix is presented in Table 3 and focuses on timing of implementation and the type of loss the activity addresses. The timing or phasing of activities is broken down into short-term, medium-term, and long-term.

In Table 4, GWA's Water Loss Control Program Status presents the activities of the AWWA M36 Standard Water Loss Control Planning Matrix with respect to GWA's current water loss control programs. This cursory review demonstrates GWA's substantial efforts towards a "bottom-up" approach to a Standard Water Loss Control Program. Therefore, GWA has demonstrated a commitment to reduce water loss through the meter replacement program, leak detection program, establishment of Water Service Area (WSA) maps, and other initiatives listed in Table 4.

Table 3: Standard Water Loss Control Program Planning Matrix

Number	Phase	Loss Control	Activity
1.1	Short Term	Real	Calibrate production flow meters.
1.2	Short Term	Real	Flowchart customer billing process; compile general demographics of the customer/meter population.
1.3	Short Term	Real	Perform meter accuracy testing on a small sample of customer meters.
1.4	Short Term	Real	Audit billing records and visit a small number of customer accounts to determine the potential for missed billing or unauthorized consumption.
1.5	Short Term	Apparent	Review maintenance records; summarize statistics on breaks and leaks.
1.6	Short Term	Apparent	Review policies for customer service connection piping ownership and maintenance, and opportunity to reduce customer service connection piping leakage durations.
1.7	Short Term	Apparent	Establish a pilot District Metered Area (DMA); perform minimum hour leakage analysis.
1.8	Short Term	Apparent	Compile data on the variation of water pressure throughout the water distribution system.
1.9	Short Term	Apparent	Launch a pilot leak detection survey, perhaps via a consultant; consider use of leak noise monitors.
2.1	Medium Term	Real	Investigate the potential costs and savings of instituting an AMR system to reduce missing or erroneous customer meter readings.
2.2	Medium Term	Real	Review/implement policies to thwart unauthorized consumption.
2.3	Medium Term	Real	Install, upgrade or replace production flow meters.
2.4	Medium Term	Apparent	Create a leak detection squad, or hire a leak detection contractor, to regularly survey the distribution system for unreported leakage.
2.5	Medium Term	Apparent	Install pressure management areas and/or deploy leak noise monitors.
3.1	Long Term	Real	Install an AMR system and institute monthly billing based on meter readings.
3.2	Long Term	Real	Install a new customer billing system.
3.3	Long Term	Real	Conduct wholesale customer meter replacement.
3.4	Long Term	Apparent	Implement a maintenance management information system.
3.5	Long Term	Apparent	Create additional DMAs.
3.6	Long Term	Apparent	Institute capital replacement program for water main infrastructure.

Table 4: Review of GWA's Progress in AWWA M36 Planning Matrix

Number	Activity	Status
1.1	Calibrate production flow meters (this is a very important procedure).	Must order meter test bench.
1.2	Flowchart the customer billing process; compile general demographics of the customer/meter population.	Complete
1.3	Perform meter accuracy testing on a small sample of customer meters.	Must order meter test bench, create procedure.
1.4	Audit billing records and visit a small number of customer accounts to determine the potential for missed billing or unauthorized consumption.	Revenue reports are updated daily as we bill, these reports are analyzed based on consumption and money. However if service orders are not updated on a timely basis, this will cause a potential missed billing or unauthorized consumption (billing by estimation).
1.5	Review maintenance records; summarize statistics on breaks and leaks.	Completed but large data gaps in previous years.
1.6	Review policies for customer service connection piping ownership and maintenance, and opportunity to reduce customer service connection piping leakage durations.	Early phase of review.
1.7	Establish a pilot DMA; perform minimum hour leakage analysis.	Started, project with Navy meters. Bubble Map.
1.8	Compile data on the variation of water pressure throughout the water distribution system.	Ongoing with Hydraulic Modeling efforts. Create procedure for record keeping.
1.9	Launch a pilot leak detection survey, perhaps via a consultant; consider use of leak noise monitors.	Completed; year one of leak detection contract complete.
2.1	Investigate the potential costs and savings of instituting an AMR system to reduce missing or erroneous customer meter readings.	Started; this project is 50% complete.
2.2	Review/implement policies to thwart unauthorized consumption.	Vastly improved.
2.3	Install, upgrade or replace production flow meters.	Ongoing – replacements of Well Sensus Meters to Mag Flow Meters. (Standardizing) as funding permits.
2.4	Create a leak detection squad, or hire a leak detection contractor, to regularly survey the distribution system for unreported leakage.	Completed; year one of leak detection contract complete.
2.5	Install pressure management areas and/or deploy leak noise monitors.	Pressure gauges to be installed late 2011 and 2012
3.1	Install an AMR system and institute monthly billing	Started; this project is 50%

	based on meter readings.	complete.
3.2	Install a new customer billing system.	CIS system being evaluated
3.3	Conduct wholesale customer meter replacement.	Started; this project is 50% complete.
3.4	Implement a maintenance management information system.	Ongoing, as of Oct. 2010, through 6 months. Training with Asset Management Module on JDE.
3.5	Create additional DMAs.	CIP
3.6	Institute capital replacement program for water main infrastructure.	CIP

Water System Monitoring Plan

In order to manage water loss, the water system first must be measured and monitored. The Guam Waterworks Authority Water Audit Worksheet provided in Appendix B, Section 1, reports on water loss in a utility as a whole; that is data reported on a utility wide or global data set. This corresponds to the "top-down" approach to the short-term phase of implementation of a Water Loss Control Program. This global data can be collected today without large capital expenditure. The next step in a Water Loss Control Program is to begin the "bottom-up" approach, which includes measuring and monitoring the GWA water system on the local level. This can be accomplished by dividing the water system into small sections or local data. The local data will help GWA prioritize which areas of the island to focus its efforts on in order to provide the most gains in water loss reduction. The AWWA M36 uses the term to measure local areas District Metered Area (DMA), which can be compared to GWA's established Water Service Areas (WSA). The establishment of a DMA is listed in the AWWA M36 Planning Matrix, but for GWA's purposes, the term WSA can be used synonymously. The measuring and monitoring of local data is only one part of the Water System Monitoring Plan, the second part is the automation of data collection.

In order to manage water loss, GWA must accurately measure water loss on the local level. To initiate water audits on the local systems, GWA will implement the Master Meter program to monitor flows as defined by the Water Service Areas (WSA). GWA's system is divided into 49 WSA, as reflected on the GWA Bubble Map and WSA Maps. As master meters are installed, GWA will commence water audits on these WSA and compare them to the global water loss data. By automating water audits for the 49 WSA, GWA will maximize resources while minimizing water losses. The Supervisory Control and Data Acquisition (SCADA) system will provide automation of data collected from the Master Meter system. This data will be compared to the demand data provided in the individual meter data collection.

Water System Planning provides the tools for establishing pressure zones. For example, the GWA Bubble Map defines a zone-based diagram for the water demands and/or supply for each individual zone. Each individual bubble on the Bubble Map

establishes a pressure zone or WSA. The Bubble Map is also a water flow schematic of the water system that defines the relationships of the different WSA to one another. A WSA on the Bubble Map represents a community of water users in a common area with their associated water consumption. There are some WSA that include the water supply within the zone including water production from wells. The Monitoring Plan must include strong system planning efforts, including maintaining the Bubble Map, WSA Map, and Hydraulic Model.

The Water System Monitoring Plan can only be accomplished with the implementation of Capital Improvement Projects, such as, the Potable Water System Planning, the SCADA System Project, and the Master Meters Project.

Review of Existing GWA Plans and Programs

The following documents and studies were reviewed with respect to the water loss reduction: GWA Priorities, the Capital Improvement Program, Water Resource Master Plan, the Baker-Tilly Management Audit, and American Public Works Association Best Management Practices.

The Capital Improvement Program

Each project was reviewed from the perspective of Water Loss Reduction in the 2011-2015 Capital Improvement Plan. Table 5 provides a list of projects contained in the 2011-2015 Capital Improvement Plan that have a positive effect on reducing water losses in the GWA system. The projects were reviewed and rated high, medium or low based on their overall affect on water loss. As demonstrated by the Water System Monitoring Plan, the large Capital Improvement Projects are required to implement the plan.

CIP PW 05-09 Leak Detection / Line Replacement is one example of a high rated project because the leak detection contract is a three-year knowledge transfer contract with GWA teams. In the first year of the leak detection contract, GWA's teams followed the contractor and confirmed the leaks. In the second year, the contractor will follow the GWA team and check their work. The high-ranked projects directly reduce water loss.

CIP EE 09-06 through 09-09 SCADA System Improvements Phase 1-4 are examples of medium-rated projects because the projects do not directly decrease water loss, but the projects provide improved information on reporting and performing the water audit. The medium-ranked projects assist GWA with planning and reporting water loss.

PW 09-11 Water System Reservoirs 2005 Improvements is an example of a low-ranked project. Due to the recent reservoir inspections, the Water System Reservoirs 2005 Improvements project will assist in the repair or replacement of existing leaky reservoirs. The low-priority projects reduce water loss but are not part of a standard water loss control program.

Table 5: Review of the Capital Improvement Plan

CIP #	Name	Water Loss Planning
PW 05-16	Master Meters	High
PW 05-10	Potable Water System Planning	Medium
PW 09-04	Pressure Zone Realignment/Development 2005 Impr.	High
PW 05-07	Meter Replacement Program	High
PW 05-09	Leak Detection / Line Replacement	High
PW 09-03	Water Distribution System Pipe Replacement	High
PW 09-05	Northern System Water Distribution System 2005 Impr.	High
PW 09-06	Central Water Distribution System 2005 Improvements	High
PW 09-07	Southern Water Distribution System 2005 Improvements	High
PW 11-01	Distribution System Upgrades	High
PW 05-02	Water Reservoir Condition Assessment	Low
PW 09-09	Water Reservoir Internal/External Corrosion Assmt.	Low
PW 09-10	Water Reservoir Internal/External Corrosion Rehab.	Low
PW 09-11	Water System Reservoirs 2005 Improvements	Low
PW 05-06	Water Booster Pump Station	Low
EE 05-02	SCADA Pilot Project	Medium
EE 09-06	SCADA Improvements – Phase 1	Medium
EE 09-07	SCADA Improvements – Phase 2	Medium
EE 09-08	SCADA Improvements – Phase 3	Medium
EE 09-09	SCADA Improvements – Phase 4	Medium

GWA Priorities

In July 2010, the GWA Priorities list was established, developed and prioritized by GWA's General Manager and GWA's Program Managers in order to provide clear direction for improving GWA. The GWA Priority List included Priority 2: Increase Meter Revenue, Priority 4: Reduce Water Loss and Priority 5: Implement the Capital Improvement Program, which is listed in Table 6.

An example of a project that directly supports water loss is the outsourcing to assist GWA with leak repairs or the Line Repair / Line Replacement Project. The GWA resources saved from leak repairs will be flexed over to assist with the meter program to increase revenues. This project will include scheduled leak repair for pipes 4" and under, 6" pipes, 8" pipes, and 12" pipes. Because many of the pipes are leaking beyond the economic point of repair, they must be replaced or abandoned when an appropriate parallel pipe is present. This project also includes service relocation of pipes and pipe abandonment for 6" pipes and under, and line replacement for 8" pipes and under.

The Line Repair/Line Replacement Project has two areas of direct financial benefit. First, GWA resources saved from the leak repair side will be flexed over to assist with the meter program to increase revenues. Second, with the pipe

abandonment and replacement portion of the project, GWA will see a decrease in water loss and a decrease in overall water cost.

Table 6: Review of General Manager Priority List

#		General Manager Priority	Status
2		Increase Meter Revenues	
	A	Change out zero and low reads	Ongoing effort, zero reads and low reads are tracked on a monthly basis
	B	Remove back flow preventers	Program ongoing ~11,000 removed ~6,000 remaining
	C	Outsource Assistance Bid	Bid package complete for Line Repair / Line Replacement Project
	D	Replace Commercial Meters	Ongoing
	E		
	F	Implement Meter performance comparison program	Not started
4		Reduce Water Loss	
	A	Reduce leak repair backlog	Bid package complete for Line Repair / Line Replacement Project
	B	Outsource Bid Assistance	Bid package complete for Line Repair / Line Replacement Project
	C	Implement Leak Detection Program	Phase II Mobilization started June 6, 2011
	D	Replace Leaking Distribution Lines	Bid package complete for Line Repair / Line Replacement Project
	E	Implement water usage accountability	Research was started as part of this plan
	F	Improve Low water pressure areas	Bid package complete for Line Repair / Line Replacement Project
5		Implement CIP programs	Implementation of this priority part of WLR Plan

Part IV. Implementation of the Plan

The implementation of this Plan will require the combined efforts of the Water Operations Division, Finance Division, Customer Service Division, Engineering Division, and Information Technology Division. The overreaching goal of this Plan is to serve as a customized manual to help train GWA's employees on the water audit program and water loss program by establishing standard definitions and applying standard instructions to the GWA Water Audit Worksheets. To this end, the Plan recommends the Consolidated Commission on Utilities (CCU) to establish policies for the water audit method. Appendix A is provided as an example of a resolution to establish the AWWA M36.

Table 7: GWA Action Plan "Now Term"

#	Phase	Activity
0.01	Now Term	Develop meter shop with meter calibration capacities.
0.02	Now Term	GWA Priority 2A, Increase Meter Revenues Change out zero and low reads.
0.03	Now Term	GWA Priority 2B, Increase Meter Revenues Remove back flow preventers.
0.04	Now Term	GWA Priority 2C, Increase Meter Revenues Outsource Assistance Bid.
0.05	Now Term	GWA Priority 2D, Increase Meter Revenues Replace Commercial Meters.

Table 8: GWA Action Plan "Short Term"

#	Phase	Activity
1.01	Short Term	Calibrate production flow meters.
1.02	Short Term	Flowchart the customer billing process; compile general demographics of the customer/meter population.
1.03	Short Term	Perform meter accuracy testing on a small sample of customer meters.
1.04	Short Term	Audit billing records and visit premises of a small number of customer accounts to determine the potential for missed billing or unauthorized consumption.
1.05	Short Term	Review maintenance records; summarize statistics on breaks and leaks.
1.06	Short Term	Review policies for customer service connection piping ownership and maintenance, and opportunity to reduce customer service connection piping leakage durations.
1.07	Short Term	Establish a pilot DMA; perform minimum hour leakage analysis.
1.08	Short	Compile data on the variation of water pressure

	Term	throughout the water distribution system.
1.09	Short Term	Launch a pilot leak detection survey, perhaps via a consultant; consider use of leak noise monitors.
1.10	Short Term	Complete CIP EE SCADA master plan.
1.11	Short Term	GWA Priority 2F.
1.12	Short Term	CIP PW 05-16 required professional service contract for System Master Meter.
1.13	Short Term	Meter Replacement Program (complete STIP).
1.14	Short Term	GWA Priority 4B & CIP PW 05-09 Line Repair / Line Replacement Contract.
1.15	Short Term	GWA Priority 4A.
1.16	Short Term	GWA Priority 4E (install meter as appropriate at unmetered GWA accounts).
1.17	Short Term	GWA Priority 4E (Complete SOP's for "Unbilled Unmetered" water).
1.18	Short Term	Fix meter clusters on private property by adding One property meter.
1.19	Short Term	Implement Baker Tilly, 5b. Improve Meter Reading Process.

Table 9: GWA Action Plan "Medium Term"

#	Phase	Activity
2.01	Medium Term	Investigate the potential costs and savings of instituting an AMR system to reduce missing or erroneous customer meter readings.
2.02	Medium Term	Review/implement policies to thwart unauthorized consumption.
2.03	Medium Term	Install, upgrade or replace production flow meters.
2.04	Medium Term	Create a leak detection squad, or hire a leak detection contractor, to regularly survey the distribution system for unreported leakage.
2.05	Medium Term	Install pressure management areas and/or deploy leak noise monitors.
2.06	Medium Term	CIP PW 05-10.
2.07	Medium Term	Add performance measures to GWA Water Audit Worksheet.
2.08	Medium Term	Begin to Implement SCADA Master Plan.
2.09	Medium Term	Develop organization capacity to maintain and operate SCADA system.

Table 10: GWA Action Plan "Long Term"

#	Phase	Activity
3.01	Long Term	Install an AMR system and institute monthly billing based on meter readings.
3.02	Long Term	Install a new customer billing system.
3.03	Long Term	Conduct wholesale customer meter replacement.
3.04	Long Term	Implement a maintenance management information system.
3.05	Long Term	Create additional DMAs.
3.06	Long Term	Institute capital replacement program for water main infrastructure.
3.07	Long Term	Complete all Low Priority CIP Projects
3.08	Long Term	Implement organization capacity to maintain and operate SCADA system.

Recommendation

This report makes the following recommendations:

- Compile the AWWA M36 Water Audit, as presented in Appendix B, on annual basis, including providing customized internal training of AWWA M36 Water Audit using Appendix B as a training manual.

- Establish proactive leakage management system; set a goal to fix leak in 48 hours. For example, if a pipe leaks at 20 gallons per minute at a cost of $1.60 per 1,000 gallons the cost to GWA if the pipe is fixed in 2 days is $92.16 versus the price of $1,382.40 if the pipe is fixed in 30 days. This leakage management system will include prioritizing large leaks and leaks that occur in area where water prices are substantially higher.

- Learn how pressure varies across the system by continuing to developing a sophisticated System Planning Section to calibrate hydraulic models. This hydraulic model must be used to determine how to reduce water loss in the potable water system.

- Complete Revenue and Billing Collection Plan combining Action Items #1.02, #1.04, #2.02, #3.02 into one comprehensive plan. This plan will include implementation of a meter replacement program for wrongly sized meters, analysis of sales volume, and re-evaluating the frequency of meter readings for cost efficiencies. Additionally, this plan will define the study of commercial/industrial customers with a view to ensure optimization of meter sizes and improve the billing procedure for high consumption customers.

- Complete a water system wide parcel based map with aerial photos, meter location, and account number overlays. This map will also provide the field staff the ability to locate meters. Combine this data with the sewer system parcel based mapping with the sewer connection, aerial photo, and account number overlay to complete a comprehensive review of all occupied structures and establish a robust revenue protection plan.

Appendix A

Guam Waterworks Authority
Guam Consolidated Commission on Utilities Resolution
Water Audit Methodology

Guam Consolidated Commission on Utilities

Implement the International Water Association/American Water Works Association Water Audit Methodology

This CCU motion will require GWA to monitor and annually report unaccounted-for water (UFW) using the water audit methodology established by the International Water Association (IWA) and the American Water Works Association (AWWA). This water audit will ensure GWA develops standard water industry practices to meet challenges and achieve a number of public interest benefits. The new water audit will also further overall infrastructure reliability, preserve water resources, limit water leakage, and enhance customer service.

The CCU expects GWA to aggressively participate for a number of reasons. First, GWA's strength and overall viability lend themselves well to straightforward adaptation of the new procedure. Second, all viable water utilities constantly strive to improve operational efficiency. Third, the water audit is consistent with current challenges facing the water industry: rising costs for aging infrastructure rehabilitation, power consumption, chemicals and other treatment required by the stringent Safe Drinking Water Act, and the limited availability and higher costs for developing new sources of supply, among others.

Achieving and maintaining low levels of UFW indicates a well-managed water utility that prevents waste of a precious resource and avoids lost revenue. In addition, during the rate case review process, expenses for power and chemicals may be disallowed when UFW levels exceed 50 percent.

New Water Audit Procedure

For many years, this Commission determined UFW by using a combination of methodologies in the AWWA training manual. Although this method was commonly used throughout the country, it became apparent that differing interpretations, adjustments, and components led to less than accurate UFW levels. The likely consequences of the inaccurate UFW representations are ineffective planning and inability to target corrective measures.

An enhanced, more comprehensive method has since been developed which offers superior data and indicators for improved operational accountability. The new water audit assists utilities to identify where the losses are occurring, how much, and at what cost. The term "unaccounted-for water" has been replaced with the term "water audit," based on the concept and underlying procedure that virtually all water can be "accounted-for."

The new procedure provides an effective, standardized structure that quantifies apparent and real water losses, assigns cost impacts to the losses, and calculates new performance indicators that allow reliable benchmarking with other water utilities and target-setting to strategically reduce excessive losses. Other features include:

- Sound, consistent definitions for the major forms of water consumption and water loss.
- Rational performance indicators that evaluate utilities on system-specific features, such as the average pressure in the distribution systems and miles of water main.

- Meaningful assessments of water losses that indicate how much of each type of loss occurs and how much it is costing the water utility.

The key concept around this method is that no water is "unaccounted-for". All water supplied is accounted for by assigning measured or estimated quantities to the major components of water consumption and losses. Costs are also assigned to assess financial impact to the water utility. For example, the water utility determines the amount of water that contributes to billed consumption including other authorized consumption and losses. Losses represent inefficiencies that are categorized as consumption and *real losses* or actual physical losses. Leakage is the largest component of real and total losses for many water systems and causes excess treatment and delivery costs. *Apparent losses* are significant since they are typically valued at higher costs than leakage and can have a substantial financial impact in terms of lost revenue for utilities that bill customers based upon metered consumption.

GWA, along with their customers, will be well served by implementing this water audit methodology. We can expect operational efficiencies through improved tracking of costs to pump and treat water that is not revenue producing. Ultimately, tighter control of water production to match actual customer demand will assist in sustaining existing water sources.

Implementation Summary

In 2003, the new water audit methodology was identified by AWWA's Water Loss Control Committee as a world-wide best management practice in water loss control. In 2006, the AWWA released a water audit software package that is available free of charge on its website, broadening the new procedure's accessibility. A year later, the AWWA Research Foundation designated the water audit methodology as the current best practice.

Today, its use continues to expand, consistent with widespread efforts to increase water supply sustainability, infrastructure remediation and overall service reliability. For example by 2008, it had been adopted by, among others, the Texas Water Development Board, which has oversight over 2,000 water utilities; the Metropolitan North Georgia Water Planning district, which oversees more than 60 water utilities in the Atlanta area; and the California Urban Water Conservation Council.

Numerous ancillary opportunities will become apparent with the implementation of the water audit:

- The effectiveness of existing billing software;
- The optimum staffing complement;
- The impact of certain pressure reductions;
- The appropriate life cycle for meter change-outs;
- The need for meter "rightsizing" to more effectively measure the customer's actual usage pattern;
- The optimum time period for conducting distribution system leak detection surveys; and
- The impact of customer service line leakage and whether more rapid repair may yield a significant reduction in non-revenue water losses.

Implementation

Currently, GWA does not have a robust water audit program. However, the CCU ongoing leak detection program is an integral part of achieving low levels of UFW.

Implementing the new water audit methodology may require dedicated resource commitments, including time to allow GWA staff to become familiar with the new procedure. It is expected that the GWA Chief Engineer leads this effort and establishes a technical working group to meet within sixty (60) days of the entry date of the final discussion matters pertaining to implementation of the new water audit methodology consistent with American Water Works Association and the International Water Association with the goal of developing an annual report for unaccounted-for water.

THEREFORE:

Within sixty (60) days, GWA will establish a technical working group, led by the GWA Chief Engineer, to implement a water audit methodology consistent with the AWWA and the IWA.

An annual report for unaccounted-for water consistent with the American Water Works Association and the International Water Association shall be implemented and submitted to the CCU within 24 months; the Commission will consider whether an extension of time is appropriate.

An implementation status report on unaccounted-for water, consistent with the AWWA and the IWA for the first 12-month period of the program, shall be submitted to the CCU.

Appendix B

Guam Waterworks Authority
GWA Water Audit Manual

Section1: Water Audit Worksheet
Section 2: Audit Worksheet Instruction Quantity of Water
Section 3: Audit Worksheet Instruction, Quality of Data

Section 1, Guam Waterworks Authority Water Audit Worksheet

Table B1. GWA Water Audit Worksheet

Number	Item	Quantity	Quality
[1]	Water Volume From Own Sources		
[2]	Wholesale Water Imported		
[3]	System Input Volume [3] = [1] + [2] (Water Supplied)		
[4]	Billed Metered		
[5]	Billed Unmetered		
[6]	Billed Authorized Consumption [6] = [4] + [5] (Revenue Water)		
[7]	Unbilled Metered		
[8]	Unbilled Unmetered		
[9]	Unbilled Authorized Consumption [9] = [7] + [8]		
[10]	Authorized Consumption [10] = [6] + [9]		
[11]	Customer Metering Inaccuracies		
[12]	Systematic Data Handling Errors		
[13]	Unauthorized Consumption		
[14]	Apparent Losses [14] = [11] + [12] + [13]		
[15]	Reported Breaks and Leaks (Leakage on Mains)		
[16]	Leakage and Overflows at Storage Tanks		
[17]	Leakage on Service Connections up to Point of Customer Metering		
[18]	Real Losses [18] = [15] + [16] + [17]		
[19]	Water Loss (Method A) [19] = [14] + [18]		
[20]	Non-Revenue Water		
[21]	Water Loss (Method B) [21] = [3] – [10]		

All units of water in Million Gallons Per Day (MGD).

Section 2: GWA Audit Worksheet Instruction, Quantity of Water

Part 1: AWWA M36 Summary Table

Table B2 defines the relationship the terms used in the AWWA M36 and the relationship between terms. For example, the Water Supplied (column 1) is defined in the Authorized Consumption in addition to the Water Losses (column 2) or the water Supplied is the Revenue Water plus the Non-Revenue water (column 5) and Apparent Losses and Real Loss (column 3).

Table B2. AWWA M36 Summary Table

			INPUTS	
Water Supplied **[3]**	Authorized Consumption **[10]**	Billed Authorized Consumption **[6]**	Billed Metered **[4]**	Revenue Water **[6]**
			Billed Unmetered **[5]**	
		Unbilled Authorized Consumption **[9]**	Unbilled Metered **[7]**	Non-Revenue Water **[20]**
			Unbilled Unmetered **[8]**	
	Water Losses **[19]** & **[21]**	Apparent Losses **[14]**	Customer Metering Inaccuracies **[11]**	
			Systematic Data Handling Errors **[12]**	
			Unauthorized Consumption **[13]**	
		Real Losses **[18]**	Leakage on Mains **[15]**	
			Leakage and Overflows at Tanks **[16]**	
			Leakage on Service Connections **[17]**	

Part 2: Definitions of Terms

[3] Water Supplied: The availability of stored water for a community or region.

[4] Billed Metered: All metered consumption billed and includes all groups of customers such as domestic, commercial, industrial or institutional.

[5] Billed Unmetered: All billed consumption which is calculated based on estimates or norms but is not metered. This might be a very small component in fully metered systems (for example billing based on estimates for the period a customer meter is out of order) but can be the key consumption component in systems without universal metering.

[6] Revenue Water: Water charged to customers to provide revenue to the utility. The term for Revenue Water is the same as Billed Authorized Consumption.

[7] Unbilled Metered: Water that is metered but not billed, such as city/government offices, city park irrigation, water treatment facility use, some fire department use, and line flushing.

[8] Unbilled Unmetered: Estimated water that is not billed or metered, such as most line flushing.

[9] Unbilled Authorized Consumption: The component of Authorized Consumption which is legitimate but not billed and therefore do not produce revenue. Unbilled Authorized Consumption is equal to Unbilled Metered Consumption plus Unbilled Unmetered Consumption.

[10] Authorized Consumption: The volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier, for residential, commercial and industrial purposes. It also includes water exported across operational boundaries. Authorized Consumption may include items such as fire fighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc. These may be billed or unbilled, metered or unmetered.

[11] Customer Metering Inaccuracies: The apparent water losses caused by the collective under-registration of customer water meters. Many customer water meters will wear as large cumulative volumes of water are passed through them over time. This causes the meters to under-register.

[12] Systematic Data Handling Errors: The apparent water losses caused by systematic data handling errors in the meter reading and billing system.

[13] Unauthorized Consumption: Any unauthorized use of water. This may include illegal water withdrawal from hydrants (for example for construction purposes), illegal connections, bypasses to customer meters or meter tampering.

[14] Apparent Losses: Apparent Losses are the non-physical losses that occur in utility operations due to customer meter inaccuracies, systematic data handling errors in customer billing systems, and unauthorized consumption. In other words, this is water that is consumed but is not properly measured, accounted or paid for. These losses cost utilities revenue and distort data on customer consumption patterns.

[15] Leakage on Mains: The water lost from leaks and breaks on transmission and distribution pipelines. These might either be small leaks which are still unreported (e.g. leaking joints) or large breaks which were reported and repaired but did leak for a certain period before that.

[16] Leakage and Overflows at Tanks: Water not billed as a result of leakage and overflows from utility storage and balance tanks.

[17] Leakage on Service Connections: Water lost from leaks and breaks of service connections from (and including) the tapping point until the point of customer use. In metered systems this is the customer meter, in unmetered situations this is the first point of use (stop tap/tap) within the property. Leakage on service connections might be reported breaks but will predominately be small leaks which do not surface and which run for long periods (often years).

[18] Real Losses: The physical losses of water from the distribution system, including leakage and storage overflows. These losses inflate the water utility's production costs and stress water resources since they represent water that is extracted and treated, yet never reaches beneficial use.

[19] & [21] Water Losses: The difference between system input and authorized consumption. Water losses are comprised of apparent losses and real losses.

[20] Non-Revenue Water: Apparent Losses plus Real Losses plus Unbilled Metered plus Unbilled Unmetered. Non-Revenue Water does not provide any revenue to the utility.

Part 3: GWA Water Audit Worksheet

Table B3. Water Audit Worksheet

Number	Item	Quantity	Quality
[1]	Water Volume From Own Sources		
[2]	Wholesale Water Imported		
[3]	System Input Volume [3] = [1] + [2] (Water Supplied)		
[4]	Billed Metered		
[5]	Billed Unmetered		
[6]	Billed Authorized Consumption [6] = [4] + [5] (Revenue Water)		
[7]	Unbilled Metered		
[8]	Unbilled Unmetered		
[9]	Unbilled Authorized Consumption [9] = [7] + [8]		
[10]	Authorized Consumption [10] = [6] + [9]		
[11]	Customer Metering Inaccuracies		
[12]	Systematic Data Handling Errors		
[13]	Unauthorized Consumption		
[14]	Apparent Losses [14] = [11] + [12] + [13]		
[15]	Reported Breaks and Leaks (Leakage on Mains)		
[16]	Leakage and Overflows at Storage Tanks		
[17]	Leakage on Service Connections up to Point of Customer Metering		
[18]	Real Losses [18] = [15] + [16] + [17]		
[19]	Water Loss (Method A) [19] = [14] + [18]		
[20]	Non-Revenue Water		
[21]	Water Loss (Method B) [21] = [3] – [10]		

All units of water in Million Gallons Per Day (MGD).

Part 4: Guam Waterworks Authority Audit Worksheet Instructions

The instructions are labeled by line number shown on the worksheet. The GWA Audit Worksheet requires general information and water supply, consumption, and loss quantities. It also requires assessment scores representing the degree of validation of individual components. For those components that include an assessment line, enter a number between 1 and 5. (See Appendix D for more information.) If a component does not apply, then enter 0 (for example, if the water utility does not import any water, enter 0 for wholesale water imported).

Units of Measurement: All units of water will be inputted in Million Gallons Per Day (MGD).

[1] Water Volume from Own Sources: Includes all water taken as source water from rivers and wells. This value is a corrected value based on meter accuracy from Table C3.

Table C3. [1] Water Volume from Own Source

A	Ugum Treatment Plant Supply	
B*	GWA Well Supply	
C = A + B	Raw Water Volume From Own Sources	
D	Production Meter Accuracy (enter a percentage)	%
E = C X D	[1] Water Volume From Own Sources	

*Include GWA Well Supply Detailed Documentation with report.

[2] Wholesale Water Imported: Amount of purchased water transferred into GWA's distribution system from DoD water suppliers.

[3] System Input Volume: The total water supplied to the infrastructure. It is the total of all production meter readings for the entire year. The [3] System Input Volume is calculated by adding [1] Water Volume From Own Sources to [2] Wholesale Water Imported or [3] = [1] + [2].

[4] Billed Metered: All water sold and metered.

[5] Billed Unmetered: All water sold but not metered.

[6] Billed Authorized Consumption: The [6] Billed Authorized Consumption is calculated by adding [4] Billed Unmetered to [5] Billed Unmetered or [6] = [4] + [5].

[7] Unbilled Metered: All water metered but not billed, such as back flushing water, parks, golf courses, and municipal government offices.

[8] Unbilled Unmetered: All water not billed or metered, such as flushing fire hydrants. Table C4 defines the elements of Unbilled Unmetered water.

Table C4. Unbilled Unmetered

	Element	Amount
A	Firefighting	
B	Firefighting Training	
C	Flow Testing	
D	Main Flushing	
E	Storm Drain Flushing	
F	Sewer Flushing	
G	Street Cleaning	
H	Bulk Water Sales	
I	Storage Tank Drainage	
J	Public Area Irrigation (parks & playgrounds)	
K	Water Plant Uses (chemical mix, filter wash, etc.)	
L	Well Purging	
M	Water Quality Testing	
N	Repaired Distribution System Leaks	
O	Other Unmetered Uses	
Sum A-O	[8] Total Authorized Unmetered Uses	

[9] Unbilled Authorized Consumption: The [9] Unbilled Authorized Consumption is calculated by adding the [7] Unbilled Metered + [8] Unbilled Unmetered or [9] = [7] + [8].

[10] Authorized Consumption: The [10] Authorized Consumption is calculated by adding [6] Billed Authorized Consumption and [9] Unbilled Authorized Consumption or [10] = [6] + [9].

[11] Customer Metering Inaccuracies: This component of the Apparent Losses is due to meter inaccuracy. The [11] Customer Metering Inaccuracies is calculated by using [4] Billed Metered water volume and the meter efficiency. Use Table C5 to calculate.

Example: If [4] Billed Metered consumption registered 30 MGD and random meter testing found customer meters to be collectively under-registering flow by 8 percent (so they are 92 percent accurate), then:

Customer Metering Inaccuracies = [(30/0.92) – 30] = 2.4 MGD.

Table C5. [11] Customer Meter Accuracy

A	Meter Efficiency	%
B	[4] Billed Metered	
C=(B/A)-B	[11] Customer Metering Inaccuracies	

The Customer Metering Inaccuracies is the composite accuracy percentage or meter efficiency for your customer's meters. This percentage is typically derived from meter testing results. A representative assessment of customer metering inaccuracies can be obtained by testing as few as 50 meters.

[12] Systematic Data Handling Error: List the estimated volume of water recorded by customer meters but distorted by meter reading or billing system error.

[13] Unauthorized Consumption: Estimate amount of water loss due to theft. Include an estimate of water taken illegally from fire hydrants, as well as water loss at the customer service connection. Theft at the customer connection can include tampering with meters or meter reading equipment, in addition to illegal taps and other similar occurrences.

[14] Total Apparent Losses: This value is calculated automatically online as the sum of customer meter accuracy loss, systematic data handling error, and unauthorized consumption.

[15] Leakage on Mains: Reported breaks and leaks brought to the attention of the water utility by customers, public safety officials, other utilities, or other members of the general public. Usually these visible water main breaks are very disruptive and water utilities respond quickly to these events, so the run duration of the break or leak is relatively short. Estimate the total volume of water loss during the water audit period from reported breaks and leaks that were repaired during the year. Leakage flow rates must be estimated for various types of breaks and leaks, as well as the approximate duration of the breaks or leaks prior to repair.

[16] Leakage and Overflows at Utility's Storage Tanks

[17] Leakage on Service Connections up to Point of Customer Metering

[18] Total Real Losses: This value is calculated automatically online as the sum of reported breaks and leaks and unreported loss.

[19] Water Losses Method A: Calculated as the sum of apparent losses and real losses. This value should equal the value of Line 21.

[20] Non-revenue Water: Calculated as the sum of apparent losses, real losses,

unbilled metered consumption and unbilled unmetered consumption. This is the water that does not contribute to the water utility billings.

[21] Water Losses Method B: Calculated as the Water Supplied minus Authorized Consumption. This value should equal the value of Line 19. This line is included as a balancing check.

Section 3: GWA Audit Worksheet Instruction, Quality of Data

Table D1. GWA Water Audit Worksheet, Assigning Quality of Data Scores

Number	Item	Quantity	Quality
[1]	Water Volume From Own Sources		
[2]	Wholesale Water Imported		
[3]	System Input Volume [3] = [1] + [2] (Water Supplied)		
[4]	Billed Metered		
[5]	Billed Unmetered		
[6]	Billed Authorized Consumption [6] = [4] + [5] (Revenue Water)		
[7]	Unbilled Metered		
[8]	Unbilled Unmetered		
[9]	Unbilled Authorized Consumption [9] = [7] + [8]		
[10]	Authorized Consumption [10] = [6] + [9]		
[11]	Customer Metering Inaccuracies		
[12]	Systematic Data Handling Errors		
[13]	Unauthorized Consumption		
[14]	Apparent Losses [14] = [11] + [12] + [13]		
[15]	Reported Breaks and Leaks (Leakage on Mains)		
[16]	Leakage and Overflows at Storage Tanks		
[17]	Leakage on Service Connections up to Point of Customer Metering		
[18]	Real Losses [18] = [15] + [16] + [17]		
[19]	Water Loss (Method A) [19] = [14] + [18]		
[20]	Non-Revenue Water		
[21]	Water Loss (Method B) [21] = [3] – [10]		

Table D2. Matrix for Assigning Quality of Data Scores

	Quality of Data Score				
Water Supplied	**1**	**2**	**3**	**4**	**5**
Volume from Own Sources [1]	No meters; volume quantified by estimates only	Partially metered several supply sources metered but not all	Fully metered; no regular testing or calibration of meters	Fully metered; partial testing or electronic calibration; no meters greater than 15 years old	Fully metered; annual electronic calibration and flow testing; no meters greater than 15 years old
Water Imported [2]	No meters; volume quantified by estimates only	Partially metered; several supply sources metered but not all	Fully metered; no regular testing or calibration of meters	Fully metered; partial testing or electronic calibration; no meters greater than 15 years old	Fully metered; annual electronic calibration and flow testing; no meters greater than 15 years old

	Quality of Data Score				
Authorized Consumption	**1**	**2**	**3**	**4**	**5**
Billed Metered [4]	No consumption data gathered; flat or fixed rate in use only	Manual meter reads and billings; no regular audits of customer billing data	Automated billing system; no annual checks of data	Automated meter reading and billing system; internally checked or checked by third party on less than annual basis	Automated meter reading and billing system audited by third party on annual basis
Billed Unmetered [5]	Estimates of consumption used	Production meters used to determine consumption; all areas not monitored	Production meters used to determine consumption; all areas monitored	District meters (each 3,000 or fewer connections) used to determine consumption; no total coverage; rest use production meters	District meters (each covers 3,000 connections or less) throughout system used to determine consumption
Unbilled Metered [7]	No testing; estimates only	Testing only where problems suspected	Systematic testing of all meters; underperforming meters not always replaced	Systematic testing of all meters within at least a five-year cycle; all meters over standards replaced or repaired and retested	Testing of all production meters conducted in year of audit; replacement of all meters outside standard accuracy range
Unbilled Unmetered [8]	Overall estimates throughout system	Partial estimates for some of variables; basic estimates for others	Estimates using formulae (for example, time x gallons per flush) for known events	Partial estimates using test data; other estimates using formulae from known number of events	Estimates using previous metered testing to determine overall estimated values

Table D2. Matrix for Assigning Quality of Data Scores (continue)

	Quality of Data Score				
Real Losses	**1**	**2**	**3**	**4**	**5**
Customer Metering Inaccuracies [11]	No testing or replacement; estimates only	Testing or replacement of 1 to 5% of meters in year of audit	Analysis of test data finds meters meeting specs, or testing or replacement of 5 to 10% of meters per year	Previous test data analyzed and all meters in specifications, or testing or replacement of 10 to 50% of meters in year of audit	Previous test data analyzed and all meters in specifications, or testing or replacement of over 50% of meters in year of audit
Systematic Data Handling Error [12]	No review of billing system	Automated system but no checks of data validity	Automated system; less than annual checks of data	Automated system; internally checked on at least annual basis	Assessment of data handling errors conducted internally and audited by third party on annual basis
Unauthorized Consumption [13]	Arbitrary volume estimates	Default of 0.25% of input volume	Number of events of each type evaluated; multiply by estimated gallons lost per event	Number of occurrences evaluated monitoring and enforcement program started	Monitoring and enforcement program well established with analyzed losses less than 0.25% and declining from previous years
Reported Leaks [15]	Arbitrary estimates; repairs of reported leaks and breaks not documented	Only visual leaks and breaks from customer calls fixed; no known duration before fixing; cursory records	Visual leaks and breaks reported by customers and city staff; call-to repair times known (greater than one week average); good records	Visual leaks and breaks reported by customers and city staff; call-to repair times average less than one week; computerized maintenance management system used to document leak repair trends	Visual leaks and breaks reported by customers and city staff; call-to repair times average less than two days; outstanding computer maintenance records track system deficiencies and repair crew performance

Appendix C

Guam Waterworks Authority
Reference Documents

Reference Documents

The "M36 Water Audit Program and Water Loss Control Program, a Manual of Water Supply Practices by American Water Works Association, Third Edition 2009" was the main document used to establish the GWA's WAP Plan. However, the following additional sources were used to understand the implementation of the AWWA M36 standard. Many of these references were used as pilot projects to help established the new AWWA M36 standard.

1. Water Audit Guidelines and Worksheet, Southwest Florida Water Management District Resource Conservation and Development Department Water Resource, March 1999.
2. Water Use Auditing, A Guide to Accurately Measure Water Use and Water Loss, New Mexico Rural Water Association, 2007 Edition.
3. The Austin City Council, Audit Report, Austin Water Utility: Water Loss, 2009.
4. Texas Water Development Board Report 367, Water Loss Audit Manual for Texas Utilities, 2008.
5. San Francisco Public Utilities Commission, AWWA Standard Water Balance and Audit for In-City Operations, FY 04/05.
6. City of Panama City, Florida, AWWA Standard Water Balance and Audit, Year 2008.
7. Pennsylvania Public Utility Commission, Docket No.: M-2008, Implement the International Water Association/American Water Works Association Water Audit Methodology.

GWA Reference Documents

GWA Priorities 06/2010
Baker Tilly
2011 - 2015 Capital Improvement Plan
Review of Water Meter and AMR Performance, GWA 10/2009
Guam Waterworks Authority
Bubble Map and Water System Area Maps

Appendix D

Guam Waterworks Authority
Sample Standard Operating Procedures