Prepared for
Guam Waterworks Authority

GUAM WATERWORKS AUTHORITY

Water Resources Master Plan Update

Volume 1: Overview and Fundamentals

Final | August 2018

Prepared by | **Brown and Caldwell** | **Hagåtña Office** | **T 671.300.4220**

100% Environmental | Employee Owned | Offices Nationwide | BrownandCaldwell.com

This page is intentionally left blank.

Water Resources Master Plan Update
Volume 1
Overview and Fundamentals
Final | August 2018

Prepared for
Guam Waterworks Authority, Mangilao, Guam
August 2018

Brown AND Caldwell
414 W. Soledad Avenue, Suite 602
Hagåtña, Guam 96910

This page is intentionally left blank.

Table of Contents

Brown AND Caldwell

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

List of Appendices

List of Figures

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

List of Tables

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

List of Abbreviations

7Q10	7-day, 10-year low average flow
7Q20	7-day, 20-year low average flow
ADD	average day demand
AFB	air force base
AM	asset management
AMPE	asset management program evaluation
AMSC	Asset Management Steering Committee
ATARA	Alliance Transformation and Realignment Agreement
AWWA	American Water Works Association
BC	Brown and Caldwell
BMP	best management practices
BOD_5	5-day biochemical oxygen demand
BPS	booster pump station
BSP	Bureau of Statistics and Planning
CAMP	computerized asset management program
CCL	Contaminant Candidate List
CCTV	closed circuit television
CCU	Consolidated Commission on Utilities
CEC	contaminants of emerging concern
CEDS	Comprehensive Economic Development Strategy
CEPT	chemically enhanced primary treatment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CIP	Capital Improvement Plan
CIS	customer information system
CLT	Chamorro Land Trust
CMCC	Civilian Military Coordination Council
CMMS	computerized maintenance management system
CMOM	capacity, management, operation and maintenance
CNMI	Commonwealth of the Northern Mariana Islands
CWA	Clean Water Act
CWMP	Comprehensive Water Monitoring Program
DBP	disinfection byproduct
DHS	U.S. Department of Homeland Security
DLM	Government of Guam Department of Land Management
DoD	Department of Defense
DODEA	Department of Defense Education Activity
DPC	distributed process control
DPRI	Defense Policy Review Initiative
DSCR	debt service coverage ratio
DWSAP	Drinking Water Source Assessment and Protection Program
EAC	Economic Adjustment Committee
EACIP	Economic Adjustment Committee Implementation Plan
EEFs	enterprise environmental factors
EIA	Environmental Impact Assessment
EIS	NAVFAC 2010 Environmental Impact Statement
ELA	Enterprise License Agreement (from Esri)
EPA	Environmental Protection Agency
ERP	Emergency Response Plan
FEBGA	Full Employment and Balanced Growth Act
FMES	Facilities Maintenance and Environmental Services
FOG	fats, oils and grease
FSM	Federated States of Micronesia
FTAC	field telemetry and control
FTE	full time equivalent
FY	fiscal year
GAC	granular activated carbon
GARR	Guam Administrative Rules and Regulations
GCA	Guam Contractors Association
GDoL	Guam Department of Labor
GDP	gross domestic product
GEDA	Guam Economic Development Authority
GFD	Guam Fire Department
GHS	Guam Hydrologic Survey
GIS	geographic information system
GM	General Manager
GPA	Guam Power Authority
gpm	gallons per minute (flow rate)
GPS	global positioning system
GPWA	GPA and GWA

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GPWA CCN	GPWA Consolidated Communication Network
GSPSSDWR	Guam Primary and Secondary Safe Drinking Water Regulations
GVB	Guam Visitors Bureau
GWA	Guam Waterworks Authority
GWQS	Guam Water Quality Standards
GWRDG	Groundwater Resource Development Group
GWUDI	Groundwater under the Direct Influence of Surface Water
HAA5	five haloacetic acids
HGR	hand grenade range
HWWTP	Hagåtña Wastewater Treatment Plant
I/I	infiltration and inflow
I/O	input/output
IFC	International Fire Code
IGPBS	Integrated Global Presence and Basing Strategy
IOC	Inorganic Compound
IRP	Installation Restoration Program
IT	information technology
JDE	J.D. Edwards
KPI	key performance indicator
LAW	local area-wide
LCR	Lead and Copper Rule
LEED	Leadership in Energy & Environmental Design
LFTRC	Live Fire Training Range Complex
LID	low impact development
LOS	level of service
Mbps	megabits per second
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDD	maximum day demand
MEC	Marianas Energy Company
MG	million gallons
mgd	million gallons per day
MHI	median household income
MHz	megahertz
MOU	memorandum of understanding
MWM	mobile workforce management
NAVFAC	Naval Facilities Engineering Command Pacific
NEIC	National Enforcement Investigations Center
NEPA	National Environmental Policy Act
NGLA	Northern Guam Lens Aquifer
NGLS	Northern Guam Lens Study
NIPP	National Infrastructure Protection Plan
NIST	National Institute of Standards & Technology
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NRW	non-revenue water
NTP	notice to proceed
NTU	nephelometric turbidity units
NWF	Andersen Air Force Base Northwest Field
O&M	operations and maintenance
OEA	Office of Economic Adjustment
OECD	Organization for Economic Co-operation and Development
OEM	original equipment manufacturer
PCA	potential contaminating activity
PCE	perchloroethylene
PEM	plant and equipment module
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic
PLC	programmable logic controller
PM/CM	preventive maintenance/corrective maintenance
PMC	performance management contract
PMCM	program management/construction management
PMO	Program Management Office
ppt	part per trillion (nanogram per liter)
PRV	pressure reducing valve
PSV	pressure sustaining valve
PUAG	Public Utility Agency of Guam
PUC	Public Utilities Commission
PWPEP	Potable Water Production Enhancement Plan
QA/QC	quality assurance and quality control
QC	Special Hotel Qualifying Certificate

Use of contents on this sheet is subject to the limitations specified at the end of this document.

QDR	Quadrennial Defense Review
RAMCAP	Risk and Resilience Management of Water and Wastewater Systems
RMI	Republic of Marshall Islands
ROD	Record of Decision
RTU	remote terminal unit
RUS	Rural Utilities Service
SCADA	supervisory control and data acquisition system
SCC	systems control center
SCC	U.S.-Japan Security Consultative Committee
SDWA	Safe Drinking Water Act
SEIS	Supplemental Environmental Impact Statement
SFP	Strategic Financial Planning
SOC	Synthetic Organic Compounds
SOP	standard operating procedure
SPORD	GPA Strategic Planning and Operations Research Division
SRF	State Revolving Fund
SSES	sanitary sewer evaluation study
SSO	sanitary sewer overflow
SUTA	Substantially Underserved Trust Area
SWDS	1994 Surface Water Development Study
SWMP	stormwater management plan
SWTP	surface water treatment plant
TEMES	Taiwan Electrical and Mechanical Engineering Services
TM	technical memorandum
TMDL	total maximum daily load
TSS	total suspended solids
TT	treatment technique
TTHM	total trihalomethane
UOG	University of Guam
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USPSSDWR	U.S. Primary and Secondary Safe Drinking Water Regulations
VA	vulnerability assessment
VOC	volatile organic compound
WERI	Water and Environmental Research Institute of the Western Pacific at the University of Guam
WHPP	Wellhead Protection Plan
WPC	Watershed Planning Committee
WRMP	Water Resources Master Plan
WRMPU	2016 Water Resources Master Plan Update
WSE	Wastewater System Evaluation
WTP	water treatment plant
WWTP	wastewater treatment plant

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Executive Summary

The Guam Waterworks Authority (GWA) 2006 Water Resources Master Plan (WRMP) summarized the condition of GWA's water and wastewater system facilities and outlined improvements needed over the subsequent 20 years to achieve regulatory compliance and improve the reliability of GWA's infrastructure and services. This Water Resources Master Plan Update (WRMPU) assesses GWA's progress towards achieving the recommendations outlined in the 2006 WRMP and further develops a capital improvement plan for the next 20 years, through 2037, to meet acceptable levels of service and maintain compliance with drinking water standards and clean water regulations.

Report Organization

This WRMPU comprises three volumes, to serve as a guide to future system development for GWA's infrastructure:

- **Volume 1** provides context and background for the master planning process. The volume summarizes the infrastructure and systems that apply to the entire GWA system and outlines recommendations for operational improvements. This volume also includes a summary of the proposed capital improvement projects and a financial program necessary to complete them.
- **Volume 2** provides a comprehensive evaluation of and presents recommendations for improvements to GWA's water system.
- **Volume 3** provides a comprehensive evaluation of and presents recommendations for improvements to GWA's wastewater system.

This Master Plan is a "living document" and is intended to be updated as needed to record progress and adjust the needs of GWA as new information is available and other external factors, such as regulatory direction and changes, become better known. Because this document is an update to the 2006 WRMP, rather than a standalone edition, relevant information from the 2006 plan is included by reference as appropriate.

Utility System Overview

GWA owns and operates an extensive network of facilities that provide water and wastewater service to most of the island residents. These facilities represent a significant investment and include substantial visible and underground infrastructure assets. The condition and performance of GWA's existing utility system assets were reviewed during master plan development.

Water System

GWA provides potable water service to most of the island's civilian population of approximately 164,900 residents. GWA's water system facilities comprise the following:

- **Supply sources:** GWA's water supply sources currently include 120 groundwater wells, the Ugum Surface Water Treatment Plant (SWTP), and one active spring. The main water supply source is the deep wells, which are in the northern and central portion of the island.
- **Piping:** the distribution system consists of approximately 586 miles of pipe constructed of a variety of pipe materials and sizes. The distribution system includes legacy systems built

Use of contents on this sheet is subject to the limitations specified at the end of this document.

principally by the Navy and then turned over to the Government of Guam to operate for the civilian population and additional systems constructed to serve Guam's development.

- **Storage tanks:** the water system has 26 active storage tanks with approximately 30.2 million gallons (MG) of capacity. The tanks provide storage for daily fluctuations in demand, fire flow storage, and emergency storage.
- **Booster pump stations:** the water system includes 27 major booster pump stations (BPSs).
- **Valves:** the water system includes control valves used to separate service areas, including pressure reducing valves (PRVs) and isolation valves.

GWA's water system includes the following areas, as shown in Figure ES-1:

- **North:** the North (brown) area is supplied by groundwater wells located in the North, where most of the island's population lives.
- **Central:** the Central (green) area is served from the Brigade BPS, which is usually supplied by groundwater from the north. Some customers within the Central area are served by a spring and U.S. Department of the Navy (Navy) water.
- **South:** the South (blue) area is usually served from the Ugum SWTP. If the Ugum SWTP is offline, this area can be served with groundwater from the north.
- **Nimitz:** the Nimitz (purple) areas are supplied by the Navy.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

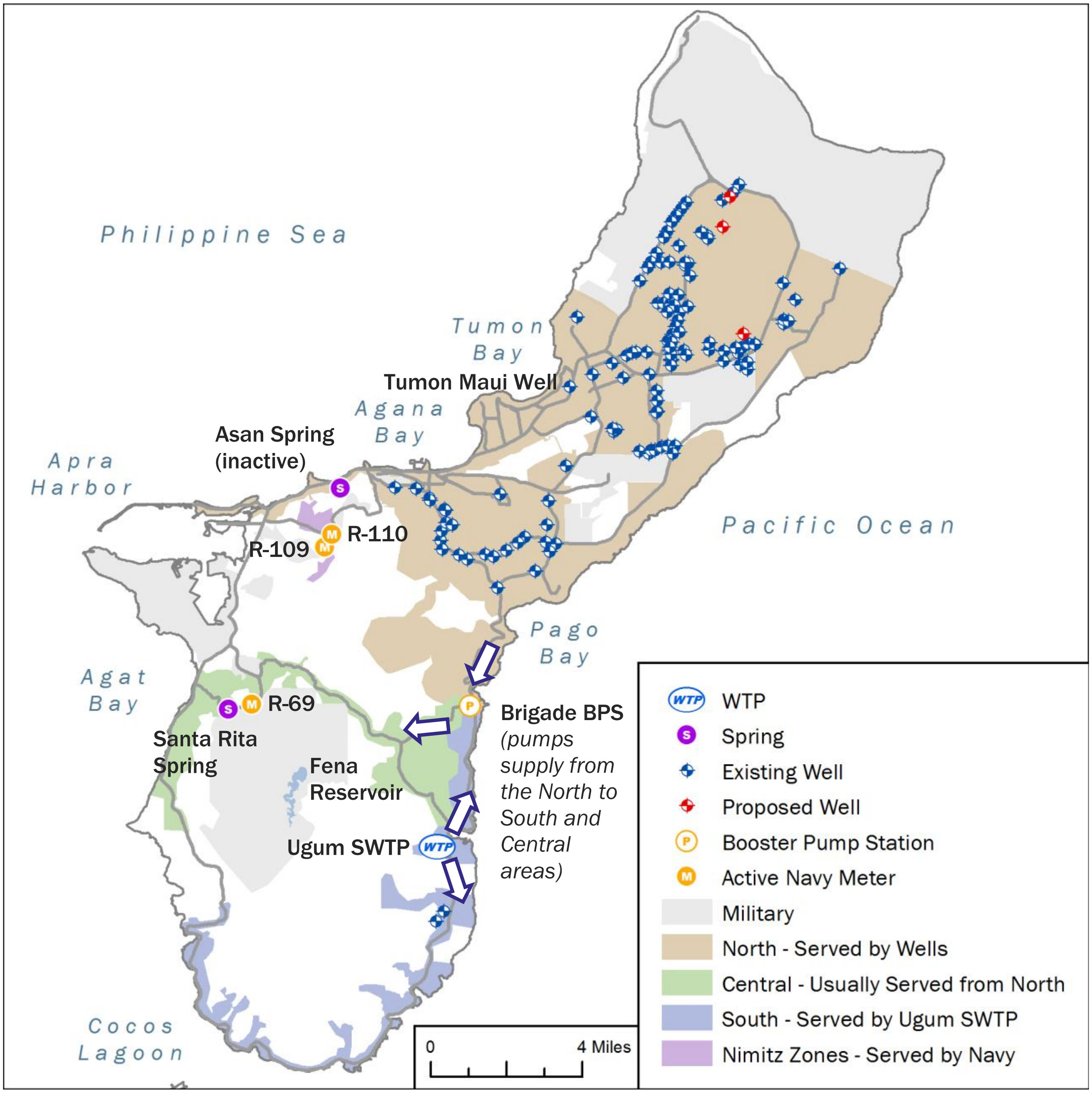


Figure ES-1. Water System Boundaries and Supply Sources

Wastewater System

GWA provides wastewater service to approximately 30,000 wastewater customers including civilian accounts island-wide and Andersen Air Force Base (AFB) and other military installations in northern Guam. GWA's wastewater system facilities include the following:

- **Treatment facilities:** GWA operates seven wastewater treatment plants (WWTPs). GWA's two largest treatment plants (Hagåtña and Northern District) provide chemically enhanced primary treatment and discharge effluent to ocean outfalls. The other treatment plants have original design capacities less than 1 mgd and were designed to provide secondary treatment. An overview of the GWA's seven WWTPs is presented in Table ES-1.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

- **Piping:** GWA's wastewater collection system consists of approximately 290 miles of gravity pipe and 27 miles of force main pipe, constructed from a variety of materials and ranging in diameter from 3 to 48 inches.
- **Lift stations:** the wastewater collection system includes approximately 82 lift stations operated by GWA. Additional private lift stations also connect to GWA's system.
- **Sewer basins:** the wastewater system consists of seven wastewater basins: Agat-Santa Rita, Baza Gardens, Hagåtña, Inarajan, Northern District, Tumon, and Umatac-Merizo. These seven sewer basins flow to six of the WWTPs. The seventh WWTP, Pago Socio, serves a small area of the island. Figure ES-2 delineates the major wastewater basins.

Table ES-1. GWA Wastewater Treatment Facilities

WWTP	Design Capacity Average Daily Flow (mgd)	Type of Treatment, Process	Current Status	Effluent Disposal System	Basins Served	Municipalities Served
Northern District	12.0 [a]	Chemically enhanced primary	Upgrade to secondary treatment design in progress	Ocean outfall	Northern District	Dededo, Yigo, Andersen AFB, portions of Barrigada, Mangilao
					Tumon	Portions of Tamuning (including Tumon)
Hagåtña (Agana)	12.0	Chemically enhanced primary	Active	Ocean outfall	Hagåtña	Hagåtña, Agana Heights, Asan, Chalan Pago Ordot, Mongmong Toto Maite, Piti, Sinajana, portions of Barrigada, Mangilao, Tamuning, Yona
Agat–Santa Rita	0.75	Secondary: contact stabilization	Expansion and upgrade to secondary treatment in progress	Ocean outfall	Agat-Santa Rita	Agat, Santa Rita
Baza Gardens	0.60	Secondary: extended aeration	Construction of new facilities to close WWTP in progress	Togcha River	Baza Gardens	Talofofo, portions of Yona
Umatac–Merizo	0.39	Secondary: aerated lagoon/ overland flow	WWTP upgrade design in progress	Dry weather: evapo-transpiration and percolation Wet weather: Toguan River	Umatac-Merizo	Umatac, Merizo
Inarajan	0.19	Secondary: aerated lagoon	Active	Percolation	Inarajan	Inarajan
Pago Socio	0.025	Secondary: packaged aeration treatment system	Active	Percolation	Serves a few homes	A very small area in Chalan Pago Ordot

a. The 2011 Court Order limits average daily flow to 6 mgd, but allows for conditional increases to 9 mgd.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

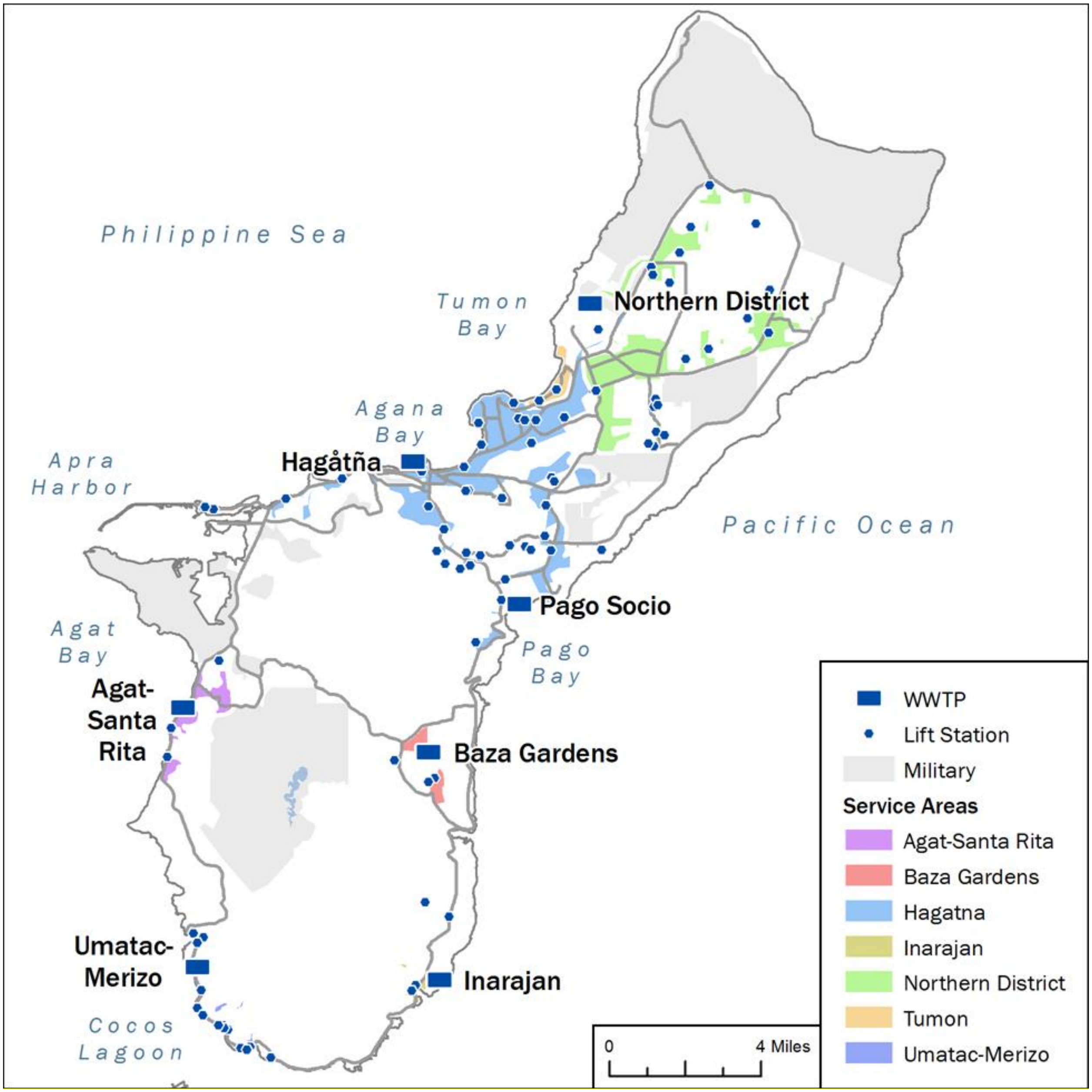


Figure ES-2. GWA Wastewater Basin Boundaries

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Existing Utility System Condition and Performance

GWA has made significant progress since the 2006 WRMP, however, there are still many areas where improvements are necessary as described below.

Water System

The overall condition of equipment in the water system varies depending primarily on its age. The condition of some production wells and booster pump stations is poor, with significant corrosion evident in some areas. In addition, non-revenue water (NRW) represents one of the most significant issues facing GWA. NRW is defined by the American Waterworks Association (AWWA) as "unbilled authorized consumption (water for firefighting, flushing, etc.) plus apparent losses (customer meter inaccuracies, unauthorized consumption and systematic data handling errors) plus real losses (system leakage and storage tank overflows)" (American Water Works Association (AWWA), 2012).

Aging water storage tanks and dividing the water system into appropriate pressure zones are also an issue. GWA is in the process of repairing or replacing storage tanks with the program anticipated to be complete in 2021. A program to properly separate the GWA water system into pressure zones is also in progress.

Wastewater System

Significant rehabilitation is underway at many of GWA's treatment plants to expand capacity and consistently meet discharge permit requirements. At the time of this WRMPU, major modifications are in progress at the Umatac-Merizo and Baza Gardens facilities to meet the requirements of the 2011 Court Order and the plants' National Pollutant Discharge Elimination System (NPDES) permits by 2018. The new Agat-Santa Rita WWTP is partially complete and currently treating Agat-Santa Rita wastewater flows. The design to upgrade the Northern District WWTP to secondary treatment standards is also in progress as one of the Military Build-up projects.

The overall condition of equipment at many of the wastewater pumping stations is poor and must be addressed. Computer modelling indicated capacity problems in various segments of the collection system in the Hagåtña basin and throughout Northern Guam. Like the water system, significant improvements have occurred and issues are being addressed at key locations through rehabilitation contracts.

Pipe rehabilitation projects are currently in progress in Baza Gardens, Agat, and Santa Rita. Additional projects are in the design stage that will upgrade sections of piping in Agat, Asan, Hagåtña, Dededo, and other areas.

Source Water

Surface water provides the predominant source of potable water in southern Guam. In the North, groundwater supplies drinking water for Guam's residents and visitors, primarily from the Northern Guam Lens Aquifer (NGLA). GWA is committed to long-term sustainable management of the NGLA and has implemented a source water CIP program, which includes both the redevelopment of existing well sites and the completion of new wells. Data is being collected in the NGLA Database and the monitoring program will undergo a significant expansion as part of the pending Military Build-up. The NGLA is being studied and monitored extensively, with the goal of sustainably managing the resource now and into the future.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

As GWA takes an active role in sustainable management of the water resources of Guam, formalization of GWA water resource policy is necessary to guide water resource development, use, and management by GWA into the future. Developing source water-related policy will create a roadmap for critical water supply decisions to be made over the next 20 years and beyond. Specific recommendations to protect the supply and quality of Guam's limited surface and groundwater resources are outlined in Volume 1, Section 5.

Planning Considerations

The master plan considered service levels, changes in population and land use, regulations, and asset conditions. Additional service-specific considerations were included in the planning for the water and wastewater systems.

Service Levels

In 2006, GWA developed four level of service (LOS) criteria that represent fundamental services routinely provided by water and wastewater utilities, which are limited to regulatory requirements of the water and wastewater treatment plants and severe service issues related to water service interruptions and sewage spills. These criteria remain important in GWA's current regulatory enforcement environment.

The GWA management team is now focusing on far more than the minimum LOS targeted in 2006. Significant additions include more pronounced attention to customer-oriented LOS including customer wait times, field service request response times, septic tank elimination, and integration with the OneGuam initiative. The introduction of additional mission-related measures further expands the 2016 LOS including goals related to distribution system pressure, asset reliability, and the delivery of the capital improvement plan. A LOS related to GWA employees' safety and employment satisfaction has also been added.

The GWA management team developed the following 15 strategic LOS categories during two workshops conducted in April 2016:

- Drinking water quality
- Reliability of water supply
- Wastewater effluent discharges
- Wastewater system spills
- Ensure financial capacity to meet operational needs
- Improve customer wait times to register issues/concerns at GWA offices
- Ensure adequate pressures in the distribution system
- CIP execution schedule
- Ensure a safe work environment
- Customer complaint response
- Distribution system integrity
- Critical asset reliability (water and wastewater plants, pump stations, wells)
- Septic tank elimination (sewer hookup program)
- Integration of GWA and Department of Defense (DoD) systems, OneGuam
- Employee satisfaction and pride

Improvements identified as part of this master plan are focused on improving performance on these essential measures. Additional information is presented in Volume 1, Section 3.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Population and Land Use Forecasts

The population of Guam is expected to grow from approximately 159,000 in 2010 to 212,000 in 2050. Guam's population fluctuates with world economic factors. As such, the development of population projections was based on 2010 U.S. Census Bureau data and tied to the combined effect of economic growth (tourism, military buildup, and other construction and economic development activity), labor market conditions, and geopolitical factors.

This growth can be attributed to the following key areas:

- **Military Buildup:** in 2014, approximately 6,000 active duty military personnel were based on Guam. By 2026, an additional 5,000 Marines and 1,300 dependents will be transferred to the island from Okinawa, Japan, increasing the military population by nearly 50 percent over 2014 levels. In addition to the increase in active duty military and dependents, Guam's population is expected to fluctuate due to construction activity related to the military buildup and civilian jobs created by buildup activities.
- **Planned Developments:** there are many new developments planned for Guam. Some of these are large commercial developments such as new hotels or additions to hotels and others are residential subdivisions. In addition, several Chamorro Land Trust tracts are planned for development, with some uncertainty as to how these areas will be serviced. The WRMPU evaluated the requirements for supply of water and sewer services to proposed developments known at the time of this report as well as the general increase in population.

Regulatory Issues

GWA must comply with territorial and federal regulations for both water and wastewater treatment and services. Water standards are based on the requirements established by the Safe Drinking Water Act (SDWA), while wastewater treatment and disposal is governed by the Clean Water Act (CWA). The U.S. Environmental Protection Agency (USEPA) issues NPDES permits for GWA facilities when required and is responsible for monitoring compliance. Guam Environmental Protection Agency (EPA) is the territorial agency in charge of monitoring GWA operations and monitoring for SDWA compliance.

Physical and Cyber Security Issues

Physical and cyber security issues require consideration in the unpredictable natural and geopolitical environment to develop resilience to natural disasters, accidents, and malevolent threats. Specific recommendations for security measures are presented in Volume 1, Section 6.3.

Capital Improvement Program

A major component of this WRMPU is to propose specific Capital Improvement Projects (CIP) for implementation between 2018 and 2037. GWA's CIP needs are organized into three key areas: water system, wastewater system, and general facilities/equipment (including supervisory control and data acquisition system [SCADA] and electrical). A summary of the number of projects and total estimated cost for each category are listed in Table ES-2. Additional detail is provided in Volume 1 for projects related to the overall organization and assets, Volume 2 for water projects, and Volume 3 for wastewater projects. A project sheet was developed for each proposed project, which includes a description, justification, anticipated schedule, and estimated budget. These project sheets can be used by GWA to develop specific 5-year CIP.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table ES-2. CIP Summary				
Project Category	Number of New Projects	Estimated Cost WRMPU Proposed Projects	Number of Ongoing Projects [a]	Estimated Cost of Ongoing Projects
Water System Improvements				
Pipeline Projects	17	$204,402,000	2	$2,500,000
Storage Tank and BPS Projects	30	$120,082,000	5	$30,808,000
Water Production Projects	10	$123,216,000	3	$8,667,000
Other Water System Projects/Studies	5	$14,449,000	4	$5,500,000
Total Water System Improvements	62	$462,149,000	14	$47,475,000
Wastewater System Improvements				
Gravity Sewer Projects	27	$250,247,000	7	$69,230,000
Force main Projects	4	$22,498,000		
Lift Station Projects	3	$68,156,000	2	$4,293,000
Wastewater Treatment Facilities	9	$71,238,000	3	$151,946,000
Other Wastewater System Projects/Studies	5	$10,978,000		
Total Wastewater System Improvements	48	$423,117,000	12	$225,469,000
General Systems Improvements				
General Facilities / Equipment Improvements	10	$59,800,000	1	
SCADA / Electrical	4	$37,176,000	2	$5,175,000
Total General System Improvements	14	96,976,000	3	$5,175,000
Total (rounded)	124	$982,242,000	29	$278,119,000

a. Projects currently in progress by GWA with available funding

A workshop was conducted in April 2016 with GWA personnel and management to establish a relative ranking system for non-economic factors important to GWA when considering project priority. Based on this non-economic prioritization, project timing (as determined by the population projections, condition assessments and hydraulic modeling), and project cost estimates, a base CIP program was developed for the 20-year planning period. The CIP improvement plan is outlined in Volume 1, Section 11.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Water System Improvements

Recommendations for improvements to GWA's water system and related facilities are summarized below, including water treatment, supply, and distribution facilities. Detailed information can be found in Volume 2.

Water Treatment

Capital improvements and general operations and maintenance (O&M) improvements are necessary to provide continued reliable operation of the Ugum SWTP. Recommended improvements include the following:

- **Intake cleaning** to remove sediment accumulation in the river at and just upstream of the intake.
- **Raw water intake upgrade** to allow GWA efficient extraction of Ugum River water even during high turbidity periods and operate at low river conditions.
- **Reliability improvements** to refurbish and upgrade existing equipment and systems at the Ugum SWTP that need repair, replacement, or modification to improve plant capacity and maintain plant operability.
- **Routine equipment overhaul program** including scheduled replacement of the treatment membranes and removal and refurbishment of major plant equipment such as raw water pumps, blowers, compressors, finished water pumps, centrifuge, control system and other components.
- **General recommendations:** Additional training is recommended to provide operations staff with the skills required to manage plant operations.

Wells

Several projects are recommended for GWA to improve the capacity, reliability, and safety of the water system with respect to existing or proposed production wells.

- **New wells:** GWA should plan for approximately 13 new wells between 2020 and 2037. A well exploration and development project is recommended to plan the location of the future wells.
- **Existing wells**: Each of the 120 system wells can be expected to require a significant rehabilitation project every 15–20 years. Two types of projects are recommended for the existing wells:
  - An annual project to address relatively minor issues that can affect production wells, such as flow meter replacement, modifications for improved motor cooling, and minor improvements based on deficiencies identified during condition assessment.
  - Extensive well overhaul projects to address significant issues and equipment replacement, new borehole development, and similar major rehabilitation requirements.
- **Wellhead Protection Plan (WHPP) implementation:** The recommendations of the 2014 WHPP should be implemented, including limiting land use within wellhead protection zones, development of a water supply contingency plan, and well abandonment practices.

Storage Tanks

All storage tanks should be inspected every five years. Based on the condition of the tanks, some tanks may need more frequent inspections, such as the existing steel tanks.

GWA will inspect some of the existing storage tanks in the next few years. Plans for new storage may change depending on the results of those tank inspections. Some storage tanks believed to be repairable may need replacement instead of repair.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Booster Pump Stations

GWA operations staff have rehabilitated some BPSs, but full rehabilitation is recommended to address all outstanding issues. BPSs recommended for rehabilitation or replacement that are not currently underway include Gayinero, Geus, Mataguac, Nimitz Hill Upper, Nimitz Hill Lower, Santa Ana, Santa Rita Spring, Toguan, Umatac 1, and Umatac 2. In addition, surge issues observed at startup or shutdown of pumps should be addressed, especially at BPSs with high suction pressures.

Distribution System

The following improvement projects are recommended for piping, PRV, and isolation valves to address capacity and condition issues and to realign existing pressure zones.

- **Piping condition improvements:** The 2006 WRMP documented the need to remove smaller diameter (less than 6 inches) and asbestos cement water lines. Annual projects are proposed to replace all 2-inch and AC piping.
- **Pressure reducing valves:** For the pressure zone realignment, existing PRVs need to be rehabilitated and new PRVs installed. New master meters should be added to each new or rehabilitated PRV. The number of PRVs anticipated to serve each pressure zone are listed in Volume 2, Section 8.
- **Valve exercise and maintenance:** To ensure all valves necessary for operations, maintenance, and isolation are functional, GWA should implement a valve exercise program. Broken valves should be documented as they are located and then repaired or replaced.

Water Loss Control

The 2006 WRMP outlined recommendations for water loss reduction and measures taken by GWA through the ongoing leak detection program. Additional tasks that should be implemented to further reduce water losses include the following:

- **Leak detection and repair:** GWA should continue with the plans to have two leak detection crews to record the estimated leak rate and location of each verified leak so that water loss and repair location data can be uploaded into the computerized maintenance management system (CMMS) and geographic information system (GIS). A prioritization schedule for leak detection should be established and GWA should set up a multi-year professional services contract for leak detection if assistance is required.
- **Line locating crew:** GWA should consider forming a dedicated line locating crew. GWA should procure the appropriate line locating equipment, train the crew in field line locating procedures, and update the existing Work Plan, protocols, and standard operating procedures (SOPs) from the original leak detection program.
- **Meter calibration:**
  - **GWA water production and master meters:** all well and master meters should be inspected annually. Based on the inspections, the meters should be repaired or calibrated as needed, with priority given to deep wells.
  - **GWA residential/commercial meters:** GWA should work toward reviewing and testing/calibrating all meters in the system.
- **Other recommendations:** GWA should continue installing master meters. A study should be performed to review the planned master meter locations. The master meters should be implemented in conjunction with an island-wide system being developed by the Guam Power Authority (GPA) with their “Smart Meter” program.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Fire Hydrants

The GWA water system was estimated to include 410 fire hydrants that have failed or are close to being in a non-usable condition and 1,548 hydrants that are close to failure. GWA has identified 300 of these 410 fire hydrants for replacement in the next five years; however, a more aggressive schedule is recommended:

- Replace the hydrants in extremely poor overall condition (score of 5 in the condition assessment) within the next five years, then begin repair or replacement of hydrants in poor overall condition (score of 4 in the condition assessment).
- Form a fire hydrant repair and replacement crew to evaluate all fire hydrants and issue work orders, perform preventive maintenance, and perform corrective maintenance including repair and replacement of the hydrants.
- Other recommendations include standardizing on two or three hydrant manufacturers to reduce parts, tools, and increase efficiency of repairs, and developing a unique ID and color-coding scheme for each fire hydrant.
- Coordinate regularly with the Guam Fire Department (GFD). GWA can share GIS and CMMS information while GFD can assist with future assessments and hydrant flow volumes.

General Water System Recommendations

- **The OneGuam** framework would potentially integrate DoD and GWA water resources and water system facilities. Recommendations to support the OneGuam framework over the planning horizon include the following:
  - Conduct a feasibility study to determine the potential for a singular, unified water utility.
  - Model the proposed combined water system to properly analyze the water systems and identify locations where piping could be shared.
  - Complete a rate study and develop a strategic plan for moving to a combined water utility.
- A **South Guam Water Supply Study** is needed to analyze options to provide adequate and reliable water supply for South Guam (including maximizing output from the Ugum SWTP).

Wastewater System Improvements

Recommendations for improvements to GWA's wastewater collection and treatment systems are summarized below.

Gravity Piping

Recommended improvements for GWA's gravity sewer system include the following:

- **Piping Improvements:** An annual program should be established to inspect, rehabilitate, and replace gravity piping based on the condition assessment risk analysis. New piping should be sized to handle future planned peak wet weather flows. Larger diameter piping, piping near reported sanitary sewer overflows (SSOs), and piping with overlapping capacity and condition improvements are prioritized for rehabilitation/replacement. This risk analysis should be updated periodically (every five years at a minimum) using the latest data.
- **Manholes:** GWA should implement a manhole rehabilitation program to fix issues as they are found, including raising manholes, cutting down brush, maintaining easements, and rehabilitating or replacing manholes. Major manhole issues should be grouped into projects and put out to bid to be repaired by a qualified contractor.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

- **Septic/Cesspool System:** Actions should be implemented to connect houses on septic/cesspool systems to the collection system according to the prioritization matrix included in Volume 1, Section 5.2.
- **CCTV:** Closed Circuit Television (CCTV) data should be collected, organized, and stored in a single centralized location on a GWA server. This information will be utilized in the piping improvements risk analysis.

Force Mains

Recommended piping projects to address identified capacity and condition issues for force mains include the following:

- **Force main rehabilitation/replacement program:** An annual program should be established to perform condition assessment and rehabilitate and replace force main piping based on the results of the condition assessment. The force mains should be inspected according to the prioritization in Volume 3, Section 5.
- **Priority Replacement Projects:** Priority force main replacement projects include the Yigo Lift Station Force Main, Route 1 Asan Force Main rehabilitation/replacement, and the Hagåtña WWTP Force Main rehabilitation/replacement.

Lift Stations

The following improvements are recommended for lift stations:

- Lift stations should be rehabilitated and replaced based on the priorities listed in Volume 3, Section 6.
- GWA should review the study recently conducted for the Fujita lift station and force main and select an option for implementation.
- A preventive maintenance program should be implemented to address operational issues at lift stations, including grease and rag build-up that clogs the pumps.

Wastewater Treatment

Recommended improvements to GWA's wastewater treatment systems are summarized below.

- **Umatac-Merizo WWTP:** The Umatac-Merizo WWTP is undergoing major modifications to meet the 2011 Court Order, which will increase the plant's capacity to be adequate through 2037 flows. The WWTP upgrade will be complete in 2018 and will require typical regular maintenance, but no additional improvement projects are expected in the near future.
- **Baza Gardens:** The Baza Gardens WWTP is undergoing major modifications to meet the 2011 Court Order, which will transform the plant into an equalization basin and pump station equipped with preliminary treatment. As part of this project, a cross-island pipeline will be constructed to transfer Baza Gardens flows to the Agat-Santa Rita WWTP for further treatment and disposal, providing adequate capacity through 2037 flows. The redesigned Baza Gardens wastewater system will require regular maintenance of the pump stations and preliminary treatment, but no other improvement projects are expected over the planning horizon.
- **Agat-Santa Rita WWTP:** The new Agat-Santa Rita WWTP will replace the existing plant and will be fully operational in 2018. The new plant will require regular maintenance, but no improvement projects are expected in the near future. A WWTP rehabilitation project is recommended after 15 years of operation to include replacement or refurbishment of mechanical equipment and controls, inspection and repair of structures, rehabilitation of electrical equipment and control systems, and rehabilitation of the backup generator.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

- **Inarajan WWTP:** Routine improvement projects are necessary to maintain the plant in sound operating condition, including rehabilitation of concrete structures, installation of new electrical and control systems, installation of new floating mechanical aerators, rehabilitation or replacement of valves and pipe appurtenances, installation of a new headworks with automatic screens and influent flow meter, and implementation of sludge removal. It is also recommended that a flow measurement and monitoring program be implemented to provide long-term assessment of the system capacity and to help dictate the timeline for future expansions.
- **Pago-Socio WWTP:** GWA plans to convert the existing Pago-Socio WWTP into a pump station. Wastewater flows will be conveyed into an existing nearby wastewater transmission line and ultimately to the Hagåtña WWTP for treatment and disposal.
- **Northern District WWTP:** A detailed design is underway to upgrade the Northern District WWTP to meet the NPDES permit's secondary treatment requirements. After the new WWTP is complete, it will require regular maintenance, but no major improvement projects are expected in the near future. A WWTP rehabilitation project is recommended after 15 years of operation to include replacement or refurbishment of mechanical equipment and controls, inspection and repair of structures, and rehabilitation of electrical equipment and control systems.
- **Hagåtña WWTP:** The Hagåtña WWTP was upgraded in 2014 to an enhanced primary treatment process. The plant will require a future rehabilitation project which is recommended in 2027. The project should include replacement or refurbishment of mechanical equipment and controls, inspection and repair of structures, and rehabilitation of electrical equipment and control systems. The design of a complete upgrade to the HWWTP to meet secondary treatment requirements is planned to begin in 2037.

Solids Management

The recommended approach for GWA's solids management is to continue disposal of dewatered sludge at the Layon landfill. GWA faces considerable challenges implementing system-wide court-ordered improvements and secondary treatment upgrades at the two largest WWTPs; therefore, attempting to add an optional biosolids recycling program to GWA's priority list is not currently advised.

In the future, GWA could choose to recycle a portion of wastewater solids by converting the dewatered sludge to a Class A biosolids product with new options for disposal or reuse. GWA should continue to discuss opportunities with other agencies and consider jointly participating in projects if opportunities arise. Two potential opportunities include:

- **Future Composting.** A portion of GWA's dewatered solids could potentially be composted, which would divert green waste and dewatered sludge from the landfill, increasing capacity. A Class A biosolids product with improved characteristics would be produced and marketed primarily for landscaping purposes. The local compost market should be evaluated in more detail to determine the potential production capacity.
- **Future Indirect Drying.** GPA is proposing to construct a new power generation facility adjacent to the Northern District WWTP. Waste heat from the GPA facility could potentially be used to dry dewatered solids to reduce landfill tip fee expenses or create a fuel for a future waste-to-energy facility (if developed). If the solids are dried to greater than 90 percent solids content, the product will qualify as Class A biosolids and could potentially be marketed for landscaping or land application purposes. GWA should continue to discuss opportunities with GPA as the power generation facility concept is developed.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

General Facilities/Equipment Improvements

Recommendations for improvements to GWA's asset management program, GIS, and SCADA/electrical systems are summarized below.

Asset Management

GWA has made significant progress in implementing many features of an asset management (AM) program. Building upon the work to date, recommendations for future progress are outlined in Volume 1 Section 7. These efforts will further define the program, ensuring the AM program is known and understood by staff and all involved stakeholders, driving the maintenance management plan to improve preventive maintenance/corrective maintenance (PM/CM) ratios in each work group from year to year, and collecting up-to-date data on assets and maintenance costs to enable improved CIP decision making.

GIS Program

Proposed improvements to the GWA GIS program include staffing, training, and hardware and software upgrades. Refining customer meter locations and the integration of GIS-based field data collection and CMMS software are also recommended. Additional detail can be found in Volume 1, Section 8.

SCADA/Electrical Improvements

Recommended improvements to GWA's SCADA system include:

- Continued implementation of the 2014 SCADA Master Plan
- Repair or replacement of control instrumentation as required at all sites and plants
- Specialized workforce development and training
- Standardization of programming language, equipment, and wiring
- Use of the GPA wireless network
- Additional physical and cyber-security measures

Financial Plan

GWA's proposed Master Plan capital improvements plan outlines a viable schedule for improvements that effectively balances system investment needs with financial impacts on GWA ratepayers.

Capital Program Expenditures

The GWA Master Plan capital program calls for approximately $1.61 billion of capital spending ($1.26 billion in current year dollars) over the 2018–2037 forecast period as shown in Figure ES-3. Of this amount, approximately $424 million has already been raised or is anticipated to be externally funded, requiring GWA to finance as much as $1.19 billion in capital project spending over the forecast period. The next four years of the program are expected to be the most capital-intensive years of the program primarily due to the overlap of the completion of court ordered projects and projects required for the military buildup.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

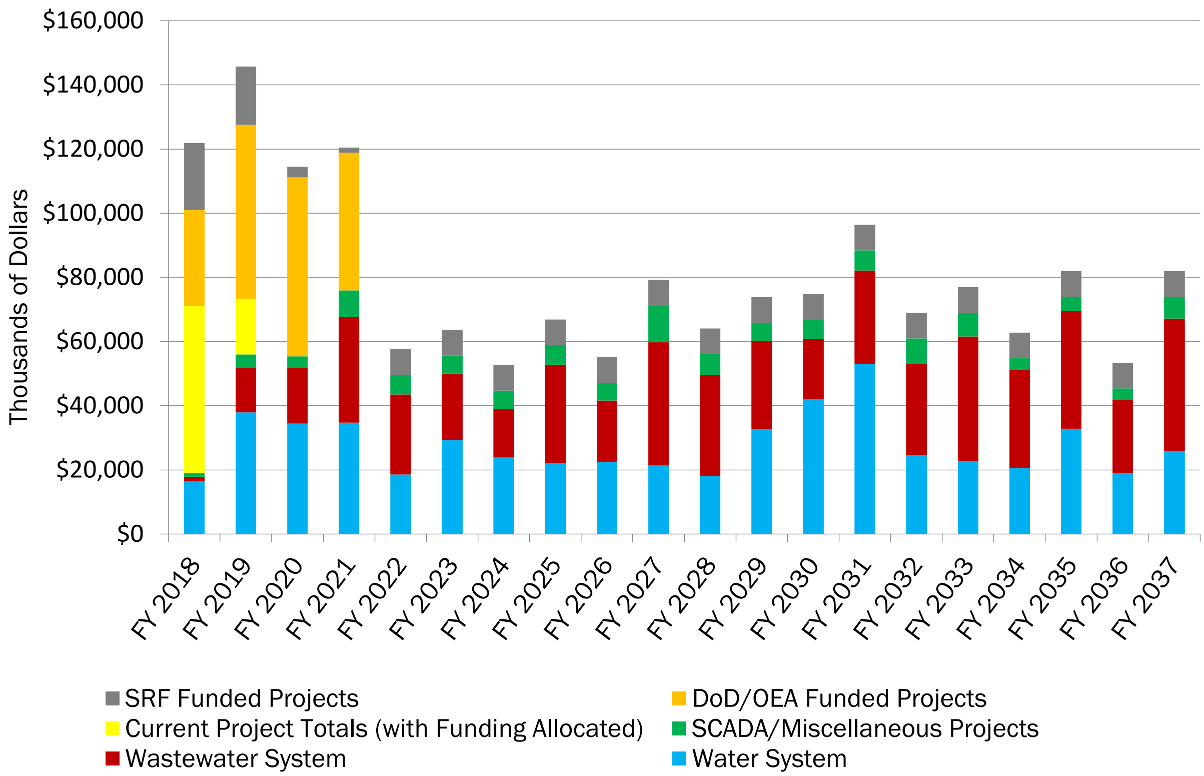


Figure ES-3. GWA Master Plan Capital Program Expenditures, FY 2018–2037

Debt Service Requirements

This capital program will require incurrence of substantial debt on a regular basis throughout the forecast period. Debt service requirements are projected to increase 2.55 times during the forecast period, from under $31.7 million per annum to $80.9 million per annum by FY 2037. Similarly, service revenues (to support these debt issuances) are projected to increase substantially over the forecast period, from approximately $112 million in FY 2018 to over $247.6 million in FY 2037.

The base case analysis assumes that GWA will issue revenue bond debt in four of the next five years and every third year thereafter. Continuing its historical practice, GWA will obtain SRF grants of $8 million per annum, and will increase current revenue funding of capital to almost $50 million by the end of the forecast period as shown in Figure ES-4.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

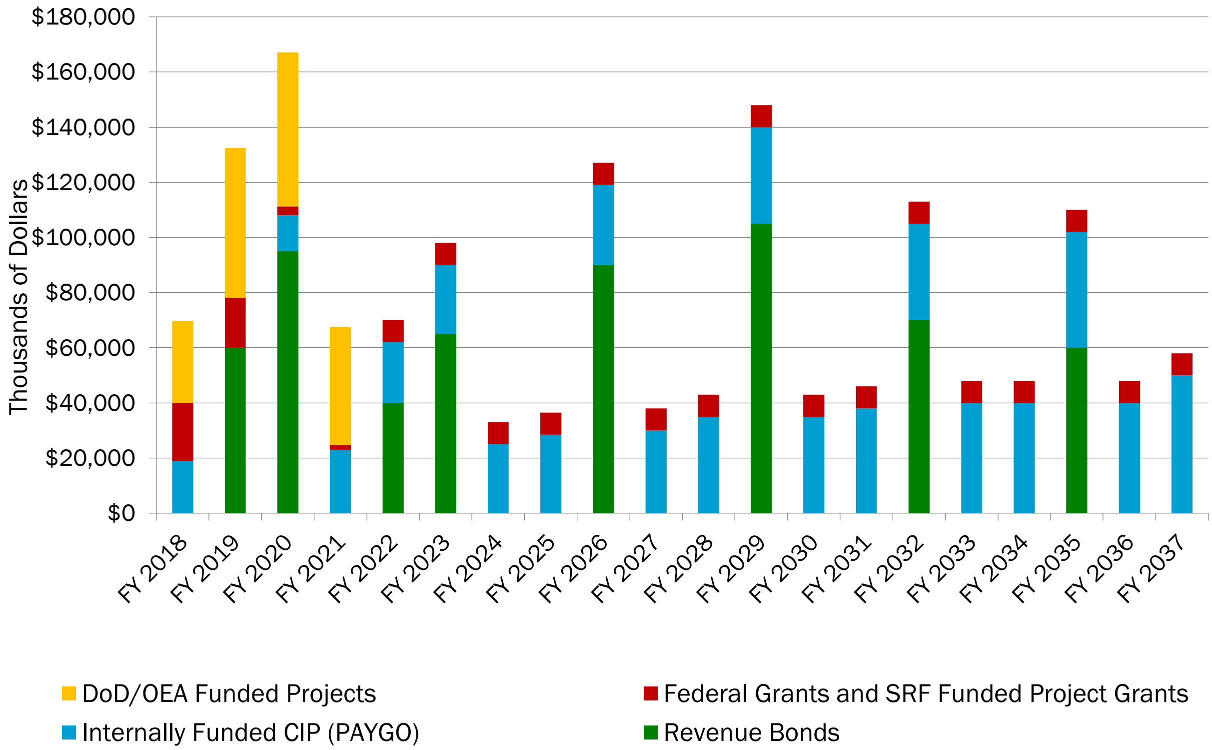


Figure ES-4. GWA Capital Program Funding Sources, FY 2018–2037

The financial plan also assumes that GWA's revenue bonds are issued under GWA's current, relatively less advantageous, borrowing terms (5 percent annual interest, 6.00 percent funded bond reserve, no insurance) that reflect its relatively low credit ratings. Given the forecasted need to issue $585 million over the 20-year planning period, GWA would be well served by improvements to the credit ratings under which it issues municipal debt obligations. Over the long term, GWA's actions to enhance its credit rating will be particularly important.

Water Affordability

Financing the Master Plan capital program will result in substantial increases in debt service obligations and increases in annual service revenues. Debt service requirements are projected to represent approximately 33 percent of service revenues by the end of the Master Plan forecast period; pay-as-you-go funding of capital expenditures will reach approximately $50 million.

The base case rate increase pattern, as shown in Figure ES-5, results from an effort to smooth rate increases while building financing capacity for annual spending levels in the range of $50–80 million. This will also position GWA to finance additional capital investments beyond the forecast period, potentially including secondary treatment upgrades at the Hagåtña WWTP or projects deferred due to atypical cost escalation.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

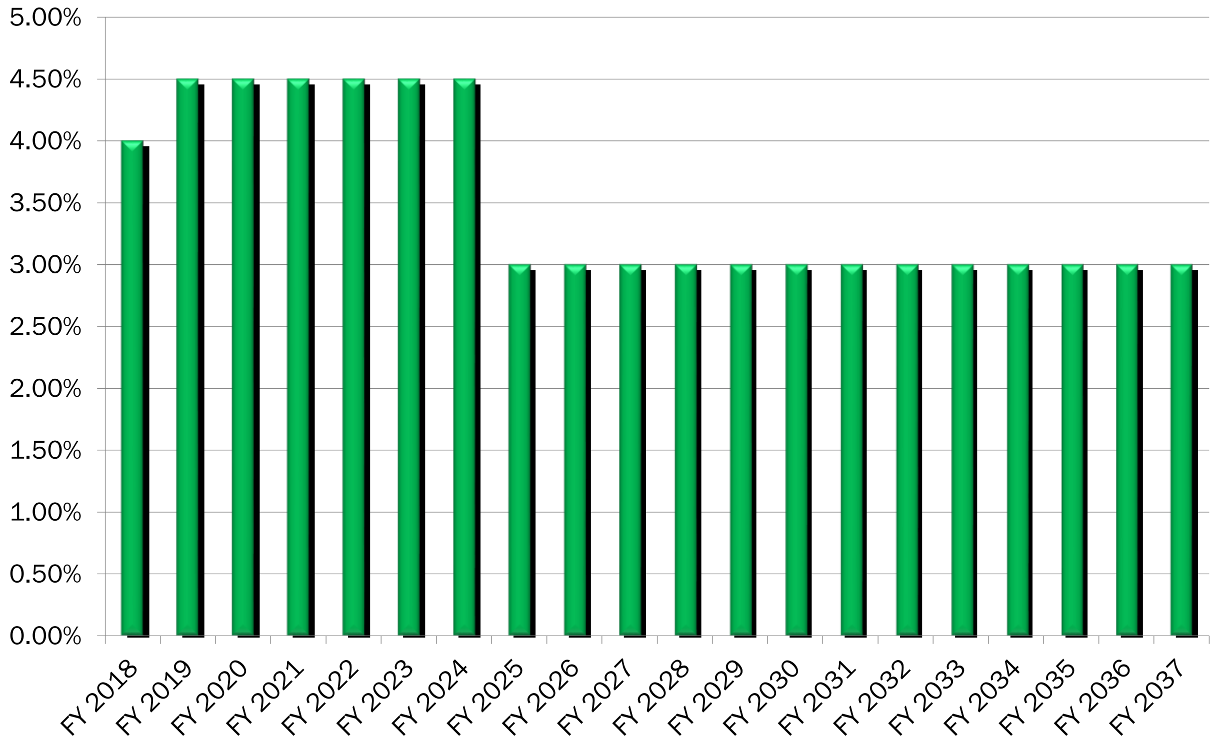


Figure ES-5. GWA Projected Water and Wastewater Service Rate Increases, FY 2018-2037

The Master Plan program may be viewed as presenting a significant yet manageable financial burden for the GWA residential population in general under the regular rate increases projected. Residential water and wastewater customers with typical water usage of 7,500 gallons per month currently pay $1,081 annually, or approximately 2.38 percent of estimated median household income (MHI). Projected systemwide rate increases, based on currently identified Master Plan projects, will drive water and wastewater bills to just over 3.5 percent of MHI over the forecast period.

Low-income residential customers currently pay approximately 5.2 percent of their incomes for water and wastewater services, and that amount rises to just under 7.0 percent over the forecast period, based on currently identified Master Plan projects. To address the anticipated impact on low-income residential customers, the Master Plan recommends that GWA review options to address low-income water affordability.

Public Outreach

A public outreach campaign was completed following the production of the WRMPU draft. The intent of the public outreach campaign was to provide information on the purpose, content and recommendations included in the WRMPU and to solicit feedback for incorporation into the final report. The public outreach campaign used a variety of methods for communication with the public and government agencies throughout Guam including mailing flyers, website access, printed reports

Use of contents on this sheet is subject to the limitations specified at the end of this document.

and public meetings. Public meetings were held at ten locations and comments were recorded and incorporated into the final WRMPU as required.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 1
Introduction

This report describes the 2017 update to the GWA WRMP. It is comprised of the following volumes:

1. **Volume 1** (this volume) covers general GWA infrastructure that applies to the entire GWA system.
2. **Volume 2** provides an evaluation and recommendations for the water supply and distribution systems.
3. **Volume 3** provides an evaluation and recommendations for the wastewater treatment and collection systems.

This WRMPU should serve as a guide to future system development for GWA's infrastructure. The WRMP is a "living document" and is intended to be updated at regular intervals to record progress and document the needs of GWA as new information becomes available and as external factors change. It is anticipated that a major update will be completed every five years and a status update will be completed between major updates. This process of continuous review and revision will serve to document progress, validate long-term objectives, and provide justification to adjust specific projects and goals as needed on a regular basis.

1.1 GWA Overview

The following section provides an overview of GWA's history, organization, and regulatory compliance drivers.

1.1.1 GWA History

GWA was established in July 1996 and became active in February 1997. GWA's predecessors included the Department of Public Works and the Public Utility Agency of Guam (PUAG). The Department of Public Works was given authority to administer all utility services by the Congress of Guam in June 1950. In response to increased water demand and a need to expand utility services, PUAG was then created in 1952 by the First Guam Legislature. PUAG consisted of the telephone, power, water, and wastewater utilities (GWA, 2016).

GWA was established as an autonomous authority responsible for water and wastewater services, and was subsequently converted into a public corporation in 2002. The Authority inherited water and wastewater systems that were in a general state of disrepair and had long histories of regulatory compliance problems.

1.1.2 GWA Organization

GWA is governed by the Consolidated Commission on Utilities (CCU), which also provides oversight of GPA. The CCU comprises five elected members and has decision-making authority over GWA operations, including the development of operating and financial budgets and overall management strategy and direction. In addition, the issuance of bonds for capital improvement projects or for refinancing purposes requires legislative approval and the approval of the Guam Public Utilities Commission (PUC), which must also approve all GWA rate adjustments.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA is currently realigning its overall organization. Figure 1-1 shows the former organizational chart, which illustrates that all GWA divisions previously reported directly to the General Manager. This arrangement placed the responsibility of many activities directly on the General Manager, including routine decisions and personnel management.

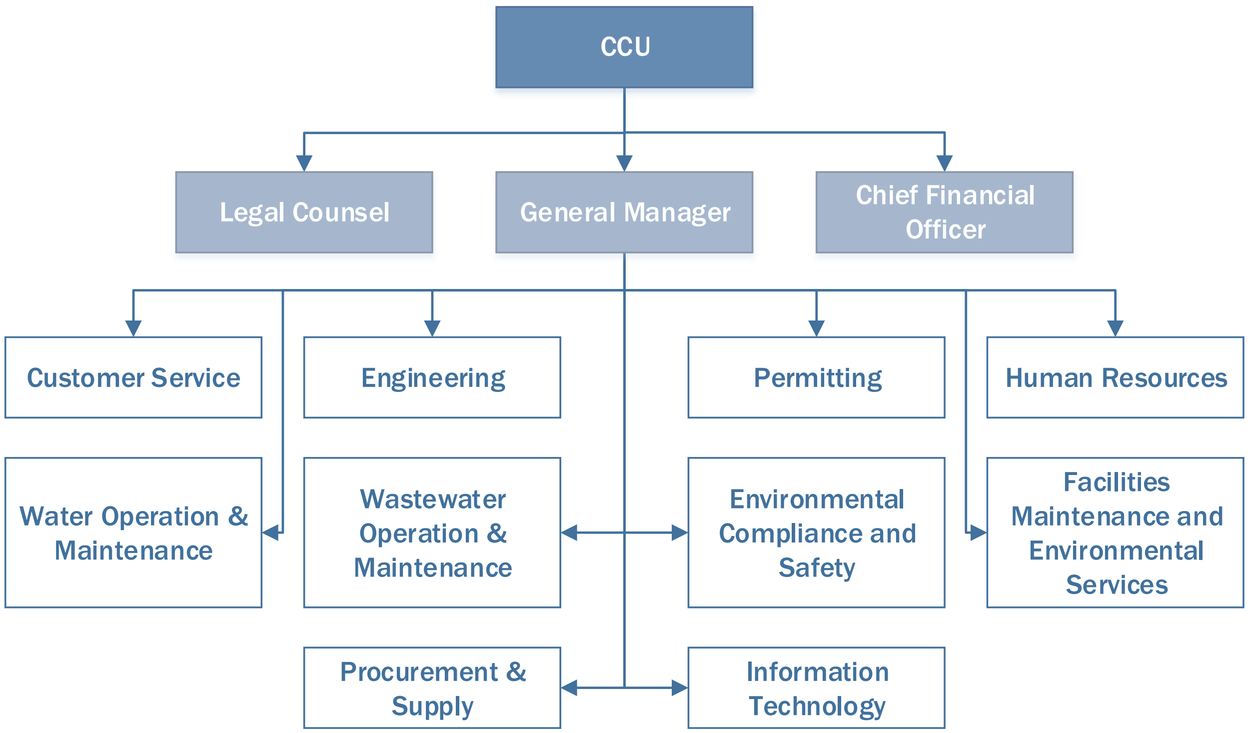


Figure 1-1. Former GWA Organizational Chart

Between July 2014 and January 2016, GWA's General Manager position was held by three Interim General Managers while the CCU searched for and evaluated potential candidates for the permanent position. On December 10, 2015, the CCU appointed Miguel Bordallo as permanent General Manager for GWA beginning January 4, 2016.

To better distribute the management roles within GWA, the CCU approved an initial restructuring at the upper management level that provides new Assistant General Manager (GM) positions as shown in Figure 1-2. The new structure will provide an additional layer of responsibility within GWA to handle day-to-day operational activities and allow the general manager to focus more on activities that will guide GWA's future. The Assistant GM position for Compliance and Safety is currently filled and the positions for Administration/Support and Operations are under or pending recruitment. The key roles and responsibilities for the final Assistant GM position are still being developed.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

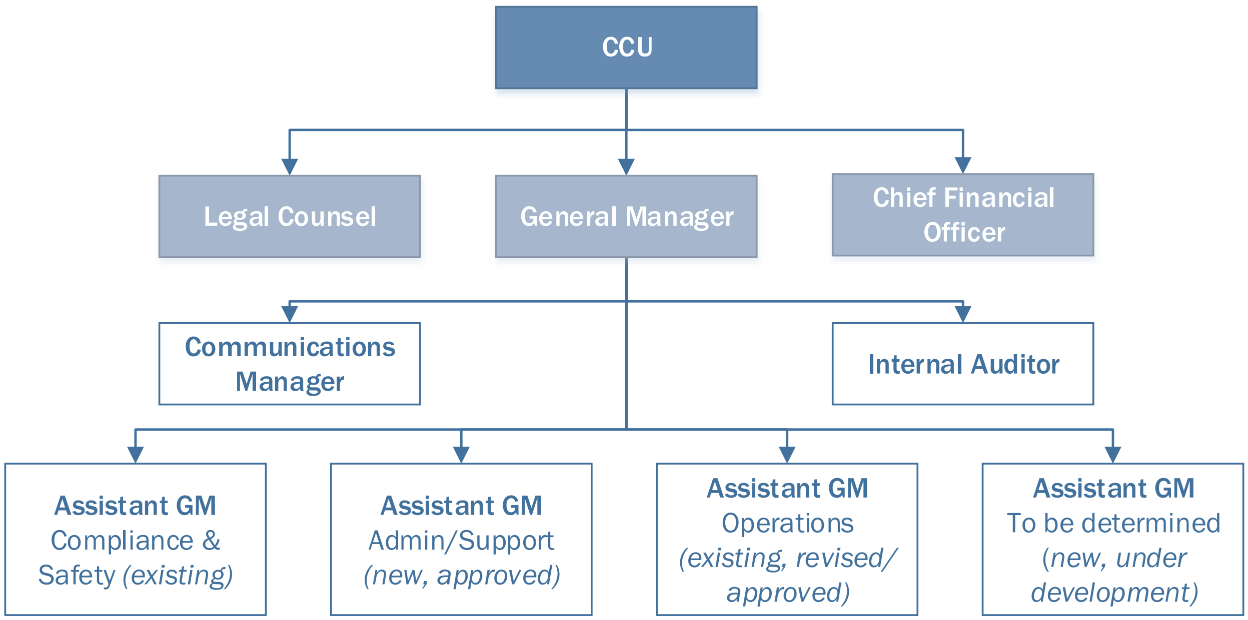


Figure 1-2. Current GWA Management Organizational Chart

Utility Staff

Overall staffing levels have increased significantly since the 2006 WRMP was published, from about 233 employees in 2007 to 327 employees in 2017. Staffing levels have fluctuated in recent years due to attrition and difficulty finding qualified replacements. Maintaining the required skill levels necessary for the utility to function and expand to meet future needs continues to be a challenge. GWA plans to increase staff to 354 by 2018 to fulfill projected requirements. An experienced Human Resources Administrator was hired in 2014, which has resulted in improvements in employment processes and the establishment of standard operating procedures for hiring staff.

1.1.3 USEPA Action 2003–2011

Shortly after GWA was formed, USEPA filed a complaint against GWA in the District Court of Guam seeking injunctive relief and the appointment of a receiver to address regulatory compliance problems and threats to public health and the environment. By June 2003, GWA and USEPA had agreed that entry of a Stipulated Order for Preliminary Relief (Stipulated Order) would be the appropriate way to begin addressing the regulatory compliance issues. The Stipulated Order established projects and an enforceable schedule to guide GWA to compliance. The Stipulated Order was subsequently amended in 2006. GWA proceeded to implement the requirements of the Stipulated Order, which included development of the 2006 WRMP.

USEPA and GWA returned to the District Court of Guam in 2010 because several projects listed in the Stipulated Order remained incomplete. On November 10, 2011, the District Court issued an *Order for Preliminary Relief Re: Deadlines for Outstanding Projects under the Amended Stipulated Order* (2011 Court Order). The 2011 Court Order established deadlines for completing outstanding projects identified in the Stipulated Order and included additional projects. The 2011 Court Order superseded the requirements of all previous orders.

GWA has made meeting the deadlines in the 2011 Court Order their top priority.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Outside Consultants

GWA initiated a Program Management Office (PMO) to help meet the deadlines defined in the 2011 Court Order. The basic responsibility of the PMO is to assist GWA in developing water and wastewater capital improvement projects for 2011 Court Order requirements, USEPA grants, and military buildup needs. Brown and Caldwell (BC) serves as the PMO contractor and assists GWA with deliverables related to water and wastewater, implementing the business model, and providing employee training and knowledge transfer. The current PMO contract expires in February 2019 and GWA has the option to extend the contract by two years to February 2021.

GWA implemented a Performance Management Contract (PMC) in 2007 to assist with wastewater operations. The selected PMC contractor was Veolia Water Guam, who provided management, training, and knowledge transfer related to O&M of the WWTPs and wastewater collection system. The PMC contract expired in January 2014. GWA staff benefited from training and knowledge gained through the PMC to the point where the contract was no longer necessary.

1.2 Water Resources Master Planning

The following section summarizes water resources master planning efforts to date, and the project approach and scope of this WRMPU.

1.2.1 Master Planning History

Throughout the history of PUAG, numerous reports were completed that evaluated the water and wastewater systems, water resource development, operating regulations, and other specific components of the utility agency. In 1992, the Barret Consulting Group completed the first comprehensive master plan that encompassed the overall utility. In 1990, Guam's total population was approximately 136,000 including a military population of approximately 26,000, and the tourism industry included approximately 4,400 hotel rooms. In the 1992 Master Plan, the population was projected to increase to 336,000, and the tourism industry was projected to grow to an estimated 44,260 hotel rooms by 2010. This rate of development was never realized, with the actual population of Guam in 2016 less than half of the 1992 projections at 167,000 and the total number of hotel rooms only 9,250.

A new Master Plan was developed for GWA in 2006 as a requirement of the stipulated order. The 2006 WRMP reviewed all existing assets and operational aspects of the GWA organization. As part of the 2006 WRMP, the first significant effort to develop computer models of the GWA water and wastewater systems was completed.

The planning horizon for the 2006 WRMP was 20 years (2006–2025). GWA has been working towards implementing the recommendations of the 2006 plan and the significant accomplishments achieved over the past decade are presented in Section 2. In the 2006 Master plan, the 2015 population was projected to range from a low of approximately 162,000 to a high of 227,000 with hotel rooms estimated at 18,000. While the projections in the 2006 master plan were based on more conservative assumptions than in 1992, population and the tourism industry have again not grown as quickly as anticipated.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

1.2.2 2016 WRMPU Project Background

In 2015, GWA authorized the use of a State Revolving Fund (SRF) Grant to update the 2006 WRMP. This update assesses GWA's progress towards achieving the recommendations outlined in the 2006 WRMP with respect to the utility's organization and water and wastewater infrastructure. The achievements accomplished since 2006 and gaps that remain are described in Section 2. This update further develops a plan for the next 20 years (through 2037) to address the capital improvements needed related to water supply demands, source water alternatives, and water and wastewater system improvements. These improvements will reinforce GWA's ability to successfully manage and operate the utility, maintaining both acceptable levels of service and compliance with safe drinking water standards and clean water regulations.

1.2.3 2016 WRMPU Project Approach and Scope

The WRMPU provides a review of current and future requirements of the water and wastewater systems. The approach to the project development included the following:

- The 2006 levels of service (LOS) were updated and expanded to reflect current GWA management and customer expectations in 2017. The LOS goals listed in Section 3 formed the basis for the planned improvements.
- Projects recommended in the 2006 WRMP were analyzed and incorporated into this updated plan as appropriate. Some of the 2006 projects have been completed, some are still required, and others are no longer needed as described in Section 2.
- GWA's management tools were evaluated, including the asset management system, geographic information system (GIS) program, and supervisory control and data acquisition (SCADA) program.
- Factors affecting future system requirements and GWA's ability to provide necessary services were reviewed, including the planned military buildup, regulatory requirements, security issues, and other impacts.
- Population projections, including potential areas of development, were analyzed to establish future capacity requirements for the water and wastewater systems. The water and wastewater hydraulic models were updated and analyzed with the future capacity requirements.
- Water supply from groundwater wells, rivers, springs, and other potential sources were evaluated.
- Condition assessment data was reviewed for water and wastewater infrastructure and condition deficiencies were identified.
- Recommendations were developed for capital improvement projects to address current and projected capacity and condition limitations.
- A method was developed for prioritizing the proposed projects.
- Planning level cost estimates were calculated for the proposed projects and a financial plan and schedule were developed for implementing the recommended projects.

Based on the information developed through completion of the above tasks, specific recommendations and capital improvement projects were identified and proposed for implementation between 2018 and 2037. A specific project sheet was developed for each proposed capital improvement, which includes a project description, project justification, recommended schedule, and estimated budget. These project sheets will be used by GWA to develop specific a 5-year capital improvement plan (CIP) required for CCU approval.

Because this document is an update to the 2006 WRMP, rather than a standalone edition, relevant information from the 2006 plan is included by reference as appropriate rather than reprinted.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

1.2.4 Project Prioritization

During the development of the water and wastewater system improvement projects, a workshop was conducted with GWA staff to discuss the projects and develop a non-financial ranking system to prioritize implementation. Each project was ranked with a score from 1 (lowest importance) to 3 (highest importance) for each of nine categories used in the rankings. Table 1-1 lists the non-financial categories, the relative importance developed during the workshop, and the corresponding scoring criteria.

Table 1-1 Project Category Scoring Criteria

Category	Percent of Total Score	Score = 1	Score = 2	Score = 3
Health and Safety	21%	No identified health and safety benefits	Enhances health and safety	Eliminates health and safety risk
Regulatory or Mandated	20%	No regulatory driver	Contributes to compliance	Required for compliance
Reliability and Redundancy	14%	No identified benefits to system reliability or redundancy	Moderately improves reliability or redundancy	Significantly improves reliability or redundancy
Capacity	9%	No identified benefits to system capacity	Moderately increases capacity	Significantly increases capacity
Operation, Maintenance, and Rehabilitation	9%	No identified O&M benefits Does not extend useful life of asset	Moderately extends useful life of asset Moderately decreases O&M costs	Significantly improves useful life of asset Significantly decreases O&M costs
Environmental Impact and Resource Use	9%	Minimal or no reduction in use of existing resources Minimal or no reduction to environmental impact	Reduces use of existing resources Reduces environmental impact	Makes best use of existing resources Significantly reduces environmental impact
Revenue and Expenditures	8%	No identified financial benefits	Contributes small financial benefits	Results in large financial benefits
Customer Service and Stakeholder Confidence	7%	No identified benefits to customer service or stakeholder confidence levels	Addresses occasional customer complaints Benefits a limited number of customers Moderately enhances stakeholder confidence	Addresses multiple complaints Benefits a larger number of customers Strongly improves stakeholder confidence.
Economic Development	3%	No identified benefits to economic development	Contributes to economic development	Essential to economic development

Rankings for water projects are listed in Volume 2, Section 11, and rankings for wastewater projects are listed in Volume 3, Section 10. The ongoing projects and organizational improvements described in Volume 1 were also ranked and are presented in Section 10.

Based on the project ranking system and overall financial analysis, selected projects to pursue in the 20-year Master Plan time frame are included in Section 11 (Capital Improvement Program).

1.2.5 Cost Estimating

Cost estimates were developed for all capital improvement projects. The cost estimating process, basis, and assumptions are presented in Appendix D. The cost estimates presented are for

Use of contents on this sheet is subject to the limitations specified at the end of this document.

budgeting purposes only and are presented in 2017 dollars. All cost estimates are Class 5 estimates where the accuracy range may vary from -50 percent to +100 percent. Some projects are recurring projects that will be executed multiple times before 2037. Project cost estimates should be reviewed and revised at each Master Plan update as part of the budget process to account for changing conditions including the volatile construction marketplace.

1.3 Public Outreach Program

A public outreach campaign was completed following the production of the WRMPU draft. The intent of the public outreach campaign was to provide information on the purpose, content and recommendations included in the WRMPU and to solicit feedback for incorporation into the final report. The public outreach campaign used a variety of methods for communication with the public and government agencies throughout Guam. Communication methods included:

Flyer – A WRMPU flyer was sent to each customer with their May 2018 water bill. The flyer provided a summary of the WRMPU process recommendations and financial impacts, and also provided information on how the WRMPU could be accessed for review and comment. A copy of the flyer is included in Appendix F.

Website Access - The WRMPU was advertised on the GWA website and was available for downloading via links included on the webpage. Any customer could download the plan after filling in some basic information. The download process included instructions on how to submit review comments to GWA via email.

Printed Access - copies of the WRMPU were provided for review and comment at the GWA Customer Service Centers and at the Agat, Tamuning and Yigo Mayor's offices.

Public Meetings - Ten Public Meetings were held to present the WRMPU to residential and commercial customers and to the Legislature, Mayor's Council, Governor's Office and other government agencies. Public Meetings included the following:

- Governor's Office / Cabinet
- Mayor's Council
- Agat Mayor's Office
- Tamuning Mayor's Office
- Yigo Mayor's Office
- Legislature
- Guam EPA, Department of Public Works and Governor's Chief of Staff
- Guam Hotel and Restaurant Association (GHRA)
- Guam Contractors Association (GCA)
- Guam Society of Professional Engineers (GSPE)

Questions and comments were accepted at each public meeting and responses were provided at the meetings when possible. A summary of all comments received from the entire Public Outreach campaign are included in Appendix F. Appendix F includes the specific comment, related section of the WRMPU, GWA response and action planned to address the comment.

This Final WRMPU incorporates all updates as necessary to address the Public Outreach comments.

1.4 Constraints for Future GWA Progress

The future of GWA will be impacted by unforeseen factors, some within the control and some beyond the reach of the organization. This WRMPU provides a proposed program for GWA based on an assessment of the current and potential future conditions and requirements. Periodic Master Plan updates must be undertaken to account for changes to future requirements. Factors affecting the environment in which GWA operates that may influence GWA's future requirements are presented in Section 6 (Enterprise Environmental Factors). Key factors discussed in Section 6 include issues related to military activities, tourism, regulatory requirements, security, and natural disasters.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 2

System Accomplishments 2006–2016

This following section includes an assessment of the work completed as recommended in the 2006 WRMP and evaluates whether the work fulfills the original intent as established at that time. In addition, this section identifies the remaining work to be completed or removed from the 2006 WRMP recommendations due to changed conditions, changes in GWA emphasis, or a determination that the proposed work is unnecessary. This assessment was based on a review of existing condition assessment reports, asset management reports, pending and completed design and construction projects, interviews with engineering and operations staff, and evaluation of collected data from various reports.

2.1 Significant Accomplishments

GWA has made significant progress since the 2006 WRMP. Some of the major accomplishments include the following:

- The Ugum Surface Water Treatment Plant (SWTP) was upgraded and converted to a membrane filtration process, virtually eliminating water quality issues for the treated water.
- The Hagåtña WWTP was upgraded to a chemically enhanced primary treatment (CEPT) process.
- The Northern District WWTP was upgraded to a CEPT process.
- Six new water storage tanks were constructed with a combined capacity of 6 million gallons (MG).
- Hydraulic models for the water and sewer systems were significantly updated and improved. The water system model is now consistently used for planning purposes.
- An island-wide pressure zone plan was developed for the water system and implementation of the plan has started.
- GWA reliance on U.S. Department of the Navy (Navy) water has been reduced by over 50 percent from an average of 4.3 million gallons per day (mgd) in 2004 to approximately 2.0 mgd in 2016.

While GWA has made significant progress in the last 10 years, there are still many areas where planned improvements that are still necessary have not been completed. GWA has recognized that significant issues still need to be addressed including improvements to water loss prevention, water supply reliability, source water protection, utility-wide standards, growth due to tourism and the pending military buildup, deteriorating infrastructure, emergency preparation for natural disasters, and others.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA continues to address these items with several major projects underway, including the major projects described below.

Water System

- Nine new water storage tank projects are currently in progress, which will provide a total capacity of more than 11 MG.
- Rehabilitation of wells D-3, D,17, D-18, D-22, and M-9 are in the construction phase.
- Rehabilitation of wells A-2, A-7, A-12, D-5, and F-3 are in the design stage.

Wastewater System

- Construction of a new Agat-Santa Rita WWTP is underway.
- Design and construction of an upgrade to the Umatac Merizo WWTP is underway.
- Construction of the Cross-Island Highway pipeline project to eliminate the wastewater discharge from the Baza Gardens WWTP is underway.
- An upgrade to the Northern District WWTP to add secondary treatment is in the design phase.
- Major pipeline refurbishments on Macheche Road and Route 1 in Asan are under construction and projects for Route 4 in Hagåtña, Route 2 in Agat and others are in the design phase.

2.1.1 Departures from 2006 WRMP Projects

There have been several significant changes in project priorities and regulatory requirements since 2006. In 2006, the WRMP envisioned upgrading the entire GWA water system to provide fire flow capacity throughout the island. Since then, it has been determined that this aggressive plan would be very expensive to implement and disruptive to system operations. The current emphasis is on overall system performance and reliability.

As shown in the project status update provided in Table 2-1, fire flow capacity improvements have not been completed. The current plan is to phase these upgrades in over a longer period with emphasis currently placed on the following improvements:

- Replace 2-inch pipes with larger diameter pipes sized to handle fire flow rates to the respective areas.
- Construct new storage tanks with capacity for fire flow storage.
- Rehabilitate and replace fire hydrants to improve access to the system for firefighting measures.

These projects will improve firefighting capabilities, but there will still be areas in the near future where flow rates available for firefighting will be lower than recommended. These areas will be addressed in future projects until fire flow capacity is ultimately provided island-wide.

Another major difference since 2006 involves a proposed plan to modify the GWA water distribution system such that all wells would pump directly to a storage reservoir rather than directly into the system. Similar to the fire flow plan, it was determined that this modification would be complicated, disruptive to customers, and very expensive. Therefore, except for in a few locations where this modification could be readily accomplished, this plan has not been implemented by GWA. The focus has been to increase system reliability with respect to maintaining desired water pressure and water availability instead of modifying the overall system configuration.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

In 2006, the Northern Guam LENS Aquifer (NGLA) was under investigation to determine if it should be classified as groundwater under the direct influence of surface water (GWUDI). If the aquifer was classified as GWUDI, additional treatment steps such as filtration would have been required at all GWA wells. Following the development of the 2006 WRMP, a study to evaluate the Northern Systems GWUDI Filtration Compliance was completed and it was determined that the GWUDI requirements did not apply. The Northern System GWUDI Filtration Compliance project was therefore not necessary.

With respect to the wastewater system, requirements for plant expansions became more extensive than planned due to changes in regulatory requirements and changes in the projects anticipated for these facilities. For example, it was determined that an upgrade to the Baza Gardens WWTP could not meet the secondary standards established for the plant. The project was therefore changed to convert the facility to a preliminary treatment system and pump station to pump the flow to the Agat-Santa Rita WWTP and the capacity of Agat Sant-Rita was increased to accommodate the additional flow. In Umatac, there were also no plans to upgrade the entire wastewater treatment process—only headworks improvements. Since 2006, it was determined that to comply with current permit requirements, the entire plant, including the overland treatment system, must be upgraded.

2.2 Status of 2006 WRMP Recommendations

This update falls near the midpoint of the 2006 WRMP's 20-year planning period. The following section summarizes the status of the recommendations included in the 2006 WRMP.

Table 2-1 summarizes the status of the recommended water projects from Volume 2, Section 9 of the 2006 WRMP. Table 2-2 summarizes the status of the recommended wastewater projects from Volume 3, Section 9 of the 2006 WRMP. A detailed analysis of the projects, project requirements, and project status is included in Appendix C. As some of the projects were composed of multiple sub-projects, Appendix C also includes a breakdown of each of these sub-projects.

Based on the projected future water and wastewater needs of GWA, each project from the 2006 WRMP not completed to date was recommended to be either included for future consideration or eliminated from further consideration. Future project requirements were based on the water system evaluations included in Volume 2 and the wastewater system evaluations included in Volume 3 of this WRMPU. Some of the projects listed in the 2006 plan were not scheduled to start until 2017 or later. These projects are identified as "Not Scheduled" in Tables 2-1 and 2-2.

In 2006, GWA was working with their first versions of the water and wastewater system models. The models were developed based on information available at that time. Each of these models has been significantly updated since 2006 and each has been updated again for this WRMPU. Based on the model updates and GWA's increasing knowledge of the system, the work that has been completed since 2006 has been based on the updated information and therefore does not always reflect the exact projects anticipated in 2006. The results shown in Tables 2-1 and 2-2 were based on the intent of the 2006 plan. For example, if the 2006 plan proposed replacement of piping in one area for capacity improvement, but a project covering similar work for a different area was completed that was not identified in 2006, the amount spent was credited to the project as the intent was to complete that type of project, and it is noted as complete even though the work may not have been at the specific project location proposed in 2006.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Some projects planned in the early period following acceptance of the 2006 WRMP have been completed, but it was not possible to define the exact cost of the completed work. These projects were noted as 100 percent complete and the cost was set equal to the planned budget shown in Tables 2-1 and 2-2. In other cases, projects were combined with other larger or similar projects; therefore, there was no exact project completed as identified in the 2006 WRMP. Where these projects were confirmed to be complete, the project was identified as complete and the budget spent was also set to equal the 2006 budget estimate. On other projects, the budgeted costs for a project may have been spent, but the entire defined project may not have been completed due to escalated costs, or the project required a larger scope to complete the work intended. In these cases, the project was also identified as complete since the allocated budget was used, but there could still be work remaining to be completed.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-1. Status of 2006 WRMP Water System Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WMPU
1	Water Reservoir Internal/External Corrosion Assessment Program	Develop and implement a corrosion assessment program for all steel water reservoirs to determine extent of internal and external reservoir corrosion and necessary course of action to rehabilitate or replace the impacted reservoirs.	55%	2007	$125,000	$738,180	Yes
2	Water Reservoir Internal/External Corrosion Rehabilitation Program	Based on the results of the corrosion assessment program for all steel water reservoirs, program the rehabilitation of designated reservoirs over a 4-year period as a phased project.	63%	2008–2011	$2,000,000	$1,540,500	Yes
3	Ugum Water Treatment Plant Membrane Filtration	This project will replace the existing sand filters at the Ugum SWTP with submerged membrane filters.	100%	2007	$8,500,000	$7,700,000	No
4	Ugum Water Treatment Plant Reservoir Replacement	This project will provide a 2-MG finished water reservoir at the Ugum SWTP. The existing reservoir shows significant damage to the cover as a result of a series of typhoons. The damage has contributed to corrosion, which could result in premature failure. This reservoir is the sole source of finished water for most of the Southern Water System. Failure of this reservoir would result in a significant hardship on customers in the system. The new reservoir would allow the existing reservoir to be taken off-line and refurbished.	5%	2009	$8,700,000	$435,000	Yes
5	Ugum Water Treatment Plant Intake Modifications	This project would improve the intake structure for the Ugum SWTP to minimize siltation and to provide more reliable raw water supply during low river flow conditions.	0%	2007	$550,000	--	Yes
6	Water Distribution System Pipe Replacement	In addition to specific pipe replacement projects identified through hydraulic modeling, there is an ongoing need for pipe replacement to address leak, failure and age issues. This project meets that need. The basis for this reserve is about 13,500 linear feet of pipe replaced per year through 2015 and 2,000 feet of pipe replaced per year thereafter.	88%	2007–2026	$45,740,000	$40,386,400	Yes
7	Mechanical/Electrical Equipment Replacement	Reserve for routine mechanical/electrical equipment replacement due to age, capacity, or failure. This reserve includes well pumps, booster pumps, valves, emergency generators, and other items associated with the Northern, Central, and Southern Water Systems.	19%	2008–2026	$8,370,000	$1,590,300	No [b]
8	Southern System Water Distribution System 2005 Improvements	The 2005 CIP hydraulic model for GWA's Southern Water System has identified deficiencies in water pipe sizes required to provide adequate fire flow. The series of projects listed in Table 9-9 of the 2006 WRMP identify the location, pipe diameter, and length to address this issue.	N/A	2008–2017	$11,700,000	--	No [c]
9	Central System Water Distribution System 2005 Improvements	The 2005 hydraulic model for GWA's Central Water System identified deficiencies in pumping capacity and pipe size to provide adequate fire flow and pressure, and reduce high velocities and friction losses. The series of projects	N/A	2008–2017	$5,400,000	--	No [c]

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-1. Status of 2006 WRMP Water System Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WMPU
		listed in Table 9-11 of the 2006 WRMP identify the location, pipe diameter, length, and pumping needs to address these issues.					
10	Northern System Water Distribution System 2005 Improvements	The 2005 hydraulic model for GWA's Northern Water System identified deficiencies in pumping capacity and pipe size to provide adequate fire flow and pressure, and reduce high velocities and friction losses. The series of projects listed in Table 9-11 of the 2006 WRMP identify the location, pipe diameter, and length to address these issues.	N/A	2008–2017	$23,400,000	--	No [c]
11	Pressure Zone Realignment/Development 2005 Improvements and the Water Model	The hydraulic modeling of the water system identified areas with inadequate service pressures and flows. Installations of PRV/PSV stations are required at strategic locations to facilitate the development of discrete pressure zones, and improve circulation of flow from a higher-pressure zone to a lower pressure zone. See projects listed in Table 9-12 of the 2006 WRMP.	11%	2008–2010	$8,100,000	$891,000	Yes
12	Water Booster Pump Station 2005 Improvements	The 2005 hydraulic model for GWA's three water systems identified deficiencies in water booster pumping capacity to provide adequate supply to areas in two systems. The projects listed in Table 9-13 of the 2006 WRMP are intended to address these limitations.	0%	2008–2009	$1,200,000	--	Yes
13	Water System Reservoirs 2005 Improvements	The 2005 hydraulic model for GWA's three water systems identified deficiencies in reservoir capacity. The projects listed in Table 9-14 of the 2006 WRMP are intended to address these deficiencies.	100%	2008–2016	$25,200,000	$36,986,740	Yes
14	Northern System Raw Water Transmission Lines	GWA currently operates a combined transmission/distribution system, which requires treatment (chlorination) at most of the individual wells. To provide more reliable and fewer points of treatment, transmission lines separate from distribution are needed. The projects listed in Table 9-15 of the 2006 WRMP are intended to address this need. The transmission lines will transport well water to a reservoir(s) where chlorination facilities will be located.	<10%	2007–2020	$104,800,000	--	No
15	Water System Supply Wells 2025 Improvements	The 2025 hydraulic model for GWA's three water systems identified deficiencies in groundwater supply wells. The projects are intended to address the deficiencies.	Not Scheduled	2024	$0	--	Yes
16	Southern System Water Distribution System 2025 Improvements	The 2025 hydraulic model for GWA's Southern Water System has identified deficiencies in water pipe sizes required to provide adequate fire flow. The series of projects listed in Table 9-17 of the 2006 WRMP identify the location, pipe diameter, and length to address this issue.	Not Scheduled	2024–2026	$0	--	Yes [c]

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-1. Status of 2006 WRMP Water System Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WMPU
17	Northern System Water Distribution System 2025 Improvements	The 2025 hydraulic model for GWA's Northern Water System identified deficiencies in pumping capacity and pipe size to provide adequate fire flow and pressure, and reduce high velocities and friction losses. The series of projects listed in Table 9-18 of the 2006 WRMP identify the location, pipe diameter, and length to address these issues.	Not Scheduled	2017–2026	$0	--	Yes [c]
18	Water Booster Pump Station 2025 Improvements	The 2025 hydraulic model for GWA's three water systems identified deficiencies in water booster pumping capacity to provide adequate supply to areas of the respective system. The projects listed in Table 9-19 of the 2006 WRMP are intended to address these limitations.	Not Scheduled	2025	$0	--	Yes
19	Water System Reservoirs 2025 Improvements	The 2025 hydraulic model for GWA's three water systems identified deficiencies in reservoir capacity. The projects listed in Table 9-20 of the WRMP are intended to address these deficiencies.	Not Scheduled	2018–2022	$0	--	Yes
20	Northern System GWUDI Filtration Compliance	This project would provide membrane filtration for all Northern Lens groundwater assuming all aquifers have been designated GWUDI of surface water. Note the assumption that all groundwater will be designated is a worst-case scenario.	N/A	2013–2022	$0	--	No
21	Electrical Upgrade - Water Booster Stations (Pago Bay, etc.)	This project is for the electrical upgrade at the Pago Bay, Brigade, and Windward Hills Water Booster Stations by replacing existing equipment, motor, motor control centers, etc. This project includes a detailed engineering assessment and preparation of design engineering plans.	100%	2007	$650,000	$650,000	No
22	Electrical Upgrade - Water Booster Stations (Gayinero, etc.)	This project is for the electrical upgrade at the Water Booster Stations by replacing existing equipment, motor, motor control centers, etc. Included is a detailed engineering assessment and preparation of design engineering plans and specifications.	100%	2008	$350,000	$350,000	No
23	Electrical Upgrade - Water Booster Stations (Other WBPS)	This project is for the electrical upgrade at the other Water Booster Stations such as Yigo Elevated Tank, Pale Kieran, etc. Project scope includes replacing existing equipment, motor, motor control centers, etc.	100%	2009	$250,000	$250,000	No
24	Electrical Upgrade – Water Wells	This project is to upgrade the electrical system at each of the water wells as recommended in the Electrical Assessment of the 2006 WRMP Report.	75%	2007	$2,000,000	$1,500,000	Yes
Water System Totals					$257,035,000	$93,018,120	

a. Costs are listed as reported in the 2006 WRMP through 2016. Projects scheduled after 2016 are not included in the total.

b. New projects are specified for each type of facility, production well, pump station, treatment plant, etc.

c. New projects for expansion or demand capacity replacement will be designed for fire flow.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-2. Status of 2006 WRMP Wastewater and Electrical Systems Recommendations

Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WRMPU
Wastewater Collection System- Capacity Related							
1	Northern District STP Rte 16 PS Overflow Study	Assess opportunity to modify the Route 16 PS overflow to avoid excess wet weather flow diversion to Hagåtña STP. Alternatively, increase station reliability.	100%	2007	$50,000	$50,000	No
2	Northern District STP Eliminate Flow Split	Eliminate the flow split that occurs in the sewer manhole that collects flow from Andersen Air Force Base and Navy Housing east of the North District STP to divert all flow to the 42-inch gravity sewer.	100%	2007	$50,000	$50,000	No
3	Northern District STP Priority 1 Sewer Upgrades	5,100 feet of sewers upstream of the Fujita Pump Station and just downstream of flow meters 7, 8, and 38 (Buena Vista) were found to be surcharged excessively both in the metering and modeling. These sewers have been assigned priority 1 for correction.	15%	2010	$2,400,000	$400,000	Yes
4	Northern District STP Priority 2 Sewer Upgrades	Two short sections of pipe in the ND STP area were prioritized at level 2 for improvement in the future as population and sewered area grows.	Not Scheduled	2020	$0	$0	No
5	Northern District STP Priority 3 Sewer Upgrades	9,000 feet of sewer were given a priority of 3. These sewers received this priority because there is some uncertainty as to the accuracy of the modeling or in the actual pipe parameters (diameter, connectivity, and slope). The pipe parameters should be verified. There is also a large un-metered flow entering the split manhole between the FM 5 and 11 sites. Monitoring of this flow and discovering its source will allow flows in this area to be redistributed.	Not Scheduled	2025	$0	$0	No
6	Hagåtña STP Priority 1 Sewer Upgrades	5,100 feet of sewers in the Hagåtña STP service area were identified as Priority 1 for upgrade.	60%	2010	$4,000,000	$2,400,000	Yes
7	Hagåtña STP Priority 2 Sewer Upgrades	16,000 feet of sewers in the Hagåtña STP service area were identified as Priority 2 for upgrade.	Not Scheduled	2020	$0	$0	Yes
8	Hagåtña STP Priority 3 Sewer Upgrades	17,000 feet of sewers in the Hagåtña STP service area were identified as Priority 3 for upgrade. The pipe parameters and flows require verification before constructing the identified upgrade.	Not Scheduled	2025	$0	$0	No
9	Hagåtña STP Pump Station Upgrades	Three pump stations in the Hagåtña STP service area were found to have insufficient capacity to deliver the projected peak flows: the Hagåtña Influent Pump Station, Asan Pump Station, and Tepungan (Piti) Pump Station. Evaluation of re-siting the Hagåtña SPS to the STP or another site will be included in this project.	0%	2010–2023	$6,160,000	$0	Yes
10	Agat-Santa Rita STP Priority 1 Sewer Upgrades	1,720 feet of sewer were assigned priority 1 for upgrade to avoid overflows as population growth occurs.	5%	2010	$1,200,000	$1,800,000	Yes

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-2. Status of 2006 WRMP Wastewater and Electrical Systems Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WRMPU
11	Agat-Santa Rita STP Priority 3 Sewer Upgrades	6,300 feet of sewer were assigned priority 3 for upgrade. These sewers where found to surcharge to near the ground surface in the model. They have been assigned lower priority to await field study of infiltration/inflow sources and correction activities.	Not Scheduled	2025	$0	$0	No
12	Baza Gardens STP Priority 1 Sewer Upgrades	1,600 feet of sewers have been assigned a Priority 1 ranking for improvement in the Baza Gardens STP service area to respond to growth in the connected population. These sewers should be addressed when areas in the Talofofo Pump Station service area that have currently unconnected sewers are brought on-line. The Talofofo Pump Station capacity should be examined at the same time.	60%	2010	$650,000	$400,000	Yes
13	Baza Gardens STP Priority 2 Sewer Upgrades	2,600 feet of sewers have been assigned a Priority 2 ranking for improvement in the Baza Gardens STP service area to respond to growth in the connected population. These sewers should be addressed as growth occurs.	Not Scheduled	2020	$0	$0	No
14	Inarajan STP Pressure Sewer Upgrades	The GIS database includes an 8-inch sewer in Chagamin Avenue with low-lying manholes, which may overflow in the event of a problem at the Inarajan Main Pump Station. The water depths measured during the August 31, 2005, monitoring exceeded the apparent elevation of manholes between Chalan Tun Juan Street and the pump station. Conversion of this 1600 feet segment of sewer to a pressure sewer would avoid potential overflows. The reliability of the pump station should be examined.	0%	2010	$1,200,000	$0	No
Wastewater Collection System – Unsewered Areas							
15	NDSTP and Hagåtña STP Unsewered Properties – Sewer Hookups [b]	843 accounts were identified by WERI (see Chapter 3–6) that are within 200 feet of existing sewers and within 1000 feet of a water supply well, which have water accounts but no sewer accounts. Research these properties and provide hook-ups to the existing sewers were no connection exists.	0%	2012–2016	$6,500,000	$0	No
16	NDSTP and Hagåtña STP Unsewered Properties – New Sewers [b]	563 properties were identified by WERI per Table 9-16 of the 2006 WRMP that are within 1000 feet of deep wells but not near existing sewers that have water accounts but not sewer accounts. Research these properties and provide new sewers as necessary to provide service. Estimated lengths by deep well are given in Table 9-16a (See Table 6-9 in Volume 3, Chapter 6).	0%	2012–2026	$13,500,000	$0	No
17	NDSTP and Hagåtña STP Unsewered Properties – Additional Sewer Hook-ups [b]	The stipulated order calls for hook-ups of all unsewered properties within 200 feet of existing sewers via a sewer hook-up revolving fund. There are 1963 properties identified by WERI in the North and Hagåtña service areas with water accounts but no sewer account.	0%	2015–2026	$2,500,000	$0	No

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-2. Status of 2006 WRMP Wastewater and Electrical Systems Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WRMPU
18	South System Sewer Hook-ups [b]	945 properties were identified by WERI in the south systems with water accounts but not sewer accounts, which are within 200 feet of existing sewers. The stipulated order specifies that a sewer hook-up revolving fund be established to provide connections to existing sewers. As water supply protection is not involved, these are scheduled late in the program.	Not Scheduled	2022–2026	$0	$0	No
Wastewater Collection System – Other Projects							
19	Manhole Frame Seal Repair	Repair the manhole cover and frame to barrel/cone seal at multiple manhole locations identified by manhole inspections: 53 in Agat, 5 in Yigo, 4 in Hagåtña.	100%	2007	$84,000	$84,000	No
20	Agat Manhole Rehabilitation	Rehabilitate four manholes that were identified to have active infiltration by manhole inspection.	100%	2007	$54,000	$48,600	No
21	Wastewater Collection System Recurring Inspection Program	Inspect approximately ⅛ (12 percent) of the collection system each year by CCTV, manhole inspections, or smoke testing. Based on GUAM EPA regulation, all of the sewers within 1,000 feet of a potable water supply well or within the groundwater protection zone must be inspected every 5 years regardless of its priority rating.	50%	2007–2026	$6,100,000	$6,100,000	Yes
22	Wastewater Collection System Replacement/Rehabilitation Program	Annual recurring design and construction project to replace/rehabilitate ¾ of the total collection system (~8,600 feet) per year. This would focus on the worst condition pipes not already scheduled for hydraulic-related rehabilitation or replacement. The cost is estimated at $240 per foot, which assumes an average pipe diameter of 10 inches and does not include the cost of potential traffic control.	50%	2007–2026	$18,650,000	$18,650,000	Yes
Wastewater Facilities							
23	Facilities Plan/Design for the Agat-Santa Rita STP Replacement	Planning and design for new wastewater treatment facilities to meet existing and future flow capacity and reliably achieve regulatory compliance. The new facilities will incorporate provisions for redundancy to improve reliability and facilitate operations and maintenance activities.	100%	2008–2010	$3,200,000	$3,200,000	No
24	Agat-Santa Rita STP Replacement	Construction of new wastewater treatment facilities to meet existing and future flow capacity and reliably achieve regulatory compliance.	25%	2012	$30,000,000	$17,146,811	No
25	Facilities Plan/Design for the Baza Gardens STP Replacement	Planning and design for new wastewater treatment facilities to reliably meet secondary treatment limits. Due to strict effluent limits imposed by the stream discharge, and difficulty in operating complex treatment systems to reliably meet these limits, an alternative means of disposal should be considered in the Facility Plan.	100%	2007–2009	$2,000,000	$1,240,000	No

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-2. Status of 2006 WRMP Wastewater and Electrical Systems Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WRMPU
26	Baza Gardens STP Replacement	Construction of new wastewater treatment facilities to reliably meet secondary treatment limits. To achieve regulatory compliance, it is assumed that a new means of disposal will be constructed.	0%	2011	$18,000,000	$0	Yes
27	Facilities Plan/Design for the Hagåtña STP Improvements & Effluent WWPS	Planning and design for wastewater treatment plant improvements. The following improvements should be considered: at least one additional primary clarifier, new headworks equipment, and a new effluent pump station for the disposal of future flows at high tide conditions.	100%	2013	$1,900,000	$1,900,000	No
28	Hagåtña STP Improvements & Effluent WWPS	Provide a new primary clarifier to meet current and future wastewater capacity and redundancy requirements. Provide screenings and grit removal for WWTP improvements. The new headworks equipment will improve performance, reduce wear on equipment, and improve reliability. The new equipment includes screenings, grit removal, and effluent WWPS sized for current and future (year 2015 projected flow).	100%	2015	$18,000,000	$24,942,000	No
29	Facilities Plan/Design for Inarajan STP Expansion	Planning and design to improve process performance and enhance O&M requirements We recommend that the Facility Plan consider addition of mechanically cleaned bar screens to enhance performance and reduce O&M requirements.	100%	2016	$190,000	$0	No
30	Inarajan STP Expansion	Construction of plant improvements identified in the Facilities Plan to improve process performance and enhance O&M requirements We recommend the addition of mechanically cleaned bar screens to enhance performance and reduce O&M requirements.	Not Scheduled	2018	$420,000	$0	No
31	Facilities Plan/Design for the Northern District STP – Biosolids	Planning and design for repairs to the biosolids stabilization facilities (digesters) and dewatering system (centrifuges) for present and future flows. Project is assumed to be built in two phases.	20%	2007–2016	2,300,000	$460,000	Yes
32	Northern District STP Expansion – Biosolids	Construction of repairs to the biosolids stabilization facilities (digesters) and dewatering system (centrifuges) for present and future flows. Design will be based on Facilities Plan recommendations. Master Plan construction budget is based on repairs to existing anaerobic digesters, construction of one additional digester tank to provide redundancy, and new centrifuge facilities to serve as a centralized facility for treating GWA biosolids. Project is assumed to be built in two phases.	0%	2009–2017	$5,000,000	$0	Yes
33	Facilities Plan/Design for the Northern District STP Expansion	Planning and design for a new primary clarifier to meet current and future wastewater capacity and redundancy requirements. In addition, planning should consider replacement of existing comminutors with mechanically cleaned screens.	100%	2013	$1,200,000	$1,200,000	No

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-2. Status of 2006 WRMP Wastewater and Electrical Systems Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WRMPU
34	Northern District STP Expansion	Construction of a new primary clarifier to meet current and future wastewater capacity and redundancy requirements. Replacement of comminutors with mechanically cleaned screens.	100%	2015	$10,000,000	$23,500,000	No
35	Facilities Plan/Design for the Umatac-Merizo STP Improvements	Planning and design for new mechanically cleaned bar screen facilities to improve reliability and facilitate operations and maintenance requirements.	100%	2012	$140,000	$140,000	Yes
36	Umatac-Merizo STP Improvements	Construction of new mechanically cleaned bar screen facilities to improve reliability and facilitate operations and maintenance requirements.	0%	2013	$420,000	$0	Yes
37	Pago Socio STP Conversion	The Pago-Socio STP was built by a developer to serve 16 homes and was dedicated to GWA for operation and maintenance. It is a Class II facility as designated by GUAM EPA. It consists of a packaged aerated treatment unit and a series of six subsurface percolation pits. Currently, the aeration system is not operating. This project includes constructing a new pump station and force main to convey the flow to the Hagåtña collection system for treatment at the regional facility.	0%	2016	$3,700,000	$0	Yes
Electrical / SCADA Projects							
38	Electrical Upgrade – Agat-Santa Rita STP	This project is for the electrical upgrade at the Agat STP to replace the existing main distribution board, auto transfer switch, Motor Control Center, and other electrical equipment and install new underground duct from the plant building to the generator building. Included are a detailed engineering assessment and the preparation of design plans for the work involved.	25%	2007	$400,000	$0	Yes
39	Electrical Upgrade – Baza Garden STP	This project is for the electrical upgrade at the Baza Gardens STP to replace the existing Main Distribution Board and Auto Transfer Switch, upgrade with premium efficiency motors, and replace other electrical equipment. Included is a detailed engineering assessment and preparation of design plans.	0%	2011	$300,000	$0	Yes
40	Electrical Upgrade – Northern District STP	This project is for the electrical upgrade at the Northern STP to replace the existing main distribution board, auto transfer switch, Motor Control Centers at the digester, centrifuge, headworks, and chlorination buildings. Premium efficiency motors, transient voltage surge suppression equipment, improvements in system grounding, and power factor correction capacitors will also be added.	100%	2008	$1,900,000	$1,900,000	No
41	Electrical Upgrade – Umatac-Merizo STP	This project is for the electrical upgrade at the Umatac–Merizo WWTP to replace the aging motor control center, improve system grounding, and add transient voltage surge suppression equipment. The major electrical aeration motors will be replaced with premium efficiency type to save energy. Included is a detailed engineering assessment and design plan preparation.	0%	2009	$300,000	$0	No

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-2. Status of 2006 WRMP Wastewater and Electrical Systems Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WRMPU
42	Wastewater Pump Station Electrical Upgrade	This project is to upgrade and standardize the electrical control system at the wastewater pump stations as recommended in the GWA WRMP. An initial assessment using a standard checklist will be conducted. Project scope will include significant electrical modifications.	5%	2007	$1,000,000	$50,000	Yes
43	GWA SCADA System – Phase 1	Phase 1 of this project includes reconnecting the existing Motorola SCADA system at the 21 critical water wells and 10 critical wastewater pump stations along with the critical chlorination system wells, which can be quickly activated and updated utilizing, in many cases, equipment already in place. The existing Government of Guam Public Safety radio system would be incorporated to convey SCADA data and status information to a GWA Central Dispatch Center where digital text messaging would be directed to key personnel.	25%	2007	$250,000	$62,500	Yes
44	GWA SCADA System – Phase 2	In Phase 1 of this project, the critical water and wastewater pump stations are monitored by activating and updating the existing Motorola SCADA system. In this phase of the project, the balance of the pump stations and the treatment facilities are to be updated and incorporated into the GWA SCADA System. The treatment facility alarms would be identified and activated to a digital telephone text messaging unit to call key operations personnel related to that specific area.	0%	2008	$1,100,000	$0	Yes
45	GWA SCADA System – Phase 3	In Phase 3 of this project, improvements in real-time data acquisition for status monitoring and process control is expanded at the treatment facilities through the incorporation of programmable logic controllers. The data is conveyed to the GWA Central as well as identified engineering and operations personnel for analysis and process optimization through the use of Virtual Private Networks or other available secured technology. Further improvements and updating of the pumping station SCADA monitoring would be expanded using digital communications (the GovGuam system is scheduled to be updated during this period) and the radio units would require replacement.	0%	2009	$2,500,000	$0	Yes
46	GWA SCADA System – Phase 4	In this Phase 4 of the project, accounting information such as equipment and part costs, along with the condition data such as equipment operating time and preventive/predictive maintenance programs, are to be incorporated into an asset management program. This portion is for the SCADA system role in being incorporated into the overall asset management program and for the updating of the SCADA equipment and hardware and software.	5%	2010	$850,000	$42,500	Yes

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-2. Status of 2006 WRMP Wastewater and Electrical Systems Recommendations							
Item	2006 WRMP Project Name	2006 WRMP Project Description	Estimated Percent Complete	Planned Project Schedule	Projected Cost to 2016 ($) [a]	Approximate Funds Spent to Date	Carry Over to 2016 WRMPU
GIS Projects							
47	GIS	Identify areas where water distribution and wastewater collection system assets are not represented in the GIS. Collect data needed to properly document the assets location using GPS and physical attributes (i.e. invert of manhole, pipe diameter, pipe material, etc.)	50%	2007–2011	$800,000	$400,000	Yes
Wastewater and Electrical Total					$168,968,000	$106,166,411	

a. Costs are listed as reported in the 2006 WRMP through 2016. Projects scheduled after 2016 are not included in the total.

b. Proposed to be Funded by Sewer Hook-up Revolving Fund.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 2-3 summarizes the status of the water and wastewater projects. The table indicates the progress made in implementing the recommended water and wastewater projects since the completion of the 2006 WRMP.

Table 2-3. 2006 WRMP Projects Summary

Status	Water		Wastewater	
	Number of Projects	Percent of Total Projects [a]	Number of Projects	Percent of Total Projects [a]
Complete	5	26.5%	14	30%
Ongoing	8	42%	19	40%
Not Started	1	5%	7	15%
Not Necessary	5	26.5%	7	15%
Not Scheduled	5	--	0	--
Total	24	100%	47	100%

a. Percent based only on scheduled projects

As shown in the table, approximately 26 percent of the scheduled water system and 30 percent of the wastewater system projects have been completed. An additional 42 percent of the projects for the water system and 40 percent for the wastewater system are ongoing. Therefore, nearly 70 percent of the projects planned for the water and wastewater systems in 2006 are in progress or complete.

Table 2-4 compares the 2006 WRMP progress based on the planned budgets and the amount spent. The budgeted amount for the water system does not include the projected costs for GWUDI compliance since this was determined to be unnecessary. To compare the budgeted amount to the actual amount spent, costs from the 2006 WRMP were escalated using the Consumer Price Index for Guam to real dollars for the respective year. The comparison in Table 2-4 is based on budget in actual dollars in the year the project was completed.

Table 2-4. 2006 WRMP Capital Summary

Item	Water System Summary	Wastewater System Summary	Totals
Budgeted – Total	$553,535,000	$344,078,000	$897,613,000
Budgeted through 2016	$257,035,000	$168,968,000	$426,003,000
Budget in Actual dollars to 2016	$291,416,000	$197,975,000	$489,391,000
Spent through 2016	$93,018,120	$105,766,411	$198,784,531
Percent Spent (2016)	32%	53%	41%

As shown in the table, approximately 32 percent of the planned funding levels for the water system and 53 percent for the wastewater system CIP have been reached. Between 2006 and 2016, GWA has utilized 41 percent of the projected funding planned in the 2006 WRMP.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Figure 2-1 shows the total amount spent by GWA from 2007 through 2016 on CIP for the entire organization. These costs include some large items such as the meter replacement programs that were unexpected and therefore not planned for in the 2006 WRMP. These costs are not included in Table 2-4 because there was no project assigned to the work. The meter replacement and meter automation projects accounted for nearly $41 million in total costs. The figure shows the initial slow pace of CIP implementation following acceptance of the 2006 WRMP. CIP work began to increase in 2012 with emphasis on the court ordered projects.

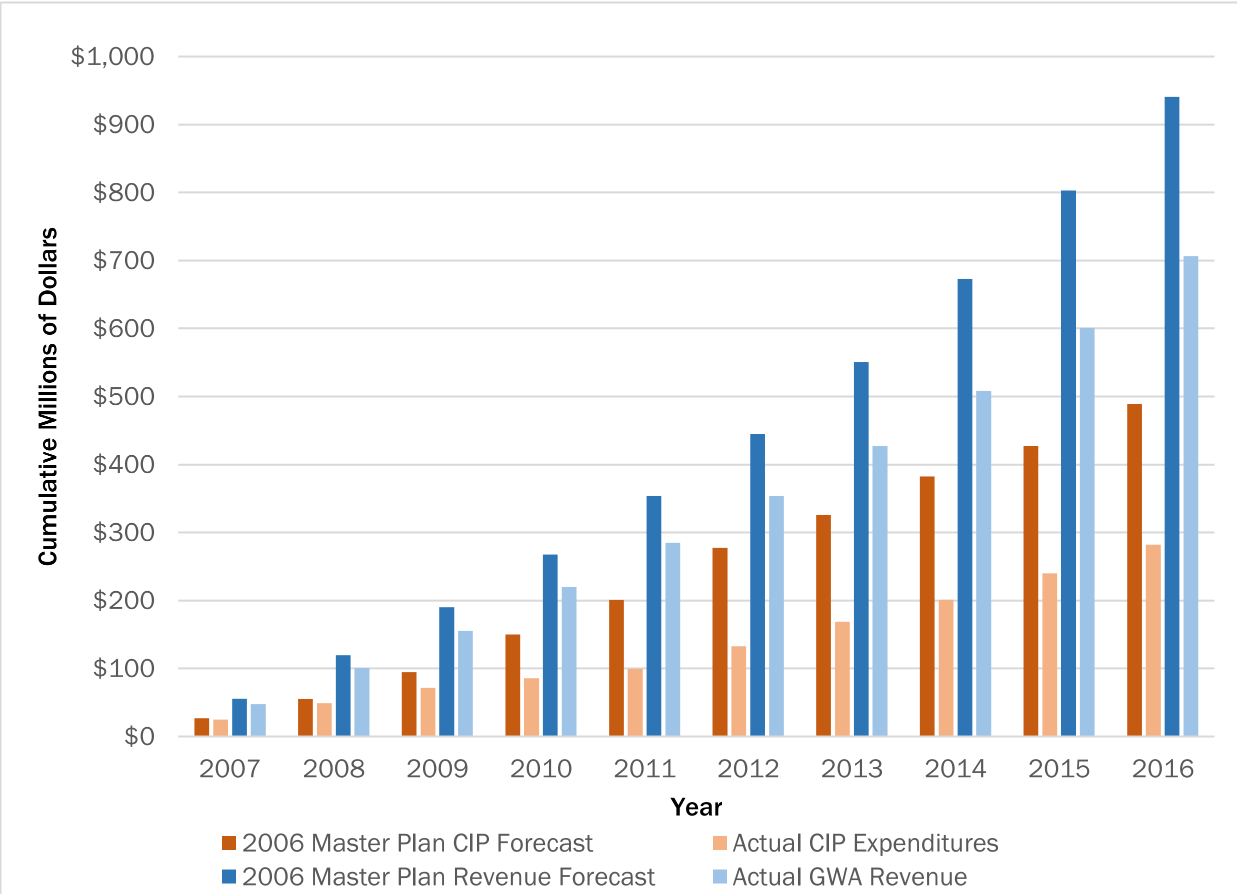


Figure 2-1. Cumulative CIP Expenditures Versus 2006 Projections

Figure 2-1 also shows the revenue projected to be necessary in the 2006 WRMP to achieve the proposed CIP and the actual GWA revenue for the same period. As the figure shows, the actual revenue has lagged with respect to the forecast revenue through the entire period. In general, the actual revenue has lagged the forecast revenue by approximately 2 years.

Based on this analysis, GWA was not able to keep pace with the initial projections of the 2006 WRMP with respect to revenue forecast or CIP expenditures. GWA could not match the aggressive increase in CIP and corresponding revenue planned between 2007 and 2012. The planned CIP exceeded the actual GWA revenue in 2012. However, since 2011 GWA has more than doubled CIP spending and is approaching the proposed CIP spending forecast in the 2006 WRMP.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 3
Levels of Service

As an essential provider of vital services to the island, it is important for GWA to understand and be able to communicate the LOS they intend to provide to their various customers and stakeholders. As part of the master planning effort, BC proposed formalizing existing and developing new GWA LOS. By defining LOS goals for the utility, GWA sets the mark for operational and capital improvement efforts aimed at enhancing services.

3.1 LOS Fundamentals

LOS are the fundamental output that a utility like GWA intends to consistently provide customers or other stakeholders while conducting business. They include the actual services provided in supplying drinking water and collecting and treating wastewater such as system pressure, service request response time, and billing accuracy. LOS may also include regulatory requirements, other customer expectations, contractor or service provider expectations, etc. LOS can be almost anything that the utility is willing to take on as a service. Because many decisions are informed by the definition of LOS, it is important that they be defined in a SMART fashion (specific, measurable, achievable, responsive, and time-bound).

While LOS can be any service, it is essential that in considering what is "achievable" the GWA considers the costs its customers are willing to assume for any particular service. Customers may want a number of different services and efforts from their utilities, and this is often expressed in public meetings. However, a LOS is not achievable if there is not a means for the utility to fund the effort. Taking on services without a funding source often leads to shortchanging other services customers are buying and expecting.

Establishing LOS is critical to the master planning effort as it sets performance goals for envisioned system improvements. By understanding the utility's chosen LOS, CIP projects can be developed to assure that the infrastructure improvements are appropriate. For example, GWA has identified water system pressure as a LOS for the water distribution system. Understanding that LOS allows the master planning effort to develop projects that will assure that the current system pressure meets the desired system pressure under various conditions. Considering LOS in the planning effort helps to assure that an optimal CIP is created. It is understood that attaining the desired LOS solely through capital improvements may not be cost-effective or practical. Adjustments in O&M strategies are often part of the solution to achieving desired LOS. For example, building a sewage collection system that will never have a spill is prohibitively expensive and unrealistic. To achieve the desired LOS with respect to system spills, a properly designed system coupled with proper O&M efforts in system cleaning and inspection is necessary.

The development of LOS by a utility is also important beyond the master planning effort. Additional benefits include:

- **Establishing priorities:** well-crafted LOS help inform utility staff and stakeholders about priorities that guide decisions.
- **Asset management risk development:** in asset management, a fundamental consideration is identifying the critical assets. LOS help define those assets that are critical to service delivery.
- **Continuous improvement:** provides the parameters for a good utility scorecard.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

3.2 LOS Development

LOS development was done by engaging a cross section of the GWA management team in two workshops during the week of April 4, 2016. The following elements of LOS were developed during the workshops:

- Identification of internal and external customers
- Definition of service measures
- Identification of current service levels
- Definition of current LOS
- Definition of internal suppliers of service
- Definition of performance measures
- Definition of quantitative measures

3.3 Customer Groups

As mentioned above, customers' expectations form the basis for the LOS provided by a highly functioning utility. Customers value services differently depending on their personal perspective and needs. For the purposes of developing LOS, GWA serves two major customer groups: rate-paying customers, and stakeholder groups that may or may not be ratepayers, but more importantly, play a role in dictating or influencing performance of the utility. Rate-paying customers include residential, commercial, and government agencies including the U.S. DoD. Stakeholder groups include the fire department, developer community, tourism industry, the islands' various villages, and regulatory agencies. Because of Guam's unique island situation, most stakeholder groups are also ratepayers, but have broader expectations in line with their various interests.

3.3.1 Rate-Paying Customers

GWA's rate-paying customer base includes approximately 47,500 residential, commercial, and government accounts for water services and 30,000 for wastewater services. Guam's population in 2015 was approximately 165,000, including the current military census at the various DoD installations on the island. Over the next ten years, the service population is expected to increase by approximately 26,000 people as discussed in Section 4 due to increases in military presence on the island and their associated additional dependents. The overall population of the island is expected to exceed 190,000 by 2025. Additionally, Guam has a significant tourism industry that is expected to exceed 2,000,000 international visitors annually by 2020.

The DoD represents a special customer group that is expected to transition in the coming years. Presently, the DoD is both a supplier of water to GWA and a customer at some locations. Part of the OneGuam initiative includes the goal of moving the operations of various water and wastewater assets to GWA to increase its role as a service provider to the DoD. This effort is in its preliminary stage, with the operation of one of the DoD-owned wells currently being assumed by GWA under a renewable license agreement and a memorandum of understanding. As the OneGuam effort continues and is proven successful, additional facilities are expected to transition to GWA operations.

3.3.2 Stakeholder Groups

Various stakeholder groups involved with GWA impact LOS decisions, or are impacted by services provided. These groups include federal and territorial regulatory agencies, GFD, village leaders, and real estate developers. Except for the USEPA, all of the mentioned groups reside on Guam and are also comprised of rate-payers.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The regulatory agencies routinely have taken note of specific performance areas in water and wastewater services provided by GWA within the context of environmental and public health regulations. The current Court Order issued by USEPA and the Department of Justice is the most recent example of this focus. As the Court Order continues to be satisfied and other discussions regarding wastewater compliance occur, there will be a federal and territorial emphasis on certain performance levels. With respect to the drinking water system, GWA has also received a "NEIC Findings of Significant Deficiencies in the Potable Water System" report from USEPA, which pointed out several LOS issues related to the water system. GWA is much attuned to these desired performance levels and is including regulatory expectations in the plans as a service provider.

The GFD relies heavily on GWA for proper water pressures and firefighting volumes. GWA has engaged GFD to better understand their needs in terms of service levels. Because upgrading the water distribution system on the island will take time, the department has been asked for input on the prioritization of water system improvements for fire protection. GFD is moving from the 2009 International Fire Code (IFC) to adopting the 2015 IFC as their code requirements. The adoption of the 2015 code will not alter the flow or pressure requirements from its predecessor.

3.3.3 Internal Customers and Providers

As with any water utility, there are a number of internal customer relationships that have a significant impact on the overall organizational performance, and on the services they provide to external customers. Internal customers specific to GWA, along with their service responsibilities or relationships, are shown in Figure 3-1. While all organizational functions have internal customer service responsibilities to others at GWA, the primary internal providers are Procurement, Finance, Human Resources, Legal, and Information Technology. These groups provide services to virtually all other departments. Areas that are primarily internal customers include Water and Wastewater Operations and Customer Service, which are outwardly focused but require the services of other departments to be effective. Finally, there are some groups that are both internal service providers and recipients of service by others such as Engineering and Permitting, Facility and Fleet Maintenance, and Compliance and Safety. As shown in Figure 3-1, these functions are at the center of the organization, accepting services from others and providing services to the outward-facing divisions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

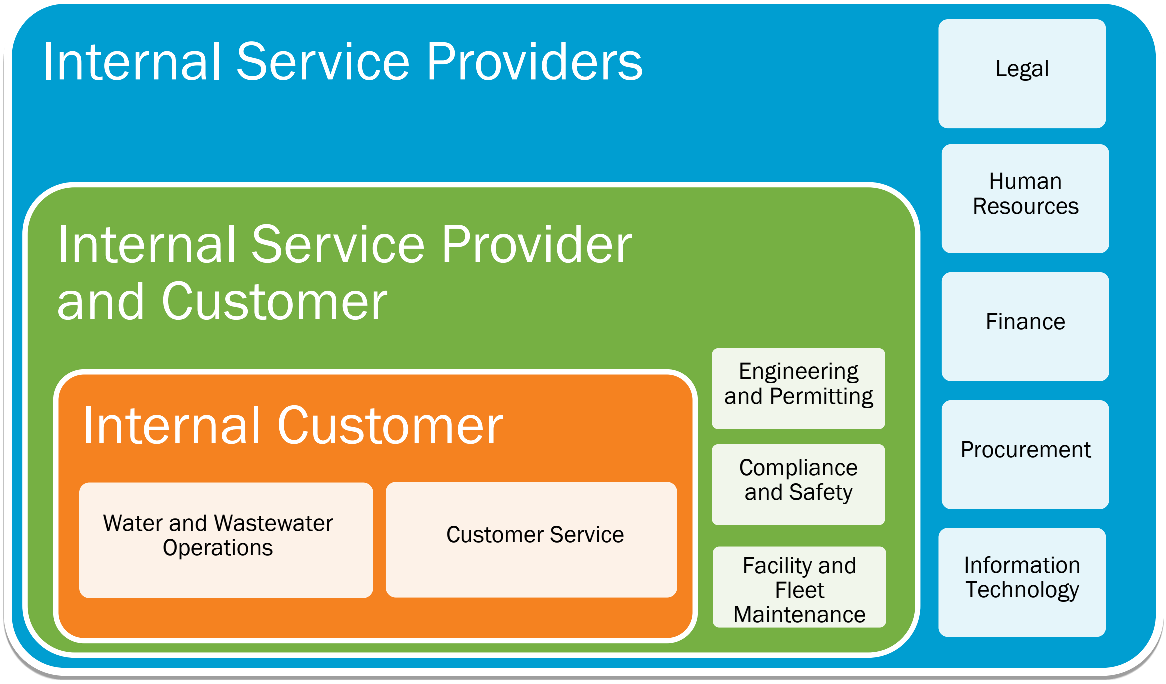


Figure 3-1. Internal Customers

3.4 LOS Development

In performing research for the development of the GWA LOS, BC engaged the GM in a discussion of the utility's present strategic direction. LOS is strategic by definition, making this information critical to the workshop process discussed below. The strategic goals identified include the following:

- GWA will continue its transition into a strong, well-organized, well-run utility.
- GWA will be a leaner organization focused on and constantly refining its core functions and strengthening critical supporting functions.
- GWA will emerge from regulatory enforcement-dominated operations, and achieve and maintain full regulatory compliance voluntarily.
- GWA will gain public confidence and trust, and deserve a reputation for reliability.
- GWA customers will experience the best customer service in government.
- GWA employees will appreciate themselves as excellent stewards of Guam's water resources, and protectors of the public's health and safety.

These organizational goals provided the basis for the LOS workshops conducted with the GWA management team. As evidenced by the stated goals, GWA continues to focus on the improvement of consistently delivering its base services island-wide.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Over the course of two 4-hour work sessions, the GWA management team developed LOS for the utility covering four areas of performance:

- Mission Accomplishment
- Customer Service
- Financial
- Employee

These four categories are well-established, balance scorecard emphasis areas used to define LOS as well as other performance measures. Over 30 candidate LOS were initially developed by the team, and these potential LOS areas were further refined into 16 strategic LOS with the balance identified as key performance indicators (KPI).

Strategic LOS are the fundamental services that GWA provides its customer groups, tied to the organizations strategic direction. They serve to guide the entire utility forward, defining for the internal and external customer groups what will be provided by GWA. KPIs are metrics that tend to be more specific to areas of the utility departments. While KPIs are not considered as overarching as the LOS, they will provide important information regarding the performance of the utility. KPIs are discussed further in Section 3.5.3. Together the LOS and KPIs will provide insight to a program of continuous improvement for GWA.

3.4.1 Strategic LOS

Strategic LOS developed from the work sessions are shown in Table 3-1, including measures, represented types of service, current and targeted numeric performance levels, and the utility group leading the service effort. For some LOS, a short-term target and a long-term target are provided. For example, the utility's effort in reducing spills from the wastewater collection system is yielding improved results. However, significant numbers of spills continue due to system inadequacies that require capital improvements. The short-term goal is an effort to continue to improve through the O&M efforts of cleaning and maintaining the sewer system. The longer-term targets reflect the overall LOS target envisioned by GWA.

As part of the LOS workshop, the group explored appropriate service levels and how they were currently measured. In one case, a LOS (employee job satisfaction) was not being measured. GWA management is currently considering an approach to measuring employee satisfaction through a periodic survey.

Table 3-1. GWA LOS

LOS #	LOS	Measure	Type	Estimated Current [a]	Target	Frequency	Lead Group
1	Drinking water quality	Compliance with Drinking Water Quality Standards	Mission	~100%	0 violations	Monthly	Water Operations
2	Reliability of water supply	Unplanned water service outages each year	Customer	90 events	70 events	Monthly	Water Operations
3	Wastewater effluent discharges	Compliance with USEPA Requirements for Wastewater Effluent Discharges from Treatment Plants during non-storm periods	Mission	75%	0 violations	Monthly	Wastewater Operations

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 3-1. GWA LOS

LOS #	LOS	Measure	Type	Estimated Current [a]	Target	Frequency	Lead Group
4	Wastewater system spills	Number of spills/100 system miles/year from Wastewater System Short-term LOS Long-term LOS	Mission	51 spills/100 miles/year	38 spills/100 miles/year [b] < 4 spills/100 miles/year	Monthly	Wastewater Operations
5	Ensure financial capacity to meet operational needs	User fee collection rate	Financial	96%	99%	Monthly	Finance
6	Ensure financial capacity to meet operational needs	Days receivable outstanding (average days needed to collect user fees)	Financial	60	30	Monthly	Finance
7	Improve customer wait times to register issues/concerns at GWA offices (CS only)	Wait time (minutes)	Customer	11 min.	8 min.	Weekly	Customer Service
8	Adequate pressure exists in the distribution system	System Pressure	Mission	<20 psi > 90 psi In places	35 psi – 90psi 20 psi during fire flow	Monthly	Water Operations
9	CIP execution schedule	CIP project expenditures encumbered per CIP plan	Mission	~70%	80%	Monthly	Engineering
10	Ensure a safe work environment	Lost time accidents	Employee	3 (2016)	0	Annually	Compliance
11	Customer complaint response	% of time that customer response is within 8 hours	Customer	17%	75%	Quarterly	Water and Wastewater Operations
12	Distribution system integrity	% of water produced that is lost Short-term LOS Long-term LOS	Mission	52%	40% [b] 20%	Quarterly	Water Operations
13	Critical asset reliability (WTPs and WWTPs, pump stations, wells)	% of time production requirements are met	Mission	60%	100%	Monthly	Water and Wastewater Operations
14	Septic tank elimination (sewer hook-up program)	Annual expansion of the sewer system near the aquifer	Customer	0	5,000 feet/year	Annually	Engineering
15	Integration of GWA/DoD OneGuam	Number of GWA facilities inter-operable with DoD	Customer	3	Approximately 10	Annually	GM
16	Employee satisfaction/pride	Satisfaction survey (to be developed)	Employee	TBD	TBD	Survey frequency	TBD

a. The "Estimated Current" LOS values were provided by GWA staff in the workshop based on their best judgement of their current level of performance.

b. Short-term LOS was considered appropriate for initial performance in the first year.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

3.4.2 Prior LOS Determinations

In 2006, GWA developed LOS criteria as part of the previous master planning effort. At that time, GWA was a much different utility with considerable challenges and different leadership. The outcome of the 2006 LOS work was a set of four parameters, which have been retained in the WRMPU and are shown as the first four LOS measures in Table 3-1. These parameters are fundamental services routinely provided by water and wastewater utilities that remain relevant in GWA's 2016 master planning effort. The criteria used to develop the original LOS were limited to regulatory requirements of the WTPs and WWTPs, and severe service issues related to water service interruptions and sewage spills. They can be viewed as minimal LOS in most of today's U.S. water utilities, but remain important in GWA's current regulatory enforcement environment.

The 2016 LOS criteria in Table 3-1 and the KPI criteria which follow in Table 3-2 are clear indications of how far GWA has come in the past ten years. The GWA management team is now focusing on far more than the minimum LOS that it targeted in 2006. Significant additions include a more pronounced attention to customer-oriented LOS including customer wait times, field service request response times, septic tank elimination, and integration with the OneGuam Initiative. The introduction of additional mission-related measures further expands the 2016 LOS with the inclusion of distribution system pressure, asset reliability, and delivery of the CIP, as well as the LOS related to GWA employees' safety and employment satisfaction.

3.4.3 Key Performance Indicators

Whereas the original LOS work developed a shortlist of LOS measures, this planning effort also included a set of 22 KPIs that serve as additional criteria aimed at utility performance improvement. These are summarized in Table 3-2. KPIs tend to be more granular than LOS, providing a deeper immersion into the performance of various aspects of the utility. Measuring these parameters is useful in driving improvements that facilitate meeting LOS. For example, in the following table, the time required to fill internal vacancies is a KPI that provides insight into the effort to keep appropriate staffing levels. At a more granular level, the effort to fill vacancies is important, but does not rise to a LOS. Instead, it is measured at the KPI level to assure that improvements in this area continue to move forward.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 3-2. GWA KPIs

KPI #	Performance Area	Measure	Type	Estimated Current [a]	Target	Frequency	Lead Group
1	Maintain appropriate levels of consumable supplies	Percent of work orders held for lack of parts	Mission	TBD	<5%	Monthly	Procurement/ Warehouse
2	Expeditiously recruit for vacancies	Time required to fill vacancies following notice	Mission	3–4 months	6 weeks	Quarterly	Human Resources
3	Improve technology for customer service	Percentage of customers using online services	Customer	TBD	>25%	Annually	Information Technology
4	Adequate storage exists in the distribution system	Volume of storage	Mission	<0.5 day	See Volume 2 for storage targets	Annually	Water Operations
5	Source control supports reliable system operations	Number of source control inspections/outreach Short-term goal Long-term goal	Mission	60/year	150/year [b] 300/year	Quarterly	Compliance
6	Timely permitting	Approver's first review of permit applications completed	Customer	2 weeks	7 working days	Monthly	Engineering
7	Reliable pump station operation	Percentage of n+1 redundancy	Customer	~60%	100%	Monthly	Water Operations
8	Fleet equipment availability	Percentage of time equipment type is available	Mission	~60%	90%	Monthly	Water Operations
9	Safety/O&M Procedures	Proficiency measured in safety and work practice audits	Mission	Not measured	>85%	Monthly	Compliance and Safety
10	Critical asset reliability	Percentage of preventive maintenance versus corrective	Mission	0%/100%	50%/50%	Monthly	Water and Wastewater Operations
11	Illicit discharge of stormwater to wastewater system	Inspections per year	Mission	0	100	Quarterly	Compliance
12	Sewer system maintenance and CCTV	Percentage of total system length cleaned and inspected per year	Mission	~16%	20%	Monthly	Wastewater Operations
13	Cross connection control plan	Inspections per year	Customer	0	100	Quarterly	Compliance
14	Prompt procurement of materials and supplies	Percentage of open quote converted to purchase orders in 30 days	Mission	30%	80%	Quarterly	Procurement
15	Maintain budgeted staffing at all times	Percentage of authorized FTEs filled	Mission	88%	95%	Monthly	Human Resources
16	Prompt vendor payment	Average days for invoice payment	Customer	60	45	Monthly	Finance
17	Reliable water well operations	Time to failure of pump/motors	Mission	1.5 years	5 years	Annually	Water Operations
18	Reliable water well operations	Percent up time	Mission	88%	95%	Monthly	Water Operations

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 3-2. GWA KPIs							
KPI #	Performance Area	Measure	Type	Estimated Current [a]	Target	Frequency	Lead Group
19	Accuracy of residential, commercial, and production water meters	Number of meters tested per year	Customer	1%	5%	Quarterly	Water Operations
20	Fire flow	Percentage of new water distribution system piping that satisfies adopted fire flow requirements	Mission	Note: pertains to new system improvements only	80%	Annually	Engineering
21	Manage, maintain, and support information technology infrastructure to meet organizational needs	Internal Customers feedback through analysis of work tickets	Mission	80%	90%	Monthly	Information Technology
22	Protect and prevent GWA information technology assets from cyber security attacks	Number of recorded incidences	Mission	99.9%	99.9%	Monthly	Information Technology

a. The "Estimated Current" KPI values were provided by GWA staff in the workshop based on their best judgement of their current performance.

b. Short-term KPI was considered appropriate for initial performance in the first year.

TBD = to be determined by GWA staff

FTE = full-time equivalent

3.5 Using LOS and KPIs for Continuous Improvement

As mentioned in Section 3.1, LOS is key to the master planning effort to assure that the infrastructure improvements identified will meet GWA's service goals. Additionally, the LOS and KPIs are essential parts of a continuous improvement process commonly used by utilities. By measuring current utility performance with these parameters, GWA can assess how its efforts are improving overall operations.

3.5.1 Measurement of Utility Performance

The first step in using LOS and KPI for performance improvement is the actual measurement method. Defining the measurement and consistently applying that definition to the measurement of results is important to create a meaningful trend and analysis. The LOS and KPIs provided above are associated with a suggested measurement frequency that provides value in driving the utility. Measurement frequency is based upon how rapidly the measured parameter can change, and thus it allows for corrections if trends are not as desired. For example, measuring the time to failure of well pump motors will not change rapidly, requiring some time to realize enough failures to draw reliability conclusions. Measuring this parameter is likely an annual frequency. On the other hand, the regulatory performance of the WTPs and WWTPs is performed monthly to satisfy regulatory requirements. Except for upset conditions in these facilities, the monthly frequency is appropriate for this parameter in most utilities. If violations are occurring, the frequency of attention is escalated until the problem is resolved.

The level of effort required to collect the data associated with LOS and KPIs is an important consideration in performance measurement. If the utility expends more energy collecting data than its worth, the program is too aggressive. By the same token, the frequency should be rapid enough to allow for corrections to achieve desired goals. For example, it is very difficult to address a low performance in an annual goal that is only measured once per year.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

To assure that performance metrics are available to the management team, it is essential that thought be given to the specifics of collecting the data described in Tables 3-1 and 3-2. The collection, collation, and dissemination of the data as information does not happen without effort. It is important that clear lines of responsibility are developed so that the organization understands why the data is important, how it will be used to make improvements in the utility's performance, and who is responsible for the improvements.

In cases where staff will manually collect data to be used in metrics, it is important to emphasize consistent, accurate reporting. Training in the specifics of the metric, how it is calculated, and what is included, will help in keeping the data quality high and help address staff reluctance in reporting negative results.

Adopting a balanced approach on what happens when the data reveals challenges is important to avoid selective sampling of data that might be of concern. There will always be a reluctance to provide measurement data that shows subpar performance. To the extent possible, it is best to avoid the impression that the information will be used in a punitive manner.

3.5.2 Process Improvement

It is suggested that GWA use information arising from the LOS and KPI measurement data in a proactive and transparent fashion. By returning the measurement information to the various working groups within the utility, two things happen: the people that have the greatest ability to make improvements understand the situation directly and can make adjustments to improve performance.

Staff training on the implementation of LOS and KPI metrics is an important part of the process. At a minimum, this should inform the staff and management team of what is being measured, why it is important, and how it will be used by GWA to improve service. This helps the measurement process improve over time and increases the likelihood that measurement will continue and not be forgotten. There is not a need for all employees to understand each measurement because it is sufficient that they understand the metrics for their part of utility operations and how their job impacts the desired outcomes.

Management has the role of seeking to understand the performance information and making adjustments as necessary to improve performance. The adoption of a "plan – do – check – act" approach to their various services will allow them to continuously improve. In this approach, with LOS and KPI measurements in place, the utility can plan and execute improvements based on how work is accomplished. Then the measures become the way the effect of the plans are seen and understood. If improvement occurs as expected, continue to repeat the same action until the goal is reached. If the results are below expectations, then actions can be revised again to strive for improved performance.

Continued focus on measuring a short list of LOS and KPI will lead to continued improvement with the proper emphasis by management. The measurements provide the trajectory of improvement over time that will indicate that the services are moving in the right direction and will help quantify services that can be somewhat intangible to the public.

3.5.3 Initial Measures for Improved Performance

In the work sessions, the GWA management team differentiated the actual LOS from KPIs by considering which measures had strategic significance and described which internal and external services were critical to success. As described above, the LOS tended to be at a higher level and thus are considered starting points in the process of truly understanding what needs to happen to assure that services are delivered. It is suggested that if choices need to be made, starting with the LOS measurement is the best approach in prioritizing these efforts.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

To avoid measurement overload, many utilities try and take a commonsense approach in deciding what to tackle as a portfolio of KPIs. Table 3-3 provides a subset of the KPIs developed in the workshop and that are suggested for GWA's attention in the short term. This provides a suggested first cut of important KPIs and the rationale when considering the complete list provided in Table 3-2.

Table 3-3. Initial High-Value Measures

Performance Area	Measure	Type	Frequency	Reason
Expeditiously recruit for vacancies	Time required to fill vacancies following notice	Mission	Quarterly	People are critical to providing service and executing GWA's mission
Source control supports reliable system operations	Number of source control inspections/outreach	Mission	Quarterly	Sanitary sewer regulatory issues related to overflows
Critical asset reliability	Percentage of preventive maintenance versus corrective	Mission	Monthly	Strengthen the mechanical and electrical reliability of the assets
Prompt procurement of materials and supplies	Percentage of open quote converted to purchase orders in 30 days	Mission	Quarterly	Long supply chain timeframe makes expediting spare parts essential
Prompt vendor payment	Average days for invoice payment	Customer	Monthly	Prompt vendor payments are important to assuring supply chain
Reliable water well operations	Percentage of up time	Mission	Monthly	Water supply reliability
Reliable pump station operation	Percentage of n+1 redundancy	Customer	Quarterly	Regulatory and customer-related service improvement
Maintain appropriate levels of consumable supplies	Percentage of work orders held for lack of parts	Mission	Monthly	Supply availability is critical to equipment reliability
Sewer system maintenance and CCTV	Percentage of required cleaning and inspection completed	Mission	Monthly	Sanitary sewer regulatory issues related to overflows

3.5.4 Continuous Reporting

Figure 3-2 illustrates the steps to create a continuous metric reporting approach. Improving GWA infrastructure and satisfying LOS will depend on the continued diligence of utility staff, and it will be important that the delivery of calculated metrics be consistent and timely. It is recommended that the responsibility for each metric's accurate and timely delivery be assigned to appropriate management personnel. To assure that the metrics are consistently measured and reported, definitions of each metric are created and adhered to. A Report Manager assignment is an approach used frequently to assure that the overall metric report is created for management review in the proper schedule.

The LOS and KPI measures described above should be reviewed no less than every year. As performance improves to meet target values, the GWA management team should consider if additional LOS or increasing existing LOS targets is appropriate to meet the needs of the island.

The measures shown in Tables 3-1 and 3-3 should be considered to be the minimum measures for GWA's current situation. The list of Initial High-Value Measures is not intended to be an unchanged, static list, but rather serves as a starting point. The periodic review mentioned above is the time to consider different or additional measures and different target goals. After starting a measurement approach, GWA may realize that, although the measure makes sense, it creates unintended and undesirable consequences. For example, the goal of having stock on hand is important given the supply chain challenges found on Guam. The quest for a high percentage of available stock can

Use of contents on this sheet is subject to the limitations specified at the end of this document.

create the unintended consequence of buying more than necessary and tying up dollars in stock that does not turn frequently. During the annual review, the GWA management team has the opportunity to fine tune the metrics to yield good results.

Finally, the use of LOS and KPI measures are only worthwhile if they can help achieve GWA's goals. Part of the annual review process should include assessing whether the measures are helping to complete the operational picture and drive performance. If a measure does not help as intended, it should either be refined for greater impact or discarded in favor of an alternative. The number of measures used is not as important as finding the right way to measure utility performance in ways that address LOS and are easily understood by stakeholders and staff.

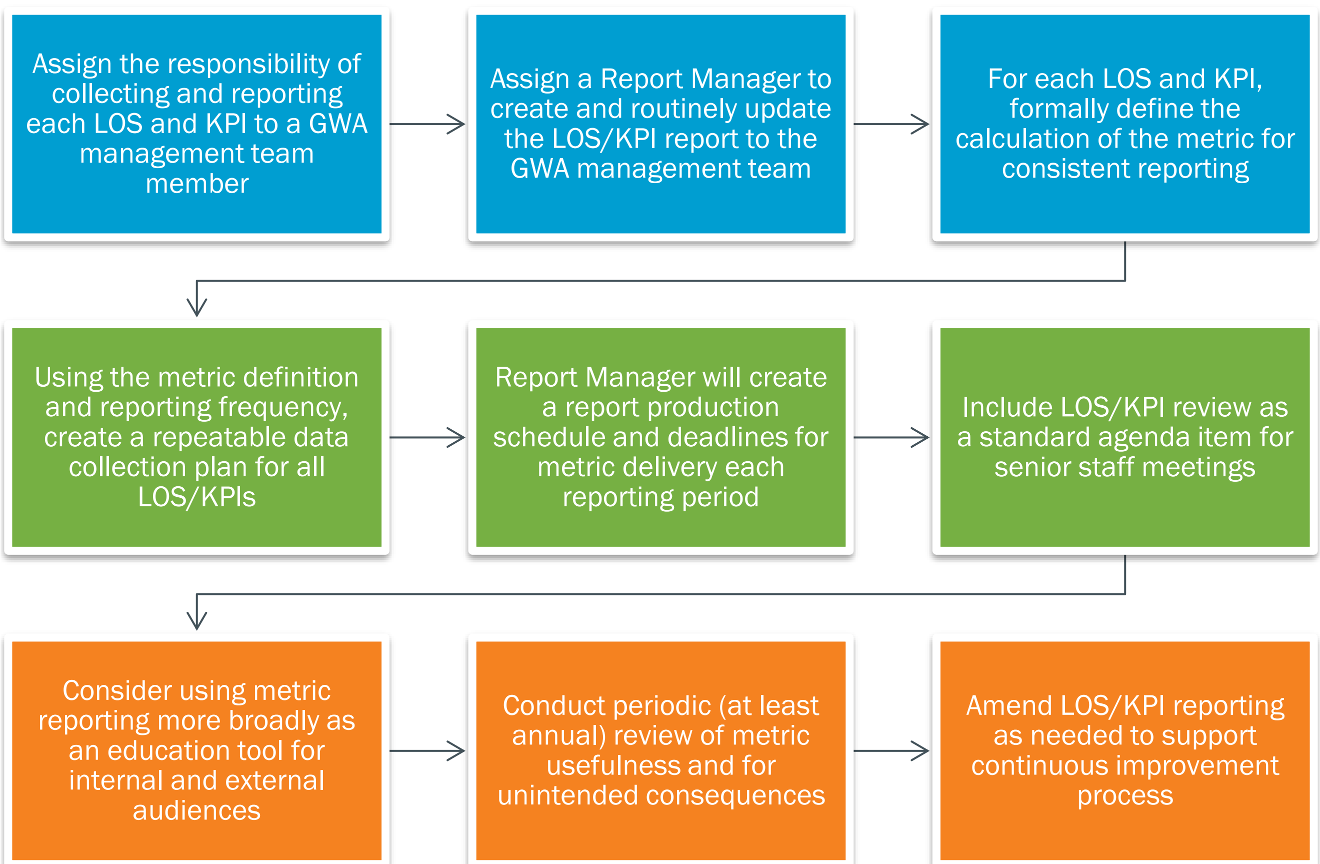


Figure 3-2. LOS/KPI Metric Reporting Methodology

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 4

2016 Guam Population and Water Demand Projections

To ensure water and wastewater infrastructure can meet the needs of Guam into the future, an updated analysis of population was undertaken as part of the master planning process. Projections of population are necessary to estimate the water consumption (and corresponding supply, transmission, and distribution requirements) and wastewater generation (and corresponding collection, treatment, and disposal needs) presented in Volumes 2 and 3.

Guam is a small isolated island territory, positioned in a location of strategic military importance and in a climate favorable for tourism. The influence of geography and economy on Guam also affects population unlike anywhere else in the United States. Planning for the future on Guam requires a consideration of the combination of all of these factors.

Population change depends on three components: fertility, mortality, and net migration. Net migration is the most challenging of these to predict for Guam, and depends on many factors external to GWA. This section begins with an economic overview, including Guam's unique labor market conditions and the impact of major economic drivers on population. The section also discusses population patterns, labor market conditions, and a summary of projections by municipality through the year 2050.

4.1 Economy

The following section provides an overview of Guam's economic drivers and performance, and the major economic sectors that impact the island's population.

4.1.1 Overview

U.S. national defense and other federal expenditures are the main drivers of Guam's economy, followed by territorial spending, tourism, and private sector construction. In 2014, total federal spending (defense and non-defense) amounted to $1.97 billion, or 35.6 percent of gross domestic product (GDP). Service exports were $940 million (17.0 percent of GDP). The value of building permits and DoD construction contracts totaled nearly $691 million (BEA, News 2015).

Despite slow growth, Guam's economy has been stable. From 2002 to 2013, real GDP experienced an average annual growth rate of 1.4 percent. The growth rate for the United States as a whole over the same period was 1.8 percent.

Guam's economic performance is closely tied to overseas markets, especially to Japan and to a lesser extent Korea, with both markets affecting tourism and foreign investment. Economic performance is also influenced significantly by occurrences of natural and manmade disasters (e.g., typhoons, earthquakes, disease, and airline transportation issues). Since 2006, the proposed relocation of military personnel from Okinawa, Japan to Guam has been expected to have a major economic impact on the local economy. All of these factors are largely outside of the control of local economic planners and policymakers, leaving the territorial economy exposed to subsequent instabilities.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

2010 Census data shows that 73 percent of those working on Guam were employed in three adjoining urban districts: Hagåtña, Dededo, and Tamuning. Employment statistics released by the Guam Department of Labor for September 2015 indicate that the public sector accounts for 25 percent of all non-military jobs in the territory. Other industries are tabulated in Table 4-1. (Bureau of Labor Statistics 2015).

Table 4-1. Employees by Industry (September 2015)

Sector	Number of Employees	Percent of Total
Private Sector		
Agriculture	270	0.4%
Construction	6,800	10.7%
Manufacturing	1,610	2.5%
Transportation and public utilities	4,530	7.1%
Wholesale trade	2,480	3.9%
Retail trade	11,430	18.0%
Finance, insurance, and real estate	2,450	3.9%
Services – hotels and lodging	6,330	10.0%
Services – other	11,490	18.1%
Private Sector Subtotal	**47,390**	**74.7%**
Public Sector		
Federal government	4,030	6.4%
Government of Guam	12,040	19.0%
Public Sector Subtotal	**16,070**	**25.3%**
Total Employment	**63,460**	**100.0%**

Sum of components may not equal total due to rounding.

4.1.2 Impact of Major Economic Sectors on Population

The major economic sectors that will affect Guam's future population include the military buildup, tourism, and construction.

Military Buildup

On August 29, 2015, the Navy released the Record of Decision (ROD) for the relocation of U.S. Marine Corps forces to Guam from Okinawa, Japan. The Navy selected the preferred alternative as identified in the 2015 Final Supplemental Environmental Impact Statement (SEIS), consisting of a cantonment at Naval Computer and Telecommunications Station Finegayan, family housing at Andersen AFB (Alternative E in the 2015 Final SEIS), and a live-fire training range complex (LFTRC) at Andersen AFB Northwest Field (NWF) (Alternative 5 in the 2015 Final SEIS). Specific details of the military buildup, including impacts and mitigation, are discussed in Section 6.2. Figure 6-1, reprinted from the SEIS, illustrates the locations of the expected development.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

In 2014, active duty military personnel numbered 6,006 (Guam Statistical Yearbook, Table 8-02). There were an additional 6,648 family members on the island, for a total military population of 12,654, or 7.9 percent of Guam's population. The SEIS indicates that by 2026, an additional 5,000 Marines and 1,300 dependents will arrive, increasing the military population by nearly 50 percent over 2014 levels.

In addition to the increase in active duty military and dependents, Guam's population is expected to fluctuate due to construction activity related to the military buildup and civilian jobs created by buildup activities.

Although current island residents are expected to fill many of the jobs created by the proposed military buildup, the available labor supply on Guam is not sufficient to meet the labor demand. This shortage applies both during the construction period (2015 through 2028) and in the "steady state" period following (2028 and beyond). Civilian labor force demand is expected to increase by a maximum of 7,031 full-time jobs in 2021 (6,150 related to construction and 881 related to operations) and of the 7,031 jobs, 3,058 are estimated to be taken by Guam residents. At steady-state, labor force demand is expected to increase by an additional 1,438 full-time jobs by 2028 (all related to operations) over pre-buildup levels, with 762 of these jobs estimated to be filled by Guam residents.

During the buildup, some foreign H-2B (non-immigrant, temporary U.S. visa) workers are planned to be utilized, and residents of other Pacific islands will likely migrate to Guam for employment opportunities (SEIS, p.4–136). It is assumed that only a limited number of construction workers brought from off-island will bring dependents, and that most of these workers and dependents will leave Guam at the end of the construction period. In contrast, many indirect and induced jobs created will continue into the "steady-state" period, and some of these off-island workers and dependents will make their home permanently on Guam.

Table 4-2 shows population changes related to the proposed military buildup over the period of 2015–2028.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 4-2. Estimated Total Population Increase on Guam from Off-Island Sources

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Direct DoD Population Increase														
Active duty Marine Corps	25	35	35	35	387	2,990	3,319	3,319	4,282	4,282	4,779	5,000	5,000	5,000
Marine Corps dependents	8	11	11	11	118	908	1,008	1,008	1,300	1,300	1,300	1,300	1,300	1,300
Civilian military workers	4	5	38	75	113	150	188	225	263	300	338	338	338	338
Civilian military worker dependents	4	5	35	71	107	143	179	214	249	285	320	320	320	320
Off-island construction workers	161	1,071	2,301	3,227	2,871	2,587	3,175	2,978	2,205	1,350	618	46	0	0
Off-island construction worker dependents	56	343	667	839	660	517	635	596	507	351	179	15	0	0
Direct DoD Subtotal	**258**	**1,470**	**3,087**	**4,258**	**4,256**	**7,295**	**8,504**	**8,340**	**8,806**	**7,868**	**7,534**	**7,019**	**6,958**	**6,958**
Indirect and Induced Population Increase														
Off-island workers for indirect and induced jobs [a]	46	130	271	338	349	455	548	529	462	361	308	257	228	227
Off-island workers for indirect/induced jobs dependents	43	124	260	325	337	441	533	517	453	355	304	255	227	227
Indirect/Induced Subtotal	**89**	**254**	**531**	**663**	**686**	**896**	**1,081**	**1,046**	**915**	**716**	**612**	**512**	**455**	**454**
Total Population	**347**	**1,724**	**3,618**	**4,921**	**4,942**	**8,191**	**9,585**	**9,386**	**9,721**	**8,584**	**8,146**	**7,531**	**7,413**	**7,412**

a. Population figures do not include Guam residents who obtain employment as a result of the military buildup.

Source: NAVFAC, Socioeconomic Impact Assessment Study, December 2014.

The peak population increase of 9,721 persons is projected to occur in 2023, with a steady-state growth of 7,412 persons reached in 2028. Construction work required to implement the proposed military buildup is expected to begin in 2015, peak between 2017 and 2023, and taper off from 2024 until the final year of construction in 2027. This lengthy 13-year construction period will not result in a massive “boomtown” style in-migration and associated sharp decrease in population upon completion of construction.

Two-thirds of the 5,000 active-duty marines will be rotational, living at the Finegayan cantonment in Dededo for 6-month rotations. Marines with dependents (1,667 marines and an estimated 1,300 dependents) will live in Yigo (SEIS, p. ES-17). There will be 535 housing units constructed specifically for Marine Corps families, and 912 family housing units constructed as replacements for existing Andersen AFB housing. The total of up to 1,447 family housing units will be integrated into one large housing pool where all eligible personnel and families will live. The DoD will be constructing utility improvements needed to accommodate the additional housing.

Both temporary and permanent workers are likely to be housed close to their jobs in central and northern Guam. Current options for temporary workers include the Core-Tech International Housing in Dededo, and the large Younex Enterprises development in south Finegayan.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Tourism

Tourism to Guam is influenced by geopolitical and economic factors. Currency fluctuations, recession, and political stability in their country of residence all affect visitors' ability and willingness to travel. Global issues such as disease outbreaks, terrorism, international conflict, and other traveler safety concerns can also have a significant impact on visitor numbers in any given year, as can natural disasters which affect Guam such as typhoons, tsunami, and earthquakes.

Tourism on the island generates $1.4 billion annually, representing 60 percent of annual business revenue. The industry employs over 18,000 island residents, or 31 percent of non-federal employment (Tourism Satellite Account, 2012).

Historic and projected visitor arrivals are presented in Figure 4-1. Data obtained from the Guam Visitors Bureau (GVB) illustrates the up-and-down nature of Guam tourism. Visitor numbers reached an all-time high in fiscal year (FY) 1997 before plummeting by nearly 40 percent in 2003, a year that spanned Typhoon Pongsona, the outbreak of sudden acute respiratory syndrome disease, and the Asian financial crisis. Despite this, and a second correction in 2009, the general trend over the past 30 years has been upward.

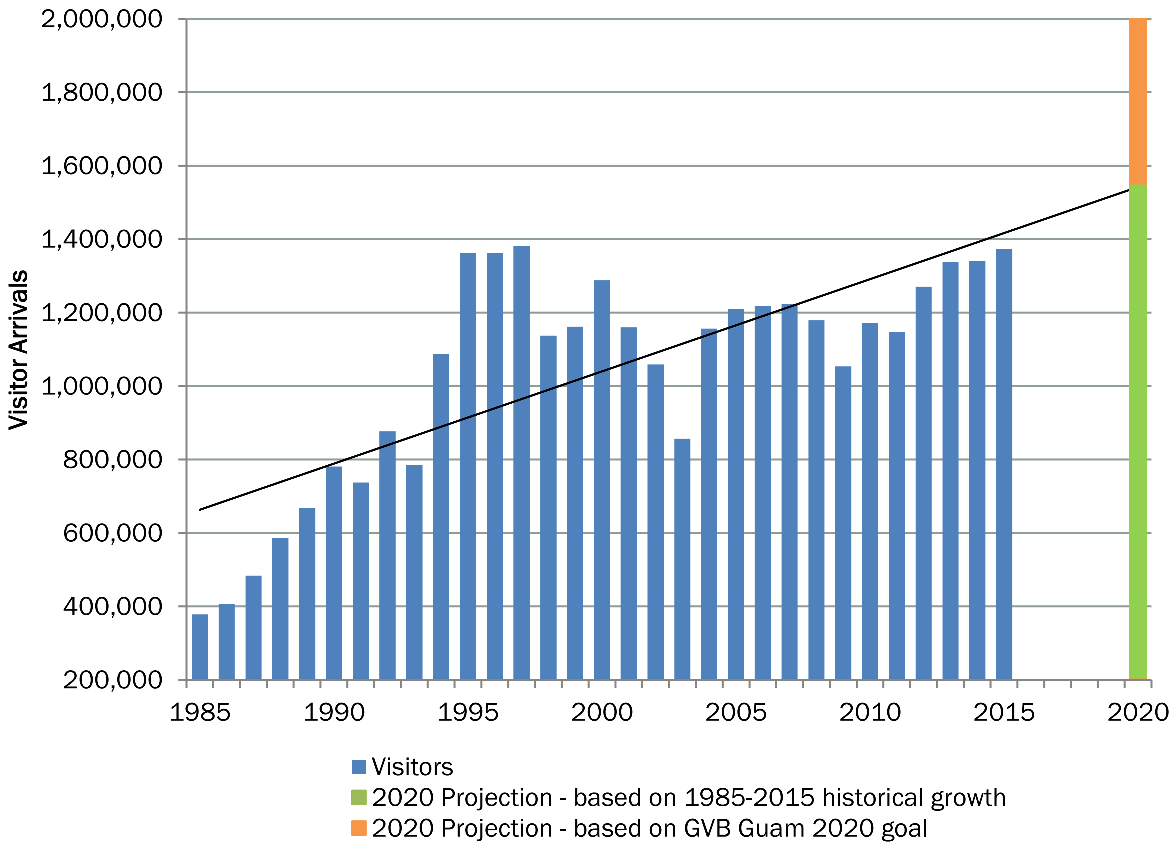


Figure 4-1. Historic and Projected Visitor Arrivals 1985–2020

In 2013, the GVB developed a strategic plan to increase the number of visitor arrivals to 2 million by 2020, and extend the average length of stay for each visitor. As illustrated in Figure 4-1, this goal represents the need to sharply accelerate the relatively gradual annual growth in tourism observed

Use of contents on this sheet is subject to the limitations specified at the end of this document.

between 1985 and 2015. At the current growth rate, annual arrivals to Guam would not reach 2 million until 2040.

Objectives to achieve these "Tourism 2020" targets include efforts to diversify source markets geographically, promote extended stay packages, focus on incentive and business travel, and develop attractions. Incremental annual goals necessary to achieve the targets are presented in Table 4-3.

Table 4-3. Guam Visitors Bureau "Tourism 2020" Annual Goals

Year	Visitor Arrivals [a]	Accommodation				Employment
		Rooms	Guest Nights [b]	Room Nights [c]	Computed Occupancy	
2013	1,337,665	8,443	3,979,553	2,094,502	67.9%	20,436
2014	1,400,000	8,451	4,165,000	2,192,105	71.1%	22,088
2015	1,486,100	8,705	4,421,148	2,326,920	73.2%	23,740
2016	1,577,495	8,966	4,693,048	2,470,025	75.5%	25,392
2017	1,674,511	9,235	4,981,671	2,621,932	77.8%	27,044
2018	1,777,494	9,512	5,288,043	2,783,181	80.2%	28,696
2019	1,886,809	9,797	5,613,258	2,954,346	82.6%	30,348
2020	2,002,848	10,091	5,958,473	3,136,039	85.1%	32,000
Total Increase (2014–2020)	602,848	1,640	1,793,473	943,934	14%	11,564

a. 2013 visitor data is actual, 2014–2020 projections were calculated in 2013.

b. Average length of stay 3.5 nights, with 85 percent of visitors staying in hotels.

c. 1.9 guests on average per room.

Source: Tourism 2020

To accommodate 2 million visitors, an additional 1600 hotel rooms will be required. In response to the need for additional room inventory, the Special Hotel Qualifying Certificate (QC) program was created under Public Law 32-233. The QC program, administered by the Guam Economic Development Agency (GEDA), provides tax incentives to hotel developers.

The first QC was issued in June 2015 for an investment of $134.7 million into Ladera Towers. This project will convert existing apartments into a new condo hotel with 218 rooms and employ up to 425 people. In January 2016, GEDA reported that QCs had been issued for two additional properties (Citta di Mare and the P.H.R Micronesia development adjacent to the Hotel Nikko), potentially adding 840 rooms, 700 jobs, and $293 million to the economy.

Achieving the Tourism 2020 goals will result in nearly 12,000 new tourism-related jobs (above 2013 levels) and temporary employment linked with construction. The labor market on Guam currently has insufficient capacity to meet this demand. A detailed labor market analysis and corresponding effect on population is presented in Section 4.3.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 4-4 outlines total arrivals and arrivals by place of residence for the Guam Visitors Bureau FYs 2010 through 2015. The "Top 5" non-U.S. countries for each year are highlighted. Although Japan is the primary source of visitors to Guam, both the overall number of visitors and percentage of the total decreased between 2010 and 2015. Arrivals from Korea have risen steadily, and efforts by the GVB to increase visitors from both China and Russia have increased tourism to Guam from those two countries.

Table 4-4. FY Visitor Arrivals by Country 2010–2015

Country of Origin	2010		2011		2012		2013		2014		2015	
	Arrivals	Percent of Total	Arrivals	Percent of Total	Arrivals	Percent of Total	Arrivals	Percent of Total	Arrivals	Percent of Total	Arrivals	Percent of Total
Japan	887,986*	75.8%	823,645	71.8%	907,765	71.5%	912,093	68.2%	825,830	61.6%	779,405	56.8%
Korea	120,065	10.3%	145,081	12.6%	165,143	13.0%	232,850	17.4%	293,437	21.9%	384,112	28.0%
Taiwan	29,420	2.5%	40,709	3.5%	49,851	3.9%	47,904	3.6%	50,924	3.8%	42,315	3.1%
U.S. mainland	49,340	4.2%	48,437	4.2%	53,329	4.2%	48,876	3.7%	53,292	4.0%	56,117	4.1%
China	4,669	0.4%	6179	0.5%	9,040	0.7%	10,384	0.8%	14,547	1.1%	23,589	1.7%
Hawaii	11,311	1.0%	11,199	1.0%	11,437	0.9%	9,670	0.7%	12,859	1.0%	13,628	1.0%
CNMI	18,369	1.6%	17,932	1.6%	17,272	1.4%	15,905	1.2%	15,466	1.2%	13,757	1.0%
Palau	3,441	0.3%	3,516	0.3%	3,668	0.3%	3,021	0.2%	2,936	0.2%	3,429	0.2%
FSM	9,520	0.8%	10,167	0.9%	10,137	0.8%	10,052	0.8%	9,188	0.7%	9,452	0.7%
RMI	1215	0.1%	1,250	0.1%	1,079	0.1%	903	0.1%	895	0.1%	872	0.1%
Philippines	12,016	1.0%	10,748	0.9%	10,240	0.8%	10,564	0.8%	11,742	0.9%	12,278	0.9%
Australia	2,896	0.2%	3,660	0.3%	4,071	0.3%	3,265	0.2%	3,830	0.3%	2,987	0.2%
Canada	672	0.1%	703	0.1%	773	0.1%	961	0.1%	1,031	0.1%	960	0.1%
Europe	1,589	0.1%	1,511	0.1%	1,566	0.1%	2,101	0.2%	1,876	0.1%	1,686	0.1%
Hong Kong	5,640	0.5%	8,519	0.7%	8,396	0.7%	8,936	0.7%	8,605	0.6%	8,163	0.6%
Thailand	327	0.0%	498	0.0%	383	0.0%	382	0.0%	400	0.0%	459	0.0%
Vietnam	80	0.0%	105	0.0%	113	0.0%	92	0.0%	100	0.0%	166	0.0%
Russia	385	0.0%	528	0.0%	2,931	0.2%	6,134	0.5%	18,291	1.4%	3,539	0.3%
Other/Unknown	3,887	0.3%	4,036	0.4%	4,441	0.3%	6,394	0.5%	6,708	0.5%	4,174	0.3%
Total Air	1,162,828	99.3%	1,138,423	99.2%	1,261,635	99.3%	1,330,487	99.5%	1,331,957	99.3%	1,361,088	99.2%
Total Sea	8,029	0.7%	8,711	0.8%	8,526	0.7%	7,178	0.5%	9214	0.7%	11,443	0.8%
Total Air + Sea	**1,170,857**	**100.0%**	**1,147,134**	**100.0%**	**1,270,161**	**100.0%**	**1,337,665**	**100.0%**	**1,341,171**	**100.0%**	**1,372,531**	**100.0%**

CNMI = Commonwealth of the Northern Mariana Islands

FSM = Federated States of Micronesia

RMI = Republic of the Marshall Islands

** Highlighted entries reflect "Top 5" non-U.S. visitor countries of origin for each year*

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Construction

The value of private construction contracts comprised 8 percent of GDP in 2014 (Bureau of Economic Analysis, December 2015). As indicated in Table 4-1, construction accounted for 10.7 percent of civilian employment in 2015. The number of workers employed in the construction sector for select years is presented in Table 4-5.

Table 4-5. Construction Employment (Select Years)

Year [a]	Total Employment	Construction Employment	
		Number of Employees	Percent of Total
1995	65,660	8,110	12.4%
2000	60,570	4,440	7.3%
2005	57,740	4,570	7.9%
2010	62,200	6,830	11.0%
2015	62,730	6,740	10.7%
2022 [b]	70,193	6,824	9.7%

a. Value as of March of each year.

b. 2022 projections from Guam Bureau of Labor Statistics employment projections.

It is challenging to project a dollar value for construction into the future. As part of the 2010 Environmental Impact Assessment (EIA), Naval Facilities Engineering Command Pacific (NAVFAC) compiled a description of completed, present, and reasonably foreseeable future projects on Guam spanning the period of military buildup construction (2009–2028). In 2011, the Guam Economic Development Authority published the Comprehensive Economic Development Strategy (CEDS), which quantified development, timelines, and job creation of major projects. The CEDS was scheduled to be updated in October 2016, but an updated version was not available prior to finalizing this WRMPU.

To forecast future construction activity, building permits provide the most immediate leading indicator of future activity for the civilian sector and U.S. military construction contracts for the defense sector. Table 4-6 summarizes building permit and construction contract data from 2010 to 2015.

Table 4-6. Building Permits and Construction Contracts 2010–2015 (in $ thousands)

	2010	2011	2012	2013	2014	2015
Building permits	184,837	211,097	364,504	449,147	308,451	221,285
U.S. military construction contracts	370,413	334,597	152,095	88,001	261,234	164,377
Japan-funded military contracts	-	89,720	-	-	44,500	-
Total	**555,250**	**635,414**	**516,599**	**537,148**	**614,185**	**385,622**

Source: Bureau of Labor Statistics Economic Outlook, FY 2016.

Note: The three major hotel projects issued QCs as described in Section 4.1.2 and are scheduled to begin construction in 2016.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Projects not yet contracted, but which are likely to be awarded by DoD in FY 2016 with continuing construction work in FY 2017, total $227 million (Marianas Business Journal, December 28, 2015). Substantial DoD contracting authority is also planned in 2016 for hundreds of millions of dollars of multiple award contracts. Other leading indicators of future construction activity are appropriations (for DoD military and civilian infrastructure) and bonds, grants, or loan funding (for Government of Guam projects).

Table 4-7 is a partial listing of major Government of Guam projects for which funding is underway or proposed. Projects which are likely to be constructed but without secured funding, such as a new power generating plant for GPA, are not included in Table 4-7.

Table 4-7. Government of Guam Planned Major Construction Projects and Funding

Planned/Ongoing Projects – Funds Available	Amount
Guam Waterworks Authority	$139,280,961
Guam International Airport Authority – Airport B	$96,710,000
Guam Power Authority	$76,470,000
Guam International Airport Authority – Airport A	$13,000,000
Port Authority of Guam	$10,000,000
Guam Community College	$6,000,000
Guam Legislature Building	$4,000,000
Subtotal	$345,460,961
Planned Projects – Bond/Loan Financing Proposed	**Amount**
Guam Waterworks Authority	$128,450,000
Department of Education	$100,000,000
University of Guam	$21,700,000
Department of Land Management	$15,750,000
Harmon Industrial Park Association	$7,000,000
Subtotal:	$272,900,000
Total	**$618,360,961**

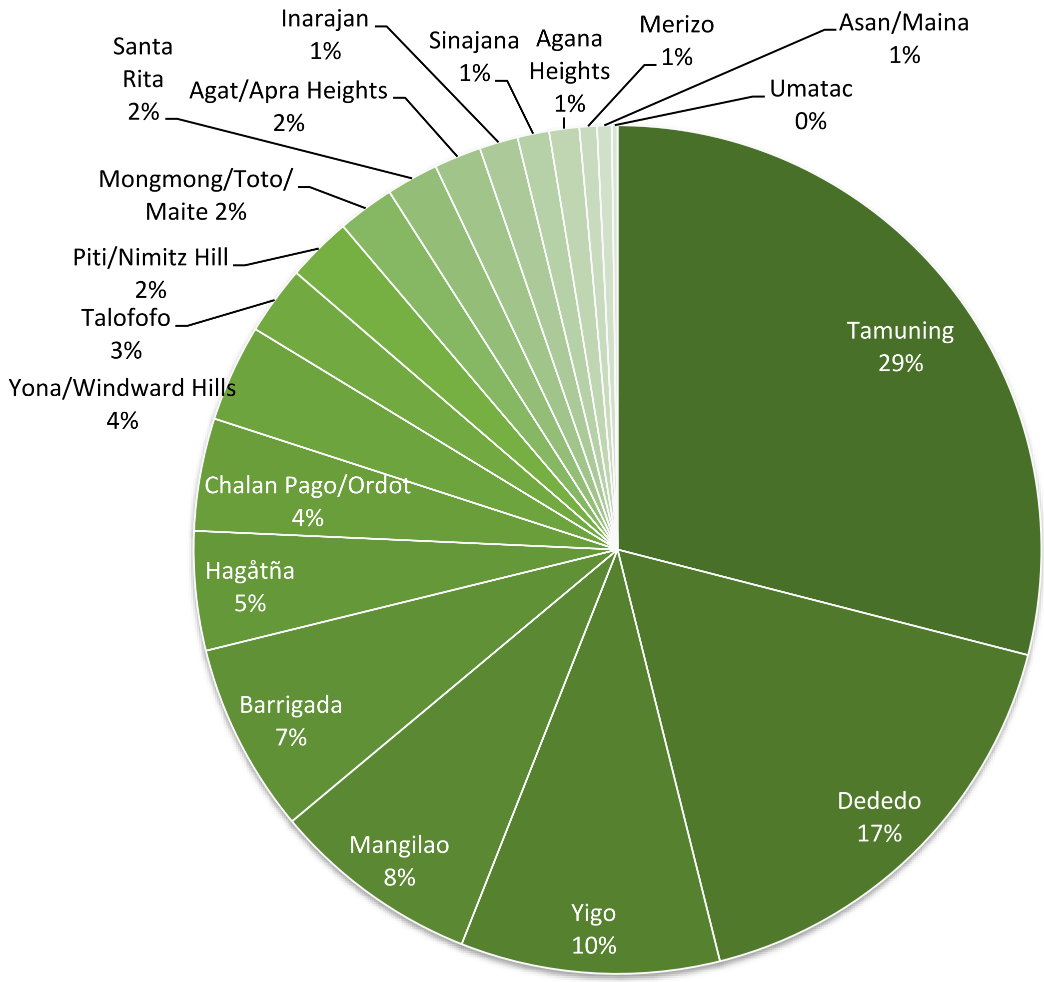
Source: Bureau of Labor Statistics Economic Outlook, FY 2016.

The timing of these projects is crucial to migration-related population growth for Guam. If all federal, private, and territorial projects are constructed as scheduled, there will be a shortage of workers on the island. In contrast, if projects are cancelled, or schedules extended, the effect on the economy, where workers can transition to another project as one finishes, will result in a more limited impact on population.

Employment-related population growth is discussed further in Section 4.3.

The percentage of building permits issued by municipality for the years 2010–2015 is presented in Figure 4-2. Construction activity was greatest in Tamuning, Dededo, and Yigo. The communities of southern Guam experienced relatively little development over that period. Although not necessarily directly correlated, economic activity and population growth is generally expected to be greatest in the municipalities with the most construction activity.

Use of contents on this sheet is subject to the limitations specified at the end of this document.



Source: Building Permits and Inspection Section, Department of Public Works, Government of Guam.

Figure 4-2. Percentage of Building Permits Issued 2010–2015 (by Municipality)

4.2 Population

The following section provides an overview of Guam's historic population, demographics, contributors to population growth, and the geographic distribution of people across the island.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

4.2.1 History

U.S. Census Bureau population statistics for the years 1950 through 2050 are presented in Figure 4-3.

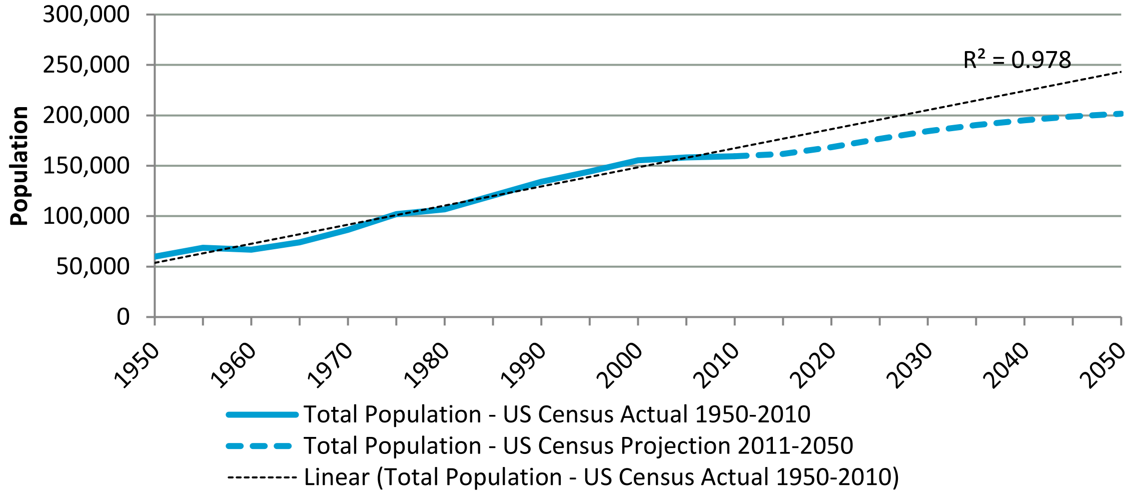


Figure 4-3. Total Guam Population 1950–2050

Data between 1950 and 2010 (the most recent census year for which data is available) is illustrated by the solid blue line and reflects actual U.S. Census-tabulated numbers. The strongly correlated line-of-best-fit for these years is represented by the linear dotted line extended to the year 2050.

The continuation of the dashed blue line from 2010 through 2050 reflects U.S. Census projections only. It is important to note that these projections do not correlate with the linear growth trend observed between end of World War II and 2010. This lack of correlation and the limitations of the U.S. Census projections for Guam are discussed in greater detail in Section 4.4.

Historic U.S. Census populations for Guam are presented in Table 4-8.

Table 4-8. Guam Population 1950–2010

Year	U.S. Census Population
1950	59,900
1955	68,700
1960	66,900
1965	74,100
1970	86,470
1975	102,110
1980	106,869
1985	120,615
1990	134,125
1995	144,190
2000	155,324
2005	158,398
2010	159,434

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Figure 4-4 illustrates average annual population growth rates in 5-year increments.

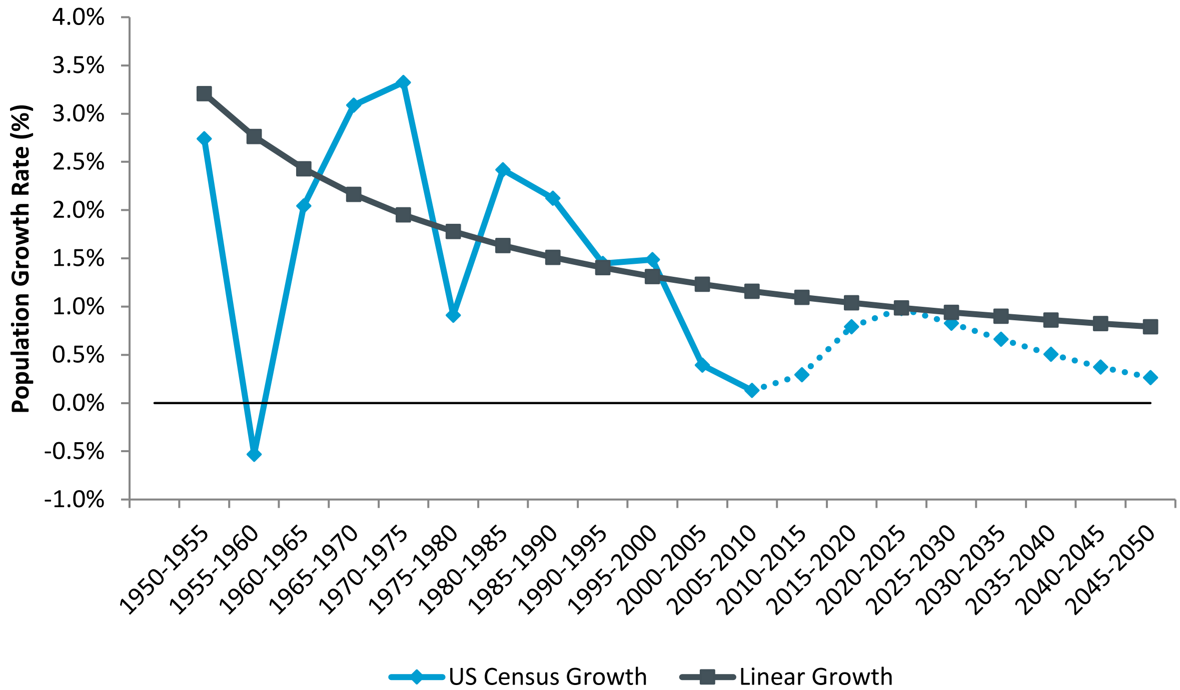


Figure 4-4. Population Growth Rates 1950–2050

The solid blue line represents the actual growth rate between 1950 and 2010. The continuation of that line illustrates U.S. Census projections extending from 2010 to 2050. The linear growth trend, a constant number of people added to the population each year, representing a smaller percentage of the population as time goes on, is also depicted for comparison.

Historically, the highest annual growth rate of 3.3 percent was observed on Guam between 1970 and 1975. The lowest was a decrease in population (-0.5 percent) between 1955 and 1960. The 2010 Census measured the rate of growth between 2005 and 2010 to be 0.1 percent. U.S. Census numbers predict that the rate of growth will increase to 1 percent between 2010 and 2015, and gradually taper to 0.3 percent by 2050. The limitations of U.S. Census projections are discussed in Section 4.4.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

4.2.2 Demographics

A comparison of the citizenship of the U.S. (2009 American Community Survey) and Guam (U.S. Census, 2010) is presented in Figure 4-5. Forty-seven percent of the population of Guam was born outside the territory, and 31 percent of the population are not U.S. citizens. This is in sharp contrast to the U.S. as a whole, where 88 percent of the population are American citizens, and 11 percent foreign.

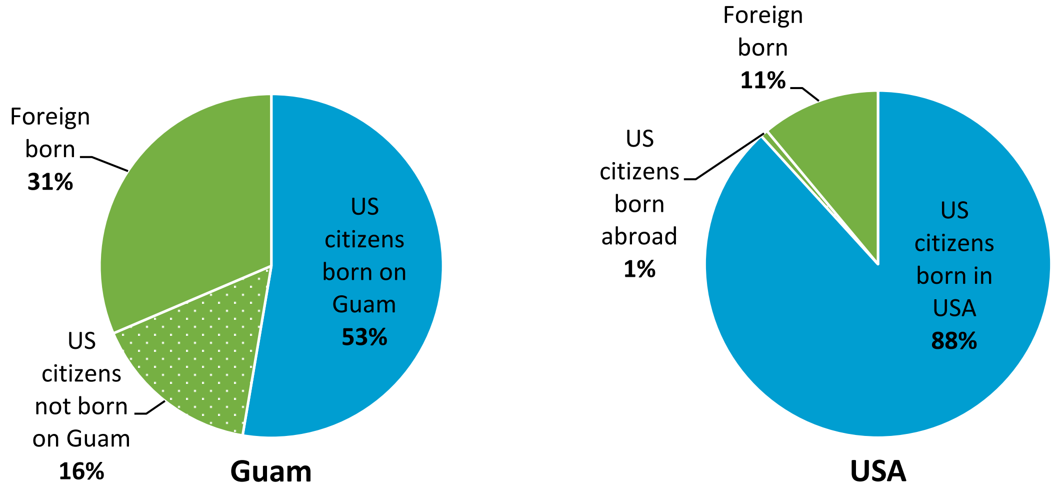


Figure 4-5. Guam and U.S. Population Comparison

Of those not born on Guam, 49 percent are from Asia (38 percent from the Philippines alone), 34 percent are from elsewhere in the U.S., and 14 percent are from nearby Oceania.

4.2.3 Migration to Guam

Civilian and military employment opportunities have been a significant contributor to population growth on Guam. Reasons for moving to Guam are outlined in Table 4-9.

Table 4-9. Reasons for Moving to Guam (Foreign-Born and Other U.S.)

Reason	2000	2010
Population born outside of Guam (including foreign-born and other U.S.)	75,416	74,068
Moved with spouse or parent	50%	47%
Employment	21%	22%
Other	12%	12%
Military	10%	9%
To attend school	5%	6%
Housing	2%	3%
Missionary activities, medical, subsistence activities	1%	1%

Use of contents on this sheet is subject to the limitations specified at the end of this document.

A relatively small number of people immigrate to Guam to attend school, find housing, or participate in missionary, medical, and subsistence activities. In both 2000 and 2010, 31 percent of the population born outside of Guam came to the territory for employment or with the military. In 2010, 47 percent of this same population arrived with a spouse or parent. Assuming that the number of arriving dependents is proportional to all categories of reasons for moving to Guam, employment-based immigration accounts for over 43,000 workers and their dependents, or more than a quarter of the entire population. In fact, when broken down by age, the 2010 Census data indicates that 58 percent of the Guam labor force (population of those 16 years and over) was born outside of the territory.

The 2015 SEIS details the expected origin of workers that will construct military facilities as part of the buildup. Most of the 3,227 workers projected to come from off-island will be H2-B workers from the Philippines. Supervisory positions will be filled by migrants from continental U.S., Hawaii, and Japan. Workers are also expected to come from the Commonwealth of the Northern Marianas Islands (CNMI) and other Pacific islands.

The employment situation is discussed further in Section 4.3.

4.2.4 Geographic Distribution

As illustrated in Figure 4-6, more than a quarter of the population resides in Dededo. Over 50 percent of the population resides in three of Guam's 19 municipalities (Dededo, Yigo, and Tamuning), and 77 percent in the largest seven municipalities.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

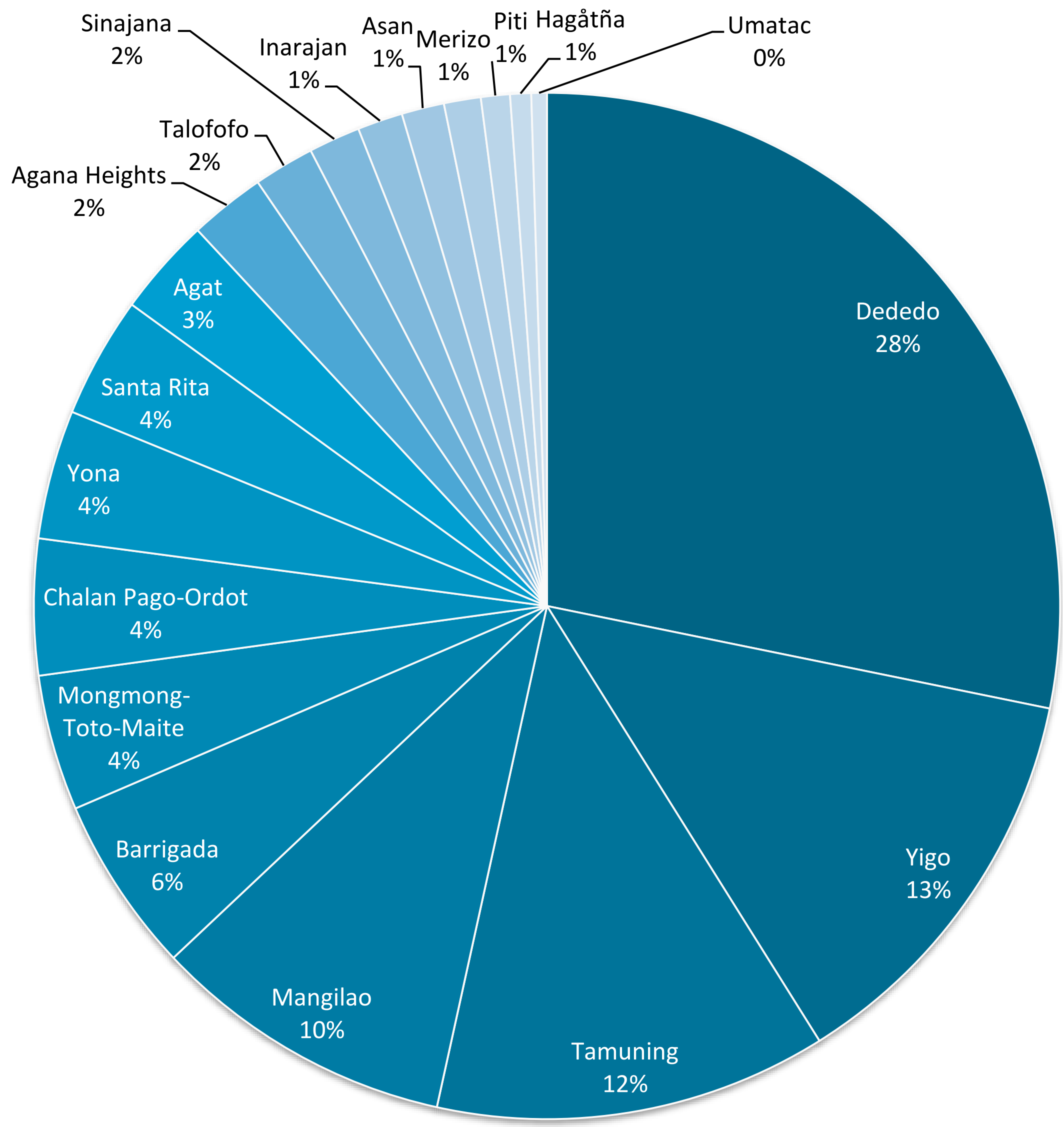


Figure 4-6. Population Distribution by Municipality (2010)

These seven municipalities also experienced the largest population increase between 2000 and 2010, as shown in Figure 4-7. In fact, except for Asan (1.3 percent of the total population), a population decrease was observed in all other municipalities over the same time.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

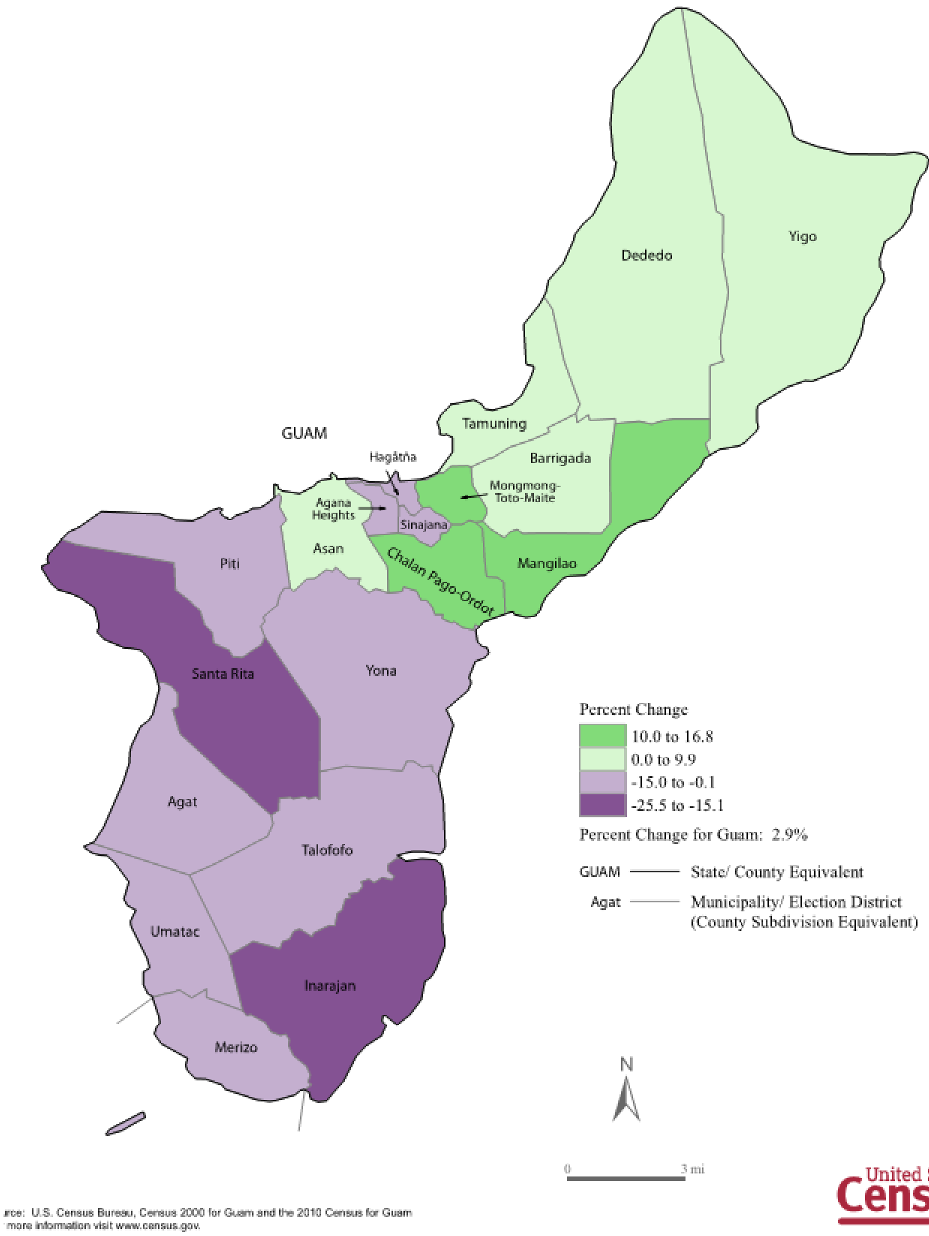


Figure 4-7. Percent Change in Population by Municipality 2000–2010

Population by municipality for 1990–2010 is presented in Table 4-10. Although the overall territory population increased between the 2000 and 2010 Census, 11 of Guam's 19 smaller municipalities actually experienced a population drop over the decade. The largest percentage drops were in the southern communities of Inarajan (25.5 percent), Santa Rita (18.9 percent), and Merizo (14.5 percent). In terms of numbers, the largest increases in population were in Dededo (1,963), Mangilao (1,878), and Tamuning (1,673).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 4-10. Population of Guam in 1990, 2000, and 2010 by Municipality					
Municipality	Population			Change, 2000–2010	
	1990	2000	2010	Number	Percent
Agana Heights	3,646	3,940	3,808	-132	-3.4
Agat	4,960	5,656	4,917	-739	-13.1
Asan	2,070	2,090	2,137	47	2.2
Barrigada	8,846	8,652	8,875	223	2.6
Chalan Pago-Ordot	4,451	5,923	6,822	899	15.2
Dededo	31,728	42,980	44,943	1,963	4.6
Hagåtña	1,139	1,100	1,051	-49	-4.5
Inarajan	2,469	3,052	2,273	-779	-25.5
Mangilao	10,483	13,313	15,191	1,878	14.1
Merizo	1,742	2,163	1,850	-313	-14.5
Mongmong-Toto-Maite	5,845	5,845	6,825	980	16.8
Piti	1,827	1,666	1,454	-212	-12.7
Santa Rita	11,857	7,500	6,084	-1,416	-18.9
Sinajana	2,658	2,853	2,592	-261	-9.1
Talofofo	2,310	3,215	3,050	-165	-5.1
Tamuning	16,673	18,012	19,685	1,673	9.3
Umatac	897	887	782	-105	-11.8
Yigo	14,213	19,474	20,539	1,065	5.5
Yona	5,338	6,484	6,480	-4	-0.1
Total Guam	133,152	154,805	159,358	4,553	2.9

4.3 Labor Market Conditions

The following section provides a history of labor market conditions on Guam, labor requirements and population growth, and employment projections.

4.3.1 History

Unemployment and labor participation data from 1987 through 2015 is presented in Figure 4-8. Unemployment rates on Guam over the past 30 years have ranged from a low of 2 percent (1989 and 1990) to a high of 15 percent (1999, 2000, and 2013).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

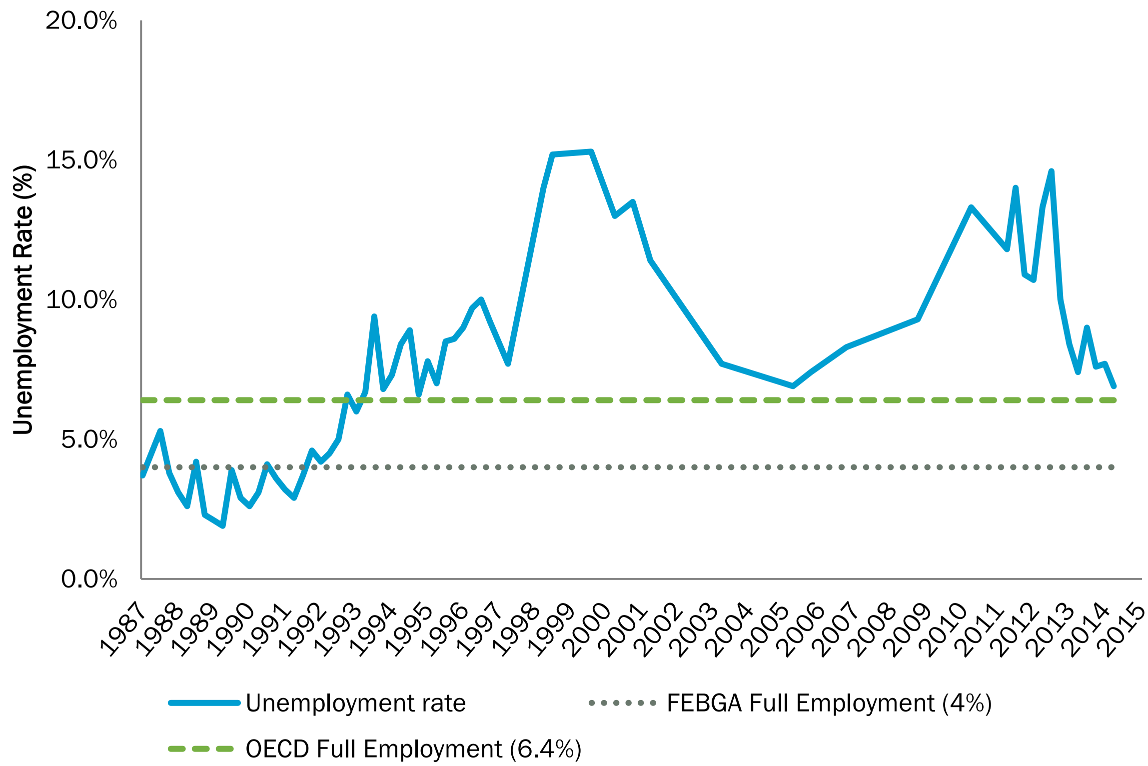


Figure 4-8. Guam Unemployment and Full Employment

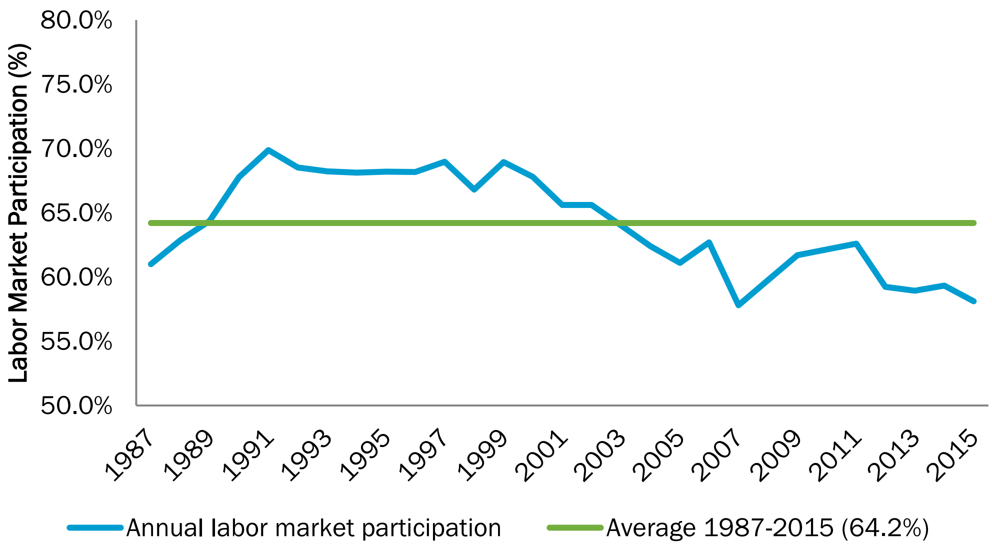
For a geographically isolated location such as Guam, the concept of "Full Employment" is important when looking at economic growth and population projections. Full employment reflects a situation in which all available labor resources are being used in the most economically efficient way. Full employment embodies the highest amount of skilled and unskilled labor that could be employed within an economy at any given time. The unemployment rate at full employment is not zero because a certain number of workers will always be changing jobs and an exact match of available jobs to labor force skills is not possible.

The Full Employment and Balanced Growth Act (FEBGA) enacted in 1978 defines full employment in the U.S. as 4 percent unemployment for persons aged 16 and over. Four percent is also the rate used by GEDA. In contrast, the Organization for Economic Co-operation and Development (OECD) estimated the "full-employment unemployment rate" as a range of 4.0–6.4 percent for the U.S. in 1999. Guam consistently exhibited characteristics of OECD-defined full employment between 1987 and 1993, and levels less than 4 percent were observed between 1988 and 1992.

Labor participation rates reflect the percentage of the civilian population willing and able to work. People choose not to participate in the labor market for various reasons, such as attendance at school, family responsibilities, and disability. Discouraged workers (those who believe no work is available and stop looking for employment) are also considered outside the labor force. To achieve full labor market participation, these barriers to labor market participation need to be overcome. Discouraged workers must re-enter the labor force, workers must have adequate options for child and family care, and the skill set of the workforce must match the jobs available.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Figure 4-9 illustrates the range of participation in the labor force by citizens 16 years of age and over. Between 1987 and 2015, the annual labor participation rate on Guam ranged between 58 percent (2007) and 70 percent (1991). The average annual rate of participation over that period for the data available was 64.2 percent. For perspective, the range for the entire U.S. over the same period was 63 to 67 percent (OECD).



Note: data extrapolated for 2003, 2008, 2010, as no data was released for those years by the Guam Bureau of Labor Statistics

Figure 4-9. Guam Labor Market Participation

Equivalent labor market participation rates of 67.8 percent were observed for 1990 and 2000, but with very different unemployment rates (2.8 percent in 1990, and 15.3 percent in 2000). This illustrates the difficulty of correlating labor market participation rates to unemployment rates, as multiple factors contribute to labor market participation. For example, more than 400 new jobs were created when the Guam Regional Medical City opened in 2015. Many of these positions are highly specialized (nurses, doctors, and technicians) and the skills of the unemployed labor pool available at the time were not an exact match for the job requirements. Recruiting for these positions from off-island was necessary, and the unemployment rate on Guam did not decrease as much as it would have if all positions had been filled from the existing on-island labor pool.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Employment data for select years is presented in Table 4-11.

Table 4-11. Annual Average Employment Data (Select Years)

Factor	1990	1995	2000	2005	2011 [a]	2012	2013	2014	2015
Total civilian population 16 years of age and over [b]	67,980	71,500	104,480	104,980	119,720	121,340	121,570	121,850	121,160
Civilian labor force participants	44,945	48,675	70,800	64,130	74950	71,708	71,378	72,133	70,420
Labor force participation rate	67.8%	68.2%	67.8%	61.1%	62.6%	59.2%	58.9%	59.3%	58.1%
Total employed	43,673	44,570	59,950	59,630	64,970	63,205	64,093	66,500	65,580
Total unemployed	1,273	3,855	10,850	4500	9970	8,505	8,285	5,720	4840
Unemployment rate [c]	2.8%	7.9%	15.3%	7.0%	13.3%	11.9%	11.6%	7.9%	6.9%
Not participating in labor force	21,343	22,720	33,680	40850	44770	49,343	49,785	49,405	50,740

a. Data for 2010 unavailable.

b. Sum of details may not equal totals due to discrepancies in raw data published by Bureau of Labor Statistics.

c. Annual unemployment rates calculated from average of available quarterly data.

Source: The Employment Situation on Guam Summary History, 1974–2014.

When full employment and maximum labor participation rates are reached, additional workers required to achieve economic goals must be brought in from off-island to fill vacant positions.

With the proposed military buildup and ambitious tourism-related goals presented by the Guam Visitors Bureau described in previous sections, full employment and maximum labor participation rates are projected to be achieved by 2017.

Previous analyses of these potentially large draws on the labor pool have tended to look at labor supply in isolation. The military observes that many of the jobs created by the buildup will be filled by the existing population, but the tourism industry is assuming that some of those same workers will be available for construction and operation of new hotels. Population increase resulting from the temporary or permanent immigration of off-island workers to achieve these goals must be considered when investigating population projections on Guam. These numbers must be reexamined periodically to ensure that the assumptions made are accurate and the proposed projects are also constructed as foreseen.

4.3.2 Labor Requirements and Population Growth

The Guam Workforce Integrated Plan outlines a strategic plan to develop a well-educated and well-trained workforce on Guam. However, even if all goals of the plan are met, the local workforce, fully employed, will be insufficient to provide all of the human capital necessary to meet the needs of a growing economy.

GEDA estimates that 1 direct job and 0.7 indirect jobs are created per $100,000 total project investment (Guam EDA, CEDS). In the 2015 SEIS, DoD estimates that 75 construction jobs are created per $10 million investment (SEIS).

Positions are categorized in three ways:

1. Direct employment refers to on-site employment in construction or operations.
2. Indirect employment is created in businesses that supply goods and services to the sectors providing direct employment.
3. Induced employment is generated when those employed directly and indirectly spend money in the broader economy on items such as food, clothing, and entertainment.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Both temporary and permanent workers migrate to Guam for employment, and mechanisms exist for U.S. companies to employ foreigners. For example, the H2-B visa is a non-immigrant program permitting U.S. employers to hire foreign workers temporarily to perform nonagricultural services or labor on a one-time, seasonal, peak load, or intermittent basis. Unlike the rest of the U.S., there is no cap (statutory numerical limit) for H2-B workers on Guam. This exemption is in recognition of the difficulty in attracting and retaining U.S. workers to Guam, but the program is not without controversy.

H2-B workers are employed in the construction, tourism, and health care industries. In 2016, there were nearly 1,500 H2-B workers on Guam, 80 percent of which were in the construction industry. A near-100 percent denial in H2-B visa applications in 2017 has resulted in a sharp and alarming decrease in the availability of foreign workers. It is estimated that 2,500 H2-B workers will be needed over the next 10 years for the military buildup.

When workers come from off-island, they bring dependents. Table 4-12 summarizes this relationship for different categories of worker.

Table 4-12. Employment and Population Impacts per $100,000 Investment

Category	Source	Number of People (per $100,000)
Direct FTE jobs created (construction)	GEDA CEDS (2011), SEIS Tables 4.2-2 and 4.2-3 and GCA interviews	0.75
Direct FTE jobs created (non-construction)	SEIS Tables 4.2-2 and 4.2-3 and GCA interviews	0.25
Indirect/induced FTE jobs created	GEDA CEDS (2011)	0.70
	Total workers required to fill new jobs	1.70
Average number of dependents for in-migrating direct, on-site construction jobs	SEIS contractor interviews (assume few temporary construction workers bring dependents)	0.15
Average number of dependents for in-migrating induced/indirect and direct non-construction jobs	U.S. Census national data on persons per job (Census 2010) and GDoL interviews	0.90
	Total dependents associated with off-island workers migrating to fill new jobs	1.05
	Total population increase per $100,000 project value (workers + dependents)	2.75

GDoL = Guam Department of Labor

GCA = Guam Contractors Association

FTE = full-time equivalent

The data presented in Table 4-12 applies to all investment, both military and civilian, and is a combination of temporary impacts during the construction phase and to long-term impacts during operations.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

4.3.3 Employment Projections

Table 4-13 details the labor force requirements necessary to achieve the construction and operational targets of the military buildup, Tourism 2020, and additional private and public sector investment for the years 2015 through 2050.

- **Column A:** 2015–2050 labor force projections for the population of those 16 years of age and older (U.S. Census International Database).
- **Column B:** the theoretical labor force is calculated using the full employment unemployment rate of 4 percent, and the historic average labor market participation rate on Guam of 64.2 percent.
- **Column C:** 2015 data is published by the Guam Bureau of Labor Statistics. 2020 and 2022 numbers are from www.hireguam.com long term industry projections, and 2023 through 2050 are a linear extrapolation of 2015, 2020, and 2022 (R value = 0.9997).
- **Column D:** the theoretical number of people available for employment is the number of jobs subtracted from the total labor force at full employment (Column B minus Column C).
- **Column E:** the number of buildup-related jobs projected to be filled by workers from Guam is published in the 2015 SEIS.
- **Column F:** job creation statistics for Tourism 2020 goals were published by the Guam Visitors Bureau (2013).
- **Column G:** the potential labor surplus/shortage is calculated by subtracting the number of additional jobs created in the future from the expected available labor force (Column D minus Column E minus Column F).
- **Column H:** the estimated number of jobs created (workers needed) for each $100,000,000 project investment exceeding 2015 levels, calculated according to Table 4-12 (one direct and 0.7 indirect/induced worker per $100,000). These numbers can be scaled up with additional investment.
- **Column I:** Column G minus Column H.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 4-13. Employment Related Population Projections 2015–2050									
	A	B	C	D	E	F	G	H	I
Year	Population 16 years +	Labor Force (Theoretical)	People Employed (Actual and Projected)	People Available for Employment (Theoretical)	On-Island Jobs Associated with Military Buildup	On-Island Jobs Associated with "Tourism 2020" Goals	Potential Labor Surplus (Shortage) for Tourism + Buildup	Additional Workers (per $100,000,000 Investment)	Potential Labor Surplus (Shortage) for Tourism + Buildup + Investment
2015	117,582	72,468	65,580	6,888	413	3,304	3,171	1,700	1,471
2016	119,082	73,393	66,253	7,139	822	4,956	1,361	1,700	-339
2017	120,766	74,431	66,915	7,516	1,506	6,608	-598	1,700	-2,298
2018	122,361	75,414	67,576	7,837	2,011	8,260	-2,434	1,700	-4,134
2019	123,944	76,389	68,238	8,151	2,241	9,912	-4,002	1,700	-5,702
2020	125,637	77,433	68,941	8,492	2,726	11,564	-5,798	1,700	-7,498
2021	127,372	78,502	69,561	8,941	3,058	11,564	-5,681	1,700	-7,381
2022	129,076	79,552	70,193	9,359	3,005	11,564	-5,210	1,700	-6,910
2023	130,750	80,584	70,884	9,700	2,596	11,564	-4,460	1,700	-6,160
2024	132,389	81,594	71,546	10,048	2,036	11,564	-3,552	1,700	-5,252
2025	134,013	82,595	72,207	10,388	1,632	11,564	-2,808	1,700	-4,508
2026	135,607	83,577	72,869	10,709	1,283	11,564	-2,138	1,700	-3,838
2027	137,177	84,545	73,530	11,015	851	11,564	-1,400	1,700	-3,100
2028	138,711	85,490	74,192	11,299	847	11,564	-1,112	1,700	-2,812
2029	140,210	86,414	74,853	11,561	847	11,564	-850	1,700	-2,550
2030	141,676	87,318	75,515	11,803	847	11,564	-608	1,700	-2,308
2035	148,565	91,564	78,823	12,741	847	11,564	330	1,700	-1,370
2040	154,667	95,324	82,130	13,194	847	11,564	783	1,700	-917
2045	159,724	98,441	85,438	13,003	847	11,564	592	1,700	-1,108
2050	163,589	100,823	88,746	12,077	847	11,564	-334	1,700	-2,034

4.4 Population Projections

The following section discusses population projections for Guam based on linear and economic growth.

4.4.1 U.S. Census Projections and Linear Growth

The U.S. Census Bureau population statistics for the years 1950 through 2050 were presented in Section 4.2, Figure 4.3.

Since 1950, population growth on Guam has exhibited a linear pattern. Sustained linear growth is unusual in a population, and indicates factors beyond demographics and cohort progression influencing growth.

In contrast to the historical growth pattern, 2010 U.S. Census numbers forecast non-linear growth in the future. U.S. Census predictions indicate that the rate of growth will increase to 1 percent between 2010 and 2015, and gradually taper to 0.3 percent by 2050.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Beyond 2015, the U.S. Census projections reflect "births minus deaths" only, with a declining birth rate offset by a longer life span and corresponding lower mortality rate. The net migration to Guam (the number of people immigrating to the island minus the number of people leaving) is assumed to be zero. This assumption of zero net migration reflects a limitation of the current U.S. Census projections, with a probable under-estimation of future population. As discussed in Section 4.1, major economic drivers of tourism, military, and construction are predicted to result in migration to Guam over the coming decade. Less significantly, the medical, educational, and other sectors of the economy are also expanding opportunities in the territory.

Both U.S. Census and linear growth are tabulated in Table 4-15 (Section 4.4.3). These two growth patterns reflect the "Low" and "High" estimate for population growth in Guam.

4.4.2 Population Projections Based on Economic Growth

For planning purposes on Guam, it is not enough to look only at fertility, birth, and death rates. As an isolated island community, Guam's population fluctuates with world economic factors. It is a challenge to quantify the combined effect of economic growth (tourism, military buildup, and other construction and economic development activity), labor market conditions, and geopolitical factors on population, but without an effort to do so, population projections are incomplete.

Table 4-14 outlines the components of the most likely population growth on Guam between 2010 and 2050, taking into account the best information available at the time of this report. The 2010 Census contains the most recent population statistics for Guam. Annual projections are presented from 2010 through 2030, and for every five years from 2030 through 2050. Census 2015 numbers were not released prior to finalization of this WRMPU, but it is important that the numbers presented in this table are examined and updated periodically to reflect both the most recent Census data, and the assumptions for economic growth contained herein. A description of each column presented in Table 4-14 is as follows:

- **Column A:** U.S. Census projections.
- **Column B:** the population increase (workers and dependents from off-island) due to military buildup estimated by NAVFAC in the 2015 SEIS.
- **Column C:** the minimum number of additional workers required to meet Tourism 2020 goals, with full employment (4 percent) and labor force participation (64.2 percent). This assumes that tourism development numbers are sustained at 2020 levels between 2020 and 2050. Migration of dependents with tourism-related workers is not included.
- **Column D:** the projected population due to U.S. Census calculated growth, military buildup, and Tourism 2020 is a combination of Column A + Column B + Column C.
- **Column E:** the impact in terms of workers and dependents of each additional $100 million investment each year on Guam in excess of 2015 numbers. This could be in the form of either public or private investment, with assumptions for job creation and as outlined in Table 4-12. Although actual investment on Guam will fluctuate from year to year, $100 million represents a realistic estimate. For each additional $100 million investment, total population numbers would be scaled up by 2750.
- **Column F:** the "most likely" total population prediction for Guam based on U.S. Census numbers combined with in-migration to achieve the goals of the military buildup, Tourism 2020, and an investment of $100 million in public or private development. For each additional $100 million investment, these numbers would be scaled up by Column E.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 4-14. Guam Population and Economic Growth						
Year	A	B	C	D	E	F
	U.S. Census population projections	Off-island workers and dependents for military buildup	Off-island workers for "Tourism 2020" goals	Projected population (buildup + tourism)	Off-island workers and dependents (per $100,000,000 investment)	Projected population (buildup + tourism + investment)
2015	161,785	347	0	162,132	2,750	164,882
2016	162,742	1,724	0	164,466	2,750	167,216
2017	163,875	3,618	598	168,091	2,750	170,841
2018	165,177	4,921	2,434	172,532	2,750	175,282
2019	166,658	4,942	4,002	175,602	2,750	178,352
2020	168,322	8,191	5,798	182,311	2,750	185,061
2021	170,071	9,585	5,681	185,337	2,750	188,087
2022	171,799	9,386	5,210	186,395	2,750	189,145
2023	173,494	9,721	4,460	187,675	2,750	190,425
2024	175,152	8,584	3,552	187,288	2,750	190,038
2025	176,770	8,146	2,808	187,724	2,750	190,474
2026	178,348	7,531	2,138	188,017	2,750	190,767
2027	179,888	7,413	1,400	188,701	2,750	191,451
2028	181,384	7,412	1,112	189,908	2,750	192,658
2029	182,831	7,412	850	191,093	2,750	193,843
2030	184,224	7,412	608	192,244	2,750	194,994
2035	190,418	7,412	0	197,830	2,750	200,580
2040	195,286	7,412	0	202,698	2,750	205,448
2045	198,953	7,412	0	206,365	2,750	209,115
2050	201,610	7,412	334	209,356	2,750	212,106

4.4.3 Summary

The range of population projections outlined in this section are summarized in Table 4-15. The "Most Likely" scenario will be used throughout the 2016 WRMPU. This scenario was determined by combining 2010 U.S. Census data with population growth predicted by economic drivers as discussed in Section 4.1.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 4-15. Guam Population Projections

Year	U.S. Census [a]	Linear [b]	U.S. Census with Projected Economic Growth [c]
2010	159,434	167,065	159,434
2015	161,785	176,476	164,882
2016	162,742	178,359	167,216
2017	163,875	180,241	170,841
2018	165,177	182,123	175,282
2019	166,658	184,006	178,352
2020	168,322	185,888	185,061
2021	170,071	187,771	188,087
2022	171,799	189,653	189,145
2023	173,494	191,535	190,425
2024	175,152	193,418	190,038
2025	176,770	195,300	190,474
2026	178,348	197,182	190,767
2027	179,888	199,065	191,451
2028	181,384	200,947	192,658
2029	182,831	202,829	193,843
2030	184,224	204,712	194,994
2035	190,418	214,123	200,580
2040	195,286	223,535	205,448
2045	198,953	232,947	209,115
2050	201,610	242,359	212,106
	LOW	HIGH	MOST LIKELY

a. Source: 2010 U.S. Census population projections.

b. Based on historical growth line-of-best-fit.

c. "Most Likely" scenario combines 2010 Census projections with military buildup data from 2015 SEIS, Tourism 2020 goals, and $100 million in additional investment.

Table 4-15 is presented graphically as Figure 4-10. The U.S. Census projections correlate with a second-degree polynomial distribution (R^2 value > 0.99). The “bump” in the U.S. Census with the Economic Growth scenario corresponds to the timeline for the military buildup (2015–2028) and Tourism 2020-related economic activity.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

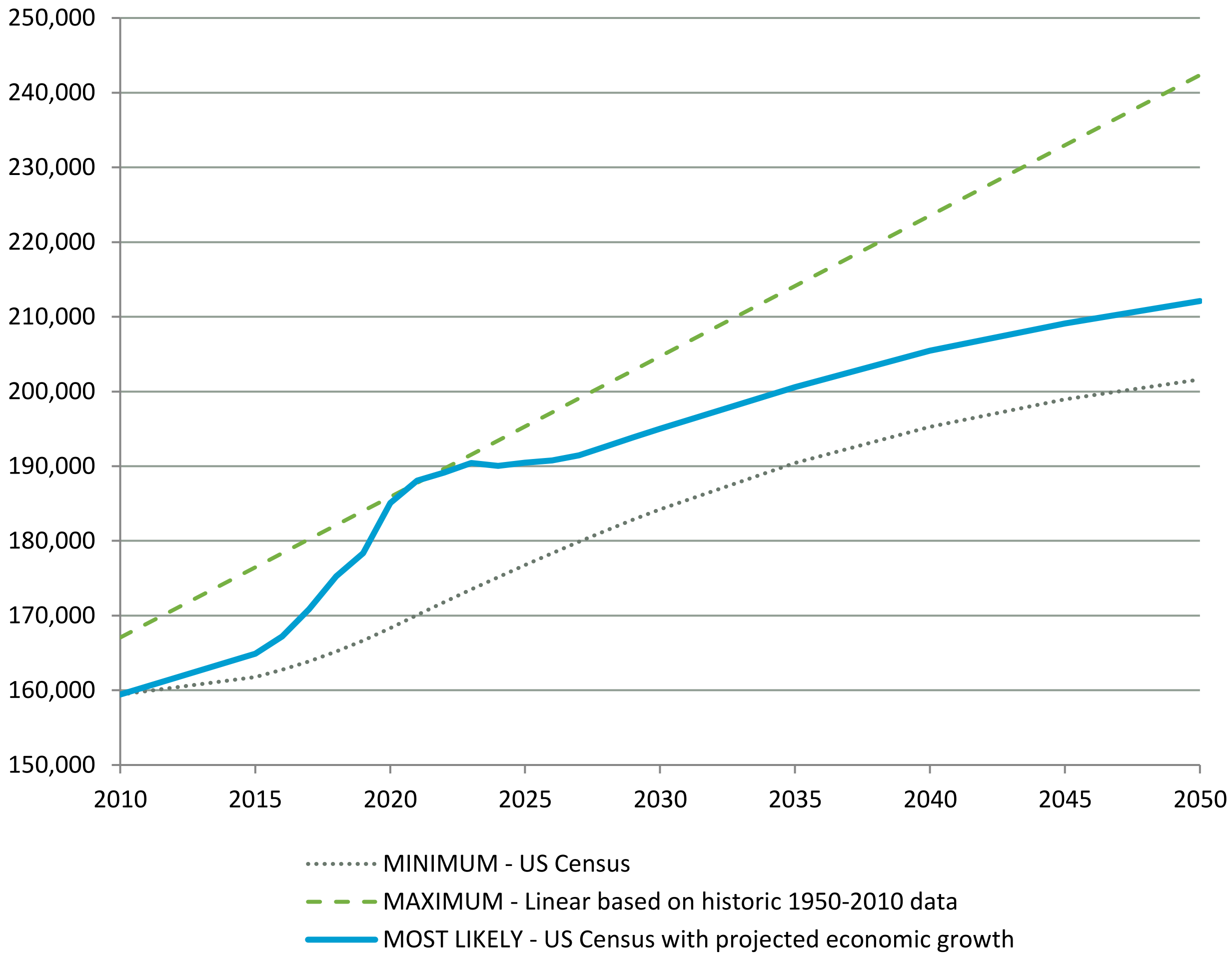


Figure 4-10. Guam Population Projections

Figure 4-11 details the components of the most likely population scenario. Figure 4-12 overlays the most likely scenario with data from 1950 through 2013 to put the projected population growth into historical perspective.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

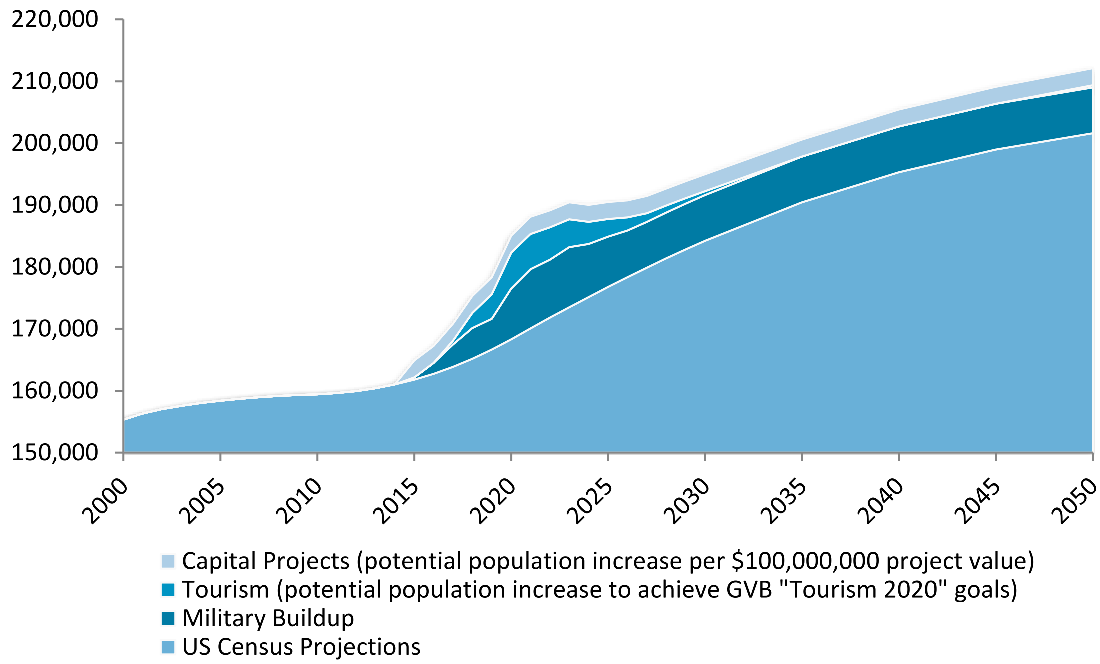


Figure 4-11. Components of Guam Population Projections – Most Likely Scenario

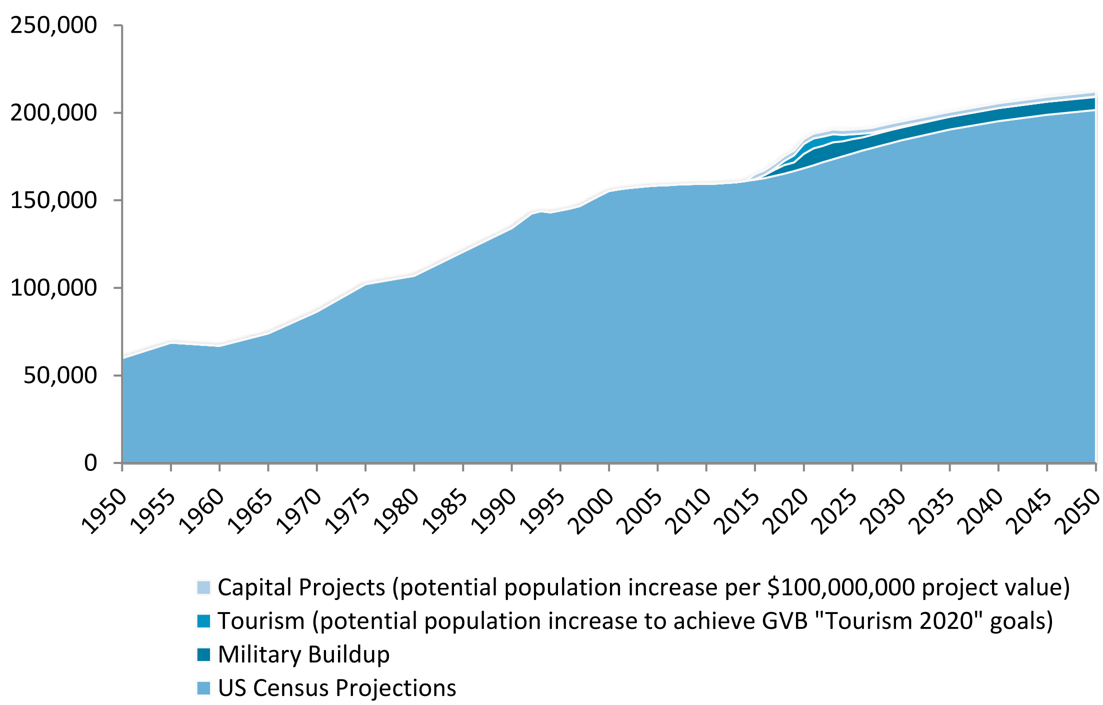


Figure 4-12. Guam Population Projections and Historic Data 1950–2050

Use of contents on this sheet is subject to the limitations specified at the end of this document.

4.4.4 Distribution by Municipality

Although it is difficult to predict whether further population decreases as discussed in Section 4.2 will be observed in south Guam, the trend to urbanization in the northern and central part of the island is expected to continue. As a result of the military buildup, population will increase in Dededo, where the cantonment and rotational troops will be based, and in Yigo, where military personnel with dependents will live. The newly opened Guam Regional Medical City in Dededo, expansions at the University of Guam in Mangilao, and planned development in other municipalities in northern and central Guam will draw people to these areas to live and work.

Figure 4-13, Figure 4-14, and Table 4-16 illustrate the projected population increase for the 19 Guam municipalities. Military personnel have been distributed according to the locations outlined in the 2015 SEIS. All other population growth has been distributed proportionally to the municipalities.

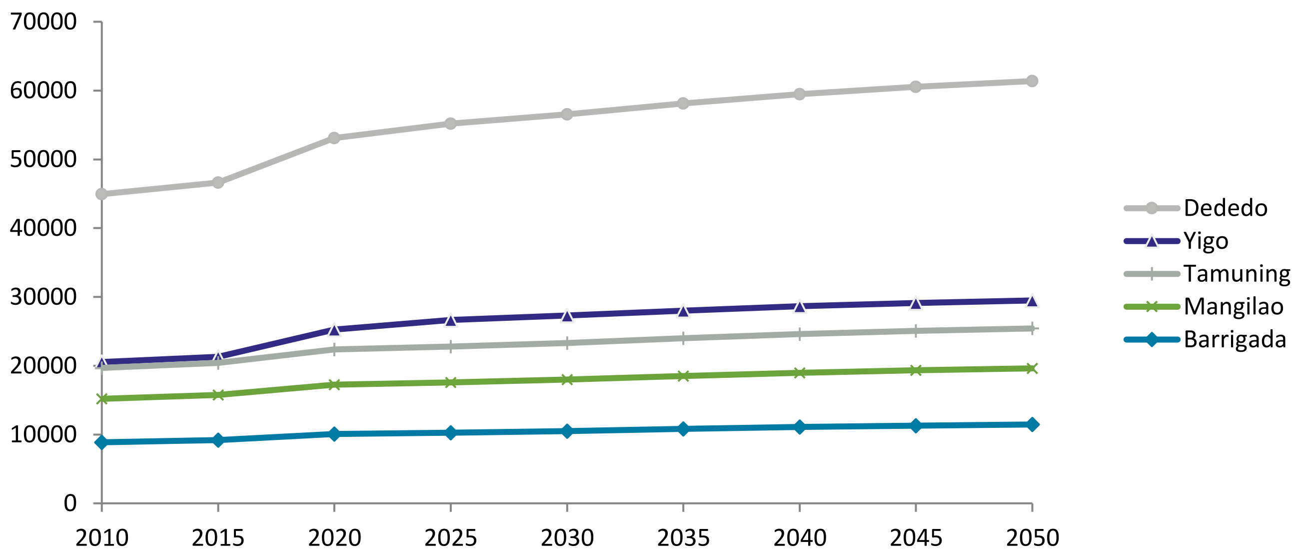


Figure 4-13. Guam Population Projections – Municipalities > 10,000

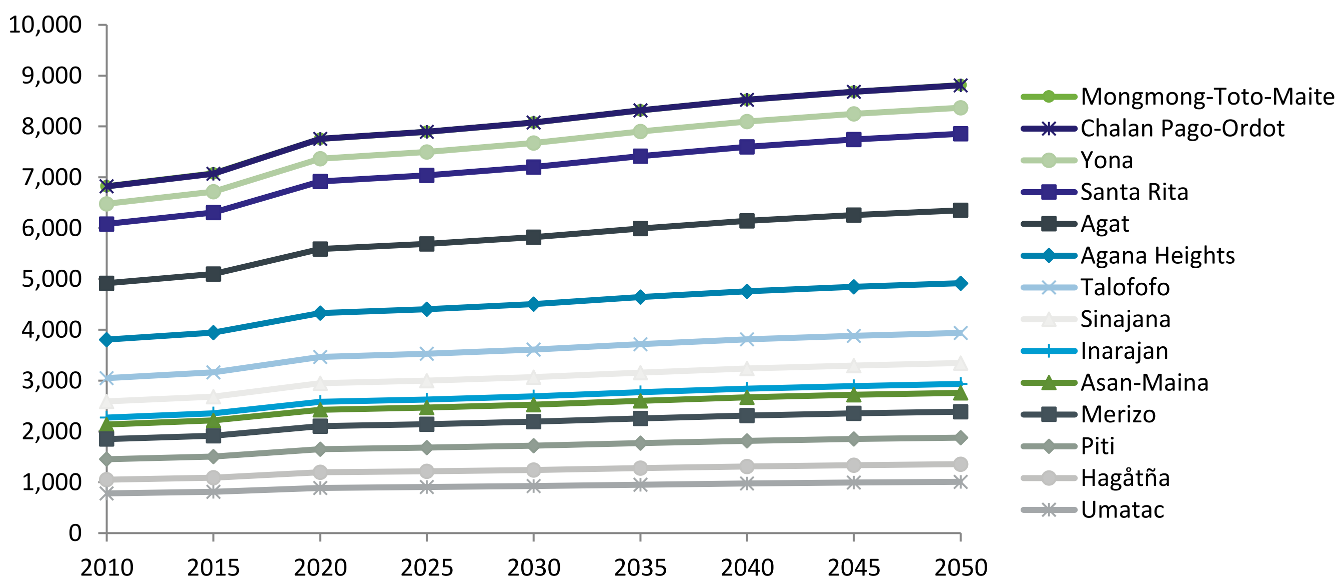


Figure 4-14. Guam Population Projections – Municipalities < 10,000

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 4-16. Guam Population Projections by Municipality										
Year	Agana Heights	Agat	Asan Maina	Barrigada	Chalan Pago-Ordot	Dededo	Hagåtña	Inarajan	Mangilao	Merizo
2010	3,808	4,917	2,137	8,875	6,822	44,943	1,051	2,273	15,191	1,850
2015	3,939	5,087	2,211	9,181	7,057	46,508	1,087	2,352	15,714	1,914
2020	4,329	5,590	2,429	10,089	7,756	53,086	1,195	2,584	17,270	2,103
2025	4,406	5,690	2,473	10,269	7,894	55,190	1,216	2,630	17,578	2,141
2030	4,509	5,823	2,530	10,509	8,078	56,550	1,244	2692	17,988	2,190
2035	4,642	5,995	2,605	10,820	8,317	58,125	1,281	2,771	18,521	2,255
2040	4,759	6,145	2,670	11,091	8,526	59,498	1,313	2,841	18,985	2,312
2045	4,846	6,258	2,720	11,295	8,683	60,532	1,337	2,893	19,334	2,354
2050	4,918	6,351	2,760	11,462	8,811	61,376	1,357	2,936	19,619	2,389
Year	Mongmong Toto Maite	Piti	Santa Rita	Sinajana	Talofofo	Tamuning	Umatac	Yigo	Yona	Total
2010	6,825	1,454	6,084	2,592	3,050	19,685	782	20,539	6,480	159,358
2015	7,060	1,504	6,294	2,681	3,155	20,363	809	21,263	6,704	164,882
2020	7,759	1,653	6,916	2,947	3,468	22,378	889	25,254	7,367	185,062
2025	7,897	1,683	7,040	2,999	3,530	22,777	905	26,659	7,499	190,475
2030	8,082	1,722	7,204	3,069	3,612	23,308	926	27,286	7,673	194,995
2035	8,321	1,773	7,417	3,160	3,719	23,998	953	28,006	7,901	200,581
2040	8,529	1,817	7,603	3,239	3,812	24,600	977	28,634	8,099	205,449
2045	8,686	1,851	7,743	3,299	3,882	25,053	995	29,106	8,248	209,116
2050	8,814	1,878	7,857	3,348	3,940	25,422	1,010	29,492	8,369	212,107

The 2016 WRMPU projects population only to the municipal level. 2010 Census tract data, block data and maps can be accessed at:
http://tigerweb.geo.census.gov/tigerwebmain/Files/tab10/tigerweb_tab10_tabblock_2010_gu_010.html

http://www2.census.gov/geo/maps/dc10map/GUBlock/st66_gu/county/c66010_guam/

4.4.5 Comparison with 2006 WRMU

Significant studies and reports completed since 2006 relevant to population projections were consulted during the writing of this 2016 WRMPU including:

- U.S. Census 2010
- NAVFAC documents (2010 EIS and 2015 SEIS) prepared for the planned military relocation
- 2011 Guam Economic Development Strategy
- Tourism 2020
- GEDA QC Program
- 2009 North and Central Guam Land Use Plan
- 2012 Economic Census of Island Areas

Use of contents on this sheet is subject to the limitations specified at the end of this document.

A comparison of 2006 and 2016 population data from 2000 through 2050 is presented in Table 4-17 and Figure 4-15. The 2006 WRMP was based on 2000 U.S. Census projections for growth rate. The U.S. Census revised these numbers significantly downward for the 2010 Census projections, based on an overall declining birth rate and population data collected in 2010. The 2016 projections were discussed in detail in Section 4.4.2.

Table 4-17. 2006 and 2016 WRMP Projections Comparison

Year	2006 WRMP [a]	U.S. Census 2010	2016 WRMPU [b]
2000	154,804	154,804	154,804
2005	166,769	158,398	158,398
2010	179,658	159,358	159,358
2015	190,699	161,785	164,882
2020	202,419	168,322	185,061
2035	N/A	190,418	200,581
2050	221,451	201,610	212,106
2100	257,232	N/A[c]	N/A[c]

a. 2006 WRMP numbers based on 2000 U.S. Census projections.

b. 2016 WRMP numbers reflect published 2010 U.S. Census data for 2000–2010 and "Most Likely" scenario as presented in this report.

c. Estimates beyond 2050 are not predicted by the 2010 U.S. Census or the 2016 WRMP.

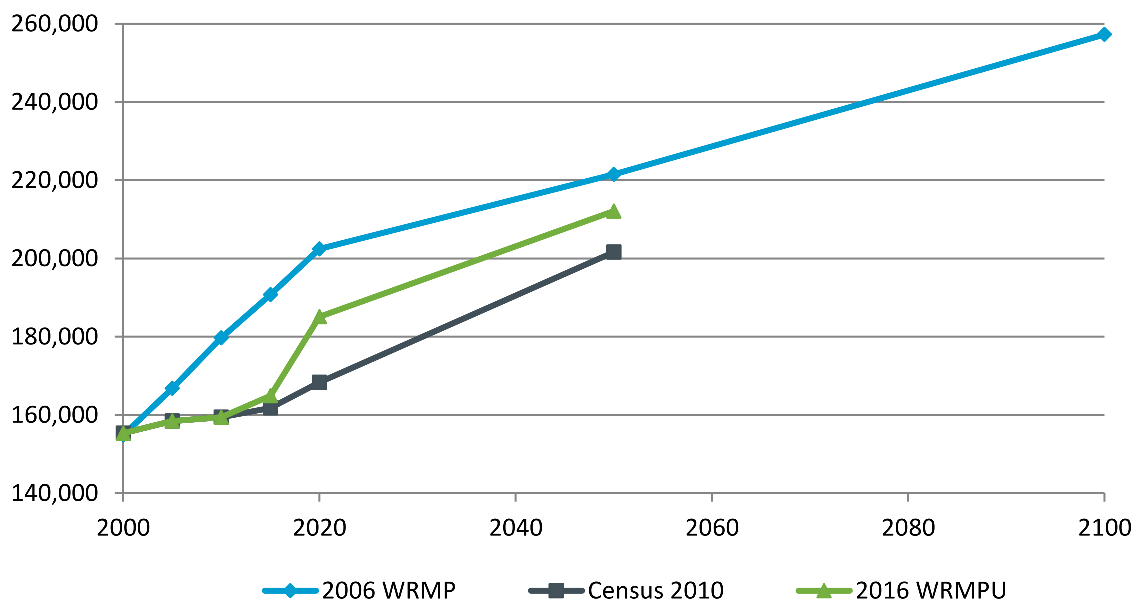


Figure 4-15. Guam Population Projections – 2006 WRMP and 2016 WRMPU

Use of contents on this sheet is subject to the limitations specified at the end of this document.

4.5 Planned Development and Water/Wastewater Projections

Development on Guam is governed by a zoning plan enacted in 1967. Two notable attempts have been made over the past 20 years to create and adopt a Master Land Use Plan, however neither the *I Tano Ta* Plan (repealed and shelved in the 1990s), nor the 2006 North and Central Land Use Plans are currently used by the Department of Land Management. Although development generally follows the zoning requirements, spot re-zoning has occurred extensively over the past 60 years. Long-term infrastructure planning by GWA and others is limited by the lack of an official Land Use Master Plan.

As with projecting population levels into the future, predicting development on Guam presents a unique challenge. Previous efforts to accurately quantify future development have met with limited success in that they have generally been very conservative and have overestimated both the pace and extent of development. Global economic factors and strategic military decisions can change planned development repeatedly and significantly over a 20-year planning horizon. For example, between the 2006 WRMP and this update, projected increases as a result of military activity have varied from 1,000 additional naval troops arriving on Guam (2006 WRMP) to 8,600 marines and 9,000 dependents (2010 EIS) to the current plan of 5,000 marines and 1,300 dependents (2015 SEIS). Similarly, new hotel developments are conceptualized, proposed, and delayed on a regular basis.

In the 2006 WRMP, development was forecast based on an analysis of project proposals approved through the Land Use Commission that had not yet been issued building permits by the Department of Public Works (2006 WRMP, Volume 1, Section 6). At that time, residential vacancies and transportation patterns were considered to determine when and where it would be feasible for potential housing projects and other development to proceed based on projected population growth allocation model. Although rigorous, the 2006 methodology was not used for this 2016 WRMPU. Instead, future demand on GWA systems has been estimated by considering population increases resulting from economic factors and distributed according to where development is projected to occur.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Figure 4-16 and Table 4-18 were generated through an investigation into areas of future growth on Guam compiled from information provided by GWA. Figure 4-16 illustrates the location of development planned on Guam determined most likely to proceed over the next 20 years. Table 4-18 summarizes those developments including projected water and wastewater flows. Five major areas of growth were identified:

1. **Military buildup:** two areas were identified for buildup-related growth as Marines are relocated to Guam from Okinawa, Japan. The areas are listed as developments 1 and 2 in Table 4-18 and Figure 4-16. The water and sewer flows for these developments were reproduced from the 2015 SEIS (2015 SEIS, pg. 4-21, 4-114).
2. **Chamorro Land Trust:** two Chamorro Land Trust tracts are planned for development. The areas are listed as developments 3 and 8. Water demands were calculated based on the size of the tracts and water demand per acre for similar developed areas. The sewer flows were estimated to be 90 percent of the water demands.
3. **Power plants:** GWA plans to provide water to the Piti power plants to replace their current reliance on Navy water. The water demands were provided by GWA. GWA already provides sewer service to the plants. The plants are listed as developments 19, 20, and 21.
4. **Planned developments:** the remainder of the growth noted in Table 4-18 and Figure 4-16 are developments that GWA has been tracking. The water demands were supplied by GWA and sewer flows were estimated to be 90 percent of the water demands.
5. **Remainder of growth:** population growth from the developments listed in Table 4-18 was subtracted from the total projected population growth discussed in Section 4.4. The remaining population growth was assumed to be distributed throughout each municipality in proportion to current population levels.

The specific projects listed in Table 4-18 reflect the best information available with respect to development at the time of report writing. It is important to reiterate that development proposals change constantly, and that a single major development can have a significant impact on water and wastewater infrastructure requirements. GWA must continue to:

- Work directly with the public and private entities involved in land development on Guam.
- Update the water and wastewater models to be able to accurately predict the impact of new development on both GWA infrastructure and existing customers.
- Support the development of both improved water resources policy and a Master Land Use Plan for the territory.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

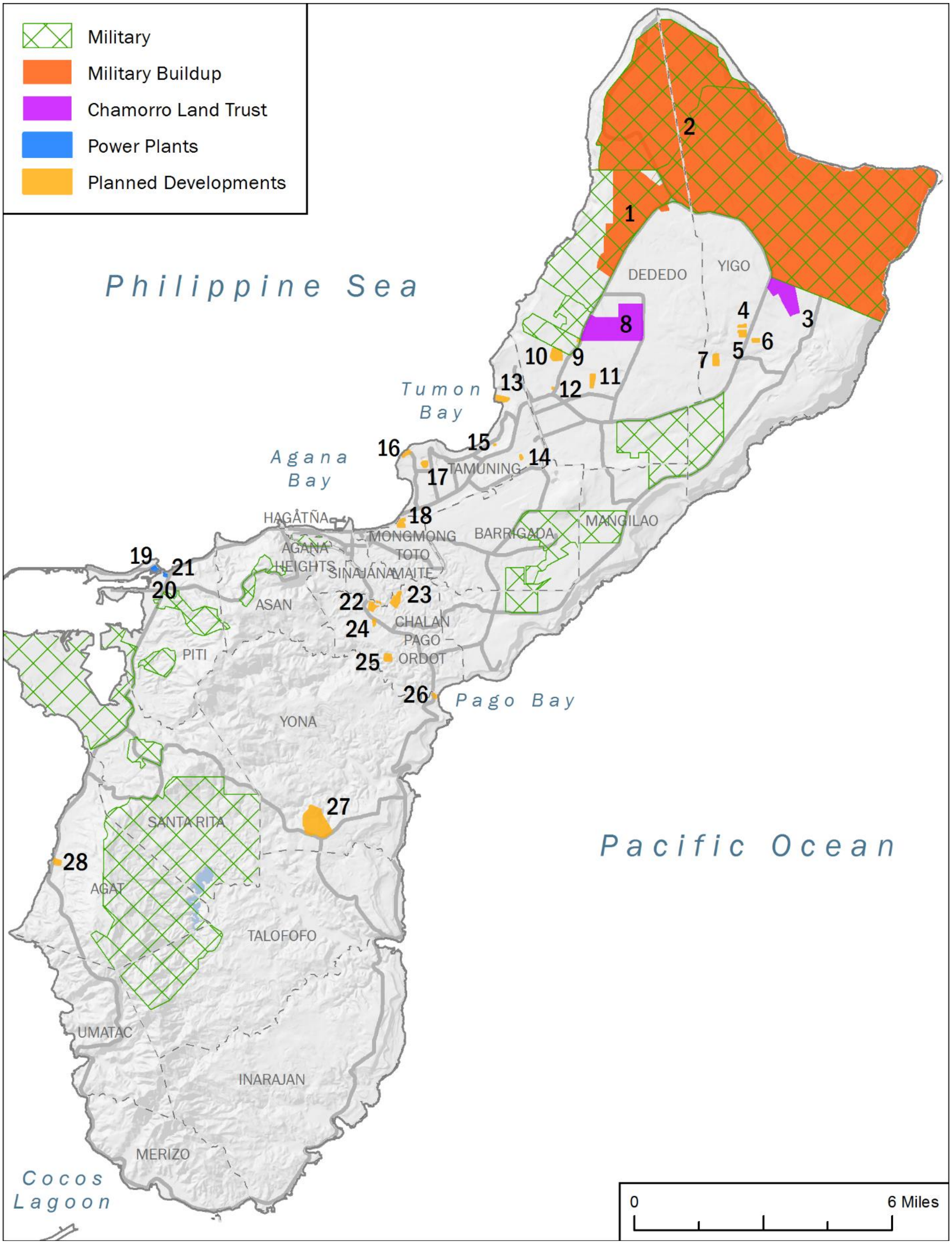


Figure 4-16. Planned Development Locations

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 4-18. Planned Developments				
Number	Development	Municipality	Average Water Demand (gpm)	Average Sewer Flow (gpm)
1	Finegayan Buildup	Military	625	441
2	Andersen AFB Main Base Buildup	Military	Not served by GWA	392
3	Chamorro Land Trust Tract 9210	Yigo	18.1	16.3
4	Paradise Meadows Subdivision	Yigo	Phase 1 = 12	Phase 1 = 10.8
			Phase 2 = 3.5	Phase 2 = 3.15
5	Songsong Hills Subdivision	Yigo	9	8.1
6	Yigo Subdivision	Yigo	9	8.1
7	KOA Subdivision	Yigo	10.5	9.5
8	Chamorro Land Trust Tract 10125	Dededo	55.1	49.6
9	Dialysis Clinic	Dededo	37	33.3
10	Pacific Industrial Park	Dededo	Initial = 65	Initial = 58.5
			Ultimate = 83	Ultimate = 74.7
11	Summertown Estates Phase 2	Dededo	7	6.3
12	Medical Arts Complex	Dededo	7	6.3
13	Nikko Hotel Annex	Tamuning	69	62.1
14	Fargo Pacific Workforce Barracks	Tamuning	46	41.4
15	Tumon 500 Room Hotel	Tamuning	125	112.5
16	Emerald Ocean View Park Condos	Tamuning	Tower 1 = 53	Tower 1 = 47.7
			Towers 2, 3, 4 = 160	Towers 2, 3, 4 = 144
17	Greyhound Park Hotel	Tamuning	70	63
18	West Tiysan Subdivision	Mongmong Toto Maite	39	35.1
19	GPA Cabras Units 1, 2, 3, 4	Piti	Cabras 1, 2 = 175	Already served by GWA
			Cabras 3, 4 = 21	
20	Marianas Energy Co. Units 8 and 9	Piti	57.4	Already served by GWA
21	Taiwan Electrical and Mechanical Engineering Services Unit 7	Piti	35	Already served by GWA
22	Ordot-Chalan Pago Residential Lots (60–80 units)	Chalan Pago Ordot	13	11.7
23	Naki Street Subdivision	Chalan Pago Ordot	6	5.4
24	Ordot-Chalan Pago Apartments (50–82 units)	Chalan Pago Ordot	60	54
25	Chalan Santa Cruz Subdivision	Chalan Pago Ordot		0
26	Pago Bay Marina Resort	Yona	173	155.7
27	Windward Hills Golf Course	Yona	27	24.3
28	Agat Hotel	Agat	35	31.5

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 5
Source Water

This section describes the occurrence, quality, and use of potable water resources on Guam by GWA. The purpose of this section is to provide a long-range plan for the provision of potable water by GWA to the people of Guam, and to identify ways to protect the island's water resources for future generations.

The section includes a discussion on the following:

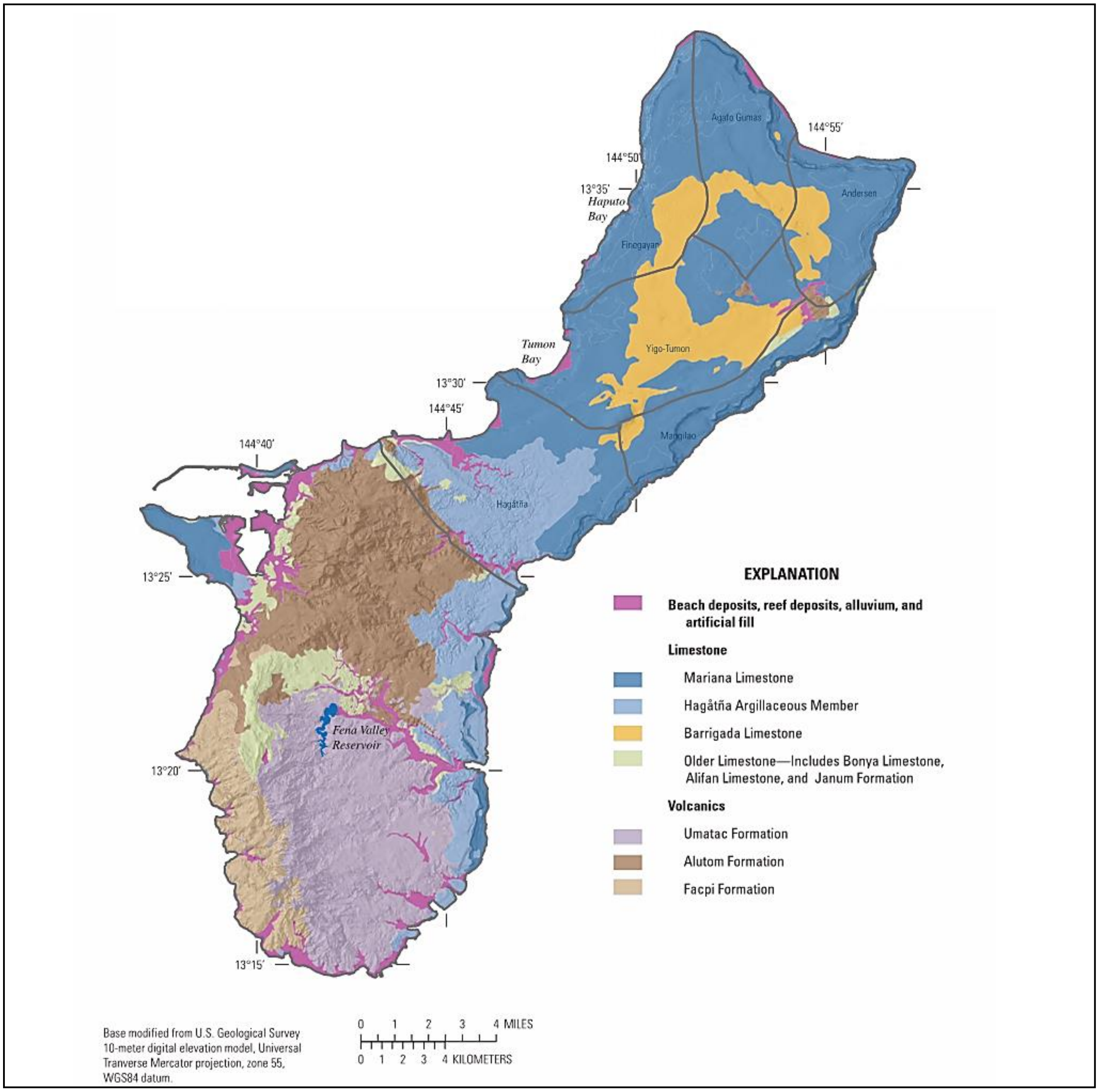
- The surface and subsurface geology of the island.
- The NGLA, which supplies more than 80 percent of the population with potable water.
- Water supply in southern and central Guam, including surface water, springs, and groundwater.
- The integration of DoD and GWA systems from a supply and resource protection perspective.
- The need for water resource policy, a discussion of supply-to-demand ratio, and the impacts of climate.
- Alternatives to extracting freshwater resources, including conservation and reuse.
- Recommendations and impacts to the CIP.

GWA water supply capacity is evaluated in Volume 2, Section 5.

5.1 Geology and Hydrology

Groundwater supplies about 80 percent of the drinking water for Guam's residents and visitors. In northern Guam, water is obtained from wells that tap the upper part of a fresh groundwater lens in an aquifer composed mainly of limestone (Gingerich, 2003). In southern Guam, the main source of freshwater is from surface water that runs off the weathered volcanic rocks that are exposed over much of the area. Figure 5-1 illustrates the surficial geological formations of the island.

Use of contents on this sheet is subject to the limitations specified at the end of this document.



Source: Gingerich 2013

Figure 5-1. Guam Geology (Surface)

In 2003, the U.S. Geological Survey (USGS), in cooperation with the Water and Environmental Research Institute of the Western Pacific at the University of Guam (WERI), published a report titled Hydrologic Resources of Guam (Gingerich, 2003). The report provides a comprehensive and clear description of the geology and hydrologic principals of Guam. Excerpts from that report (and others as noted) comprise the following narrative:

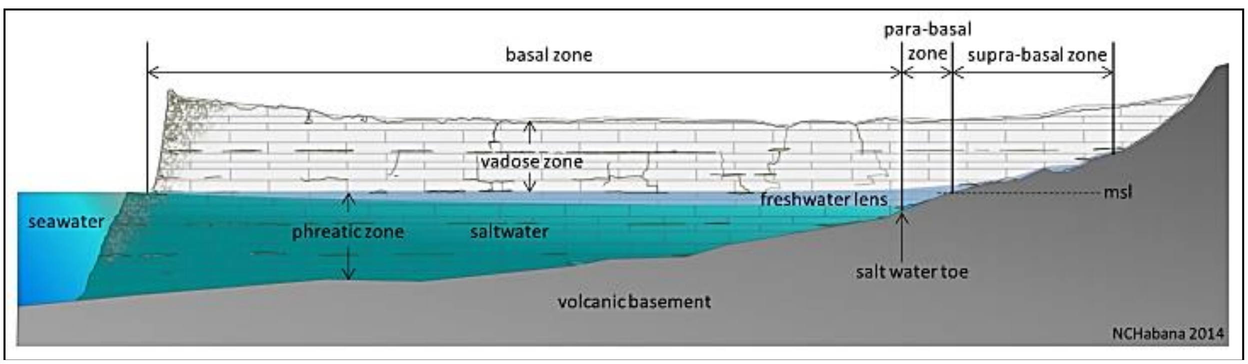
Use of contents on this sheet is subject to the limitations specified at the end of this document.

On Guam, the major fresh groundwater systems are fresh water lens systems (Gingerich, 2003). The freshwater lens floats on salt water and is separated from the salt water by a transition zone of brackish water. Transition zone thickness depends on the extent of mixing between fresh water and salt water and is generally dozens of feet thick in northern Guam. Mixing in the transition zone results from tidal and pumping fluctuations superimposed on the gravity-driven flow of fresh water toward the shore (Gingerich, 2003). Under conditions of steady recharge and no pumping, the lens would have a fixed size. In reality, rainfall is episodic and seasonal, and lens volume fluctuates naturally with time. Groundwater discharges continuously throughout the year, and the lens shrinks during dry periods when recharge diminishes or ceases, and expands when recharge increases (Gingerich, 2003).

Fresh water lens systems on Guam are found in both limestone and volcanic rocks. The most important sources of groundwater are from the fresh water parts of these systems in the highly permeable limestones that occur in the northern half of Guam (Gingerich, 2003). In the most permeable limestone, the water table is no more than a few feet above mean sea level, the slope of the water table is nearly flat, and the fresh water lens is underlain by sea water. The fresh water lens in these rocks is relatively thin and is commonly referred to as **basal water**. Where the fresh water in the limestone extends downward far enough to intersect the underlying volcanic rock, it is referred to as **parabasal water** (Gingerich, 2003). The low permeability of the volcanic rock acts as a barrier between the fresh water and salt water. This parabasal water is fresher, thicker and much less vulnerable to salt water contamination than the basal water downstream, which floats on the underlying sea water and becomes progressively thinner and saltier until it discharges at coastal springs and seeps (Khosrowpanah, 2014).

The term **suprabasal** is used to describe areas where the groundwater is underlain by low-hydraulic-conductivity rock above sea level (Gingerich, 2013). Evidence indicates that the suprabasal water is not hydrologically connected to the fresh water lens except where it spills over the edge of the basin to recharge the lens (Gingerich, 2013) and is therefore invulnerable to contamination by sea water.

A schematic of basal, parabasal, and suprabasal groundwater systems on Guam is presented in Figure 5-2.



Source: Vann 2004, AECOM Technical Services, Inc., 2011, revised by N. Habana, 2013.

Figure 5-2. Groundwater Zones

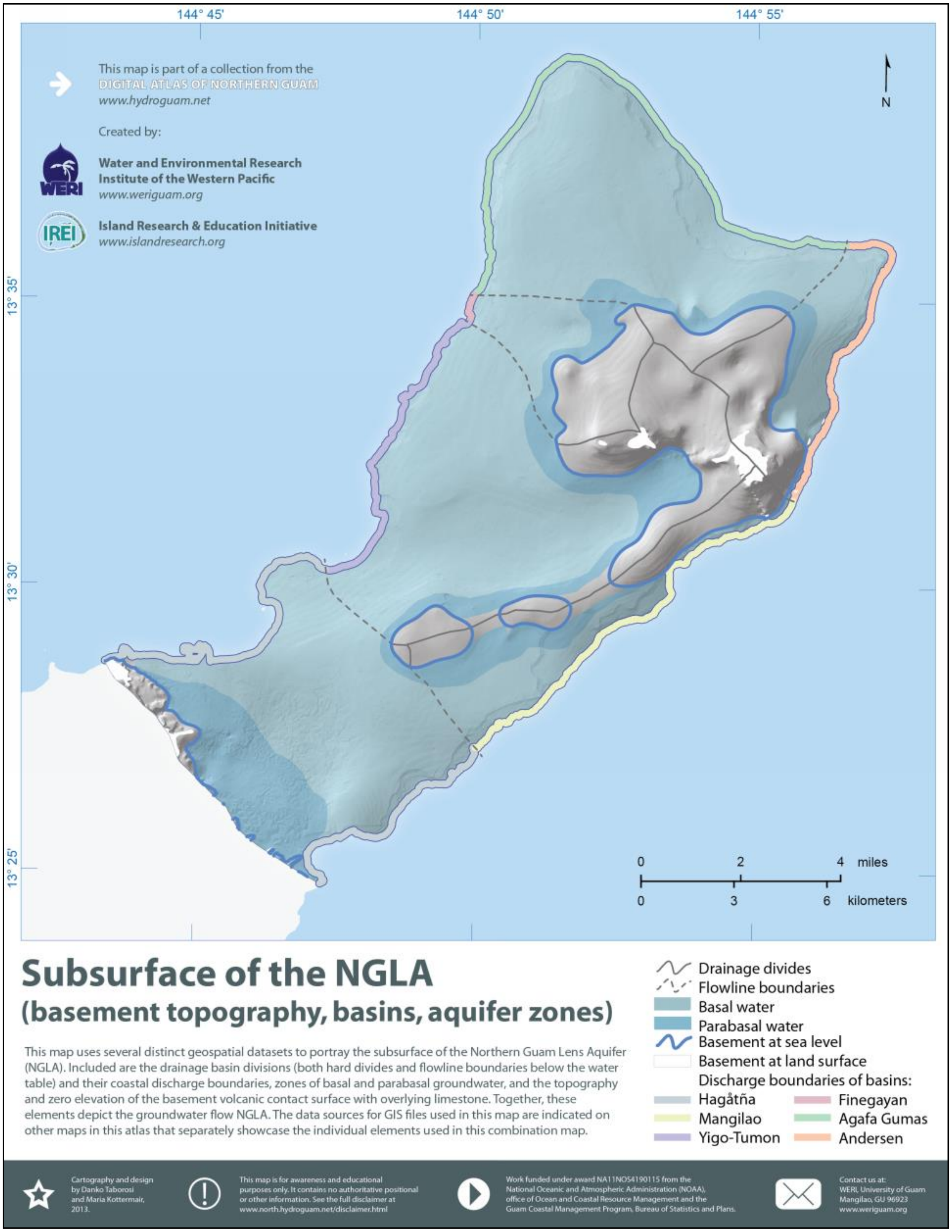
Fresh water lens systems are recharged by direct infiltration of rainfall, irrigation, and septic systems and by inflow from perched groundwater systems. Discharge from the fresh water lens system in northern Guam occurs as withdrawals from wells, coastal springs, diffuse seepage to the ocean, and minor discharge to the Hagåtña Swamp (Gingerich, 2013). In southern Guam, much of the fresh groundwater discharges directly to stream valleys above sea level where the ground surface intersects the water table (Gingerich, 2003).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The primary aquifer on NGLA that extends from the northernmost tip of the island to where the southern highlands start north of Apra Harbor. The NGLA was designated as a sole-source aquifer in 1978, reflecting its importance in supplying drinking water to approximately 80 percent of the island's residents. The Guam EPA has delineated the NGLA into six hydrologically connected aquifer basins for management purposes: the Agafa Gumas, Andersen, Finegayan, Hagåtña, Mangilao, and Yigo-Tumon basins (Gingerich, 2013). A re-delineation of the aquifer basins has been proposed based on recent updating of the basement rock topography map for the NGLA and groundwater flow paths but is not yet commonly utilized.

The subsurface features of the NGLA are illustrated in Figure 5-3. Location of basal and parabasal groundwater can be seen, in addition to the aquifer basins. The very accessible basal zone occupies about 75 percent of the aquifer by area. The parabasal zone occupies less than 5 percent of the aquifer, but it has historically been the zone of choice for development. Because this ribbon-like zone is narrow in most places, however, drillers targeting it run the risk of missing it, and thus striking either the downstream basal zone or the upstream suprabasal zone. Although not noted on Figure 5-3, suprabasal water is found in discontinuous patches above sea level and the edge of the parabasal zone. The suprabasal zone, although it occupies some 20 percent of the aquifer, presents even greater challenges to drillers and developers than the parabasal zone. Historically, most attempts to find productive sites in it have been unsuccessful. On the other hand, when successful, wells installed in the suprabasal zone are invulnerable to saltwater contamination and include some of the aquifer's most productive sources of high-quality water (Vann, 2014).

Use of contents on this sheet is subject to the limitations specified at the end of this document.



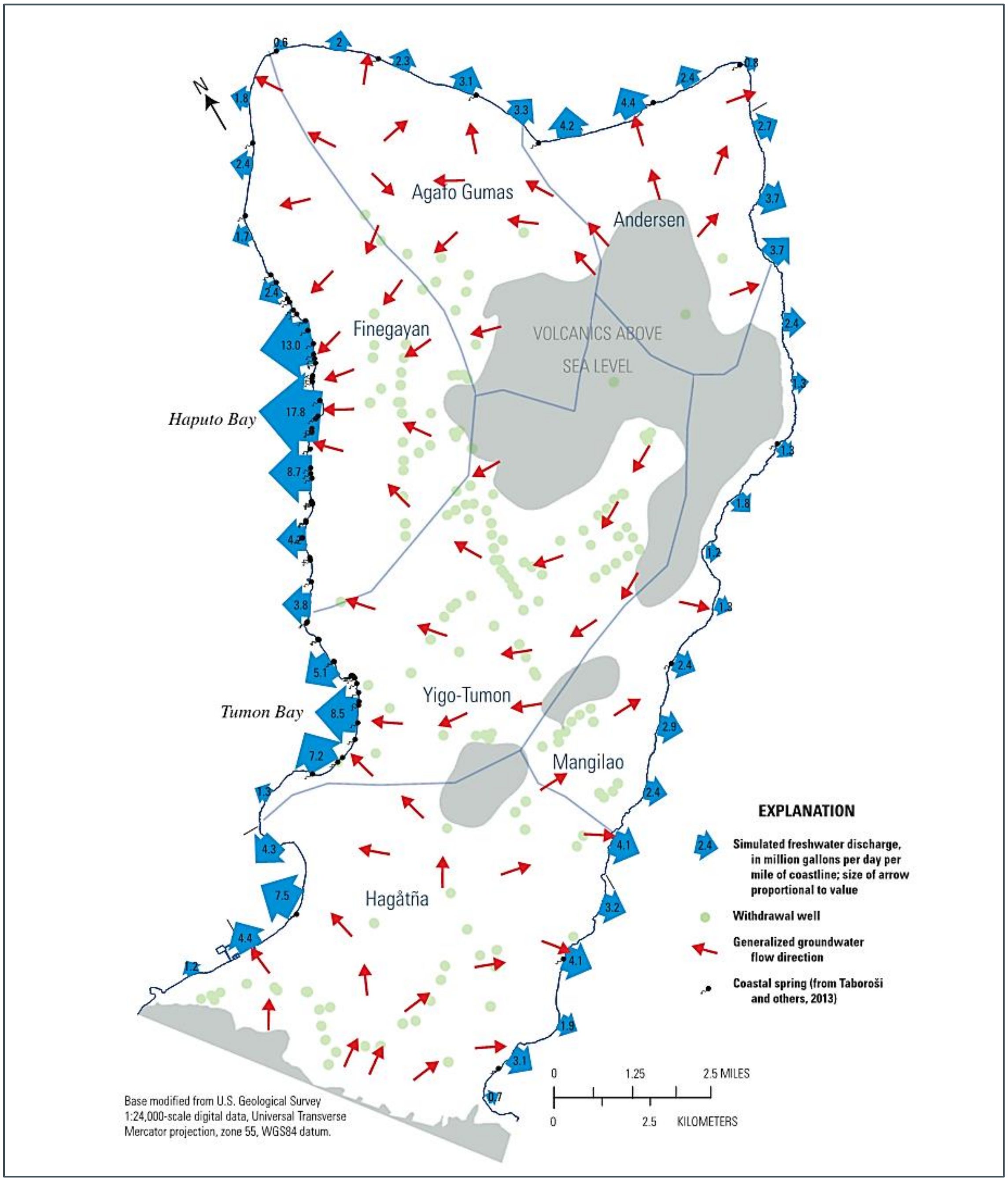
Source: www.north.hydroguam.net

Figure 5-3. Subsurface of the NGLA

Brown AND Caldwell

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The limestone of northern Guam is karst terrain, created from the dissolution of limestone. Karst terrain is characterized by springs, caves, sinkholes, and a unique hydrogeology that results in aquifers that are highly productive. Karst hydrogeology is typified by a network of interconnected fissures, fractures, and conduits (USGS, 2016). Most of the groundwater flow and transport occurs through the network of openings making flow modelling particularly challenging. Figure 5-4 illustrates the six sub-basins, estimated direction of groundwater flow and estimated groundwater discharge volume through the NGLA (Gingerich, 2013). Withdrawal wells and the location of volcanic formations above sea level are also depicted.



Source: Gingerich 2013

Figure 5-4. NGLA Groundwater Flow and Discharge

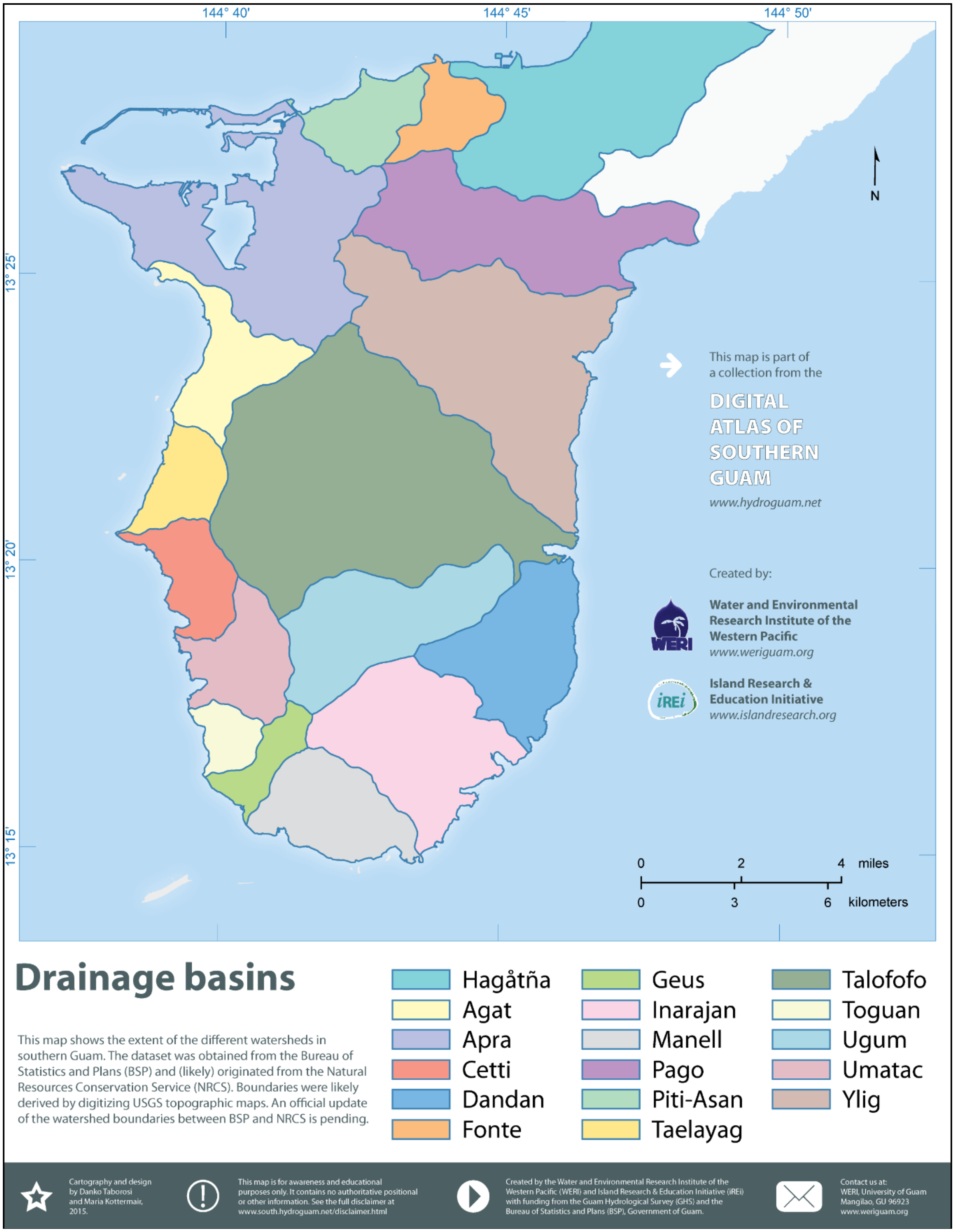
Use of contents on this sheet is subject to the limitations specified at the end of this document.

Water levels in the NGLA vary daily and seasonally in response to ocean tides, recharge rates, and groundwater withdrawal. Well water levels can increase several feet in a matter of days when large storm events and associated runoff occur.

Surface water provides the predominant source of potable water in southern Guam. Guam has 97 rivers and streams, ranging in length from 0.6 miles to more than three miles. All of the rivers and streams are found in the central and southern half of the island. In southern Guam, a mountain ridge runs along the western coast and creates small, steep drainage basins to the west. To the east, broader floodplains drain into longer, larger rivers. The watersheds of South Guam are illustrated in Figure 5-5. The most important basins for water supply are the Ugum and the Talofofo basins.

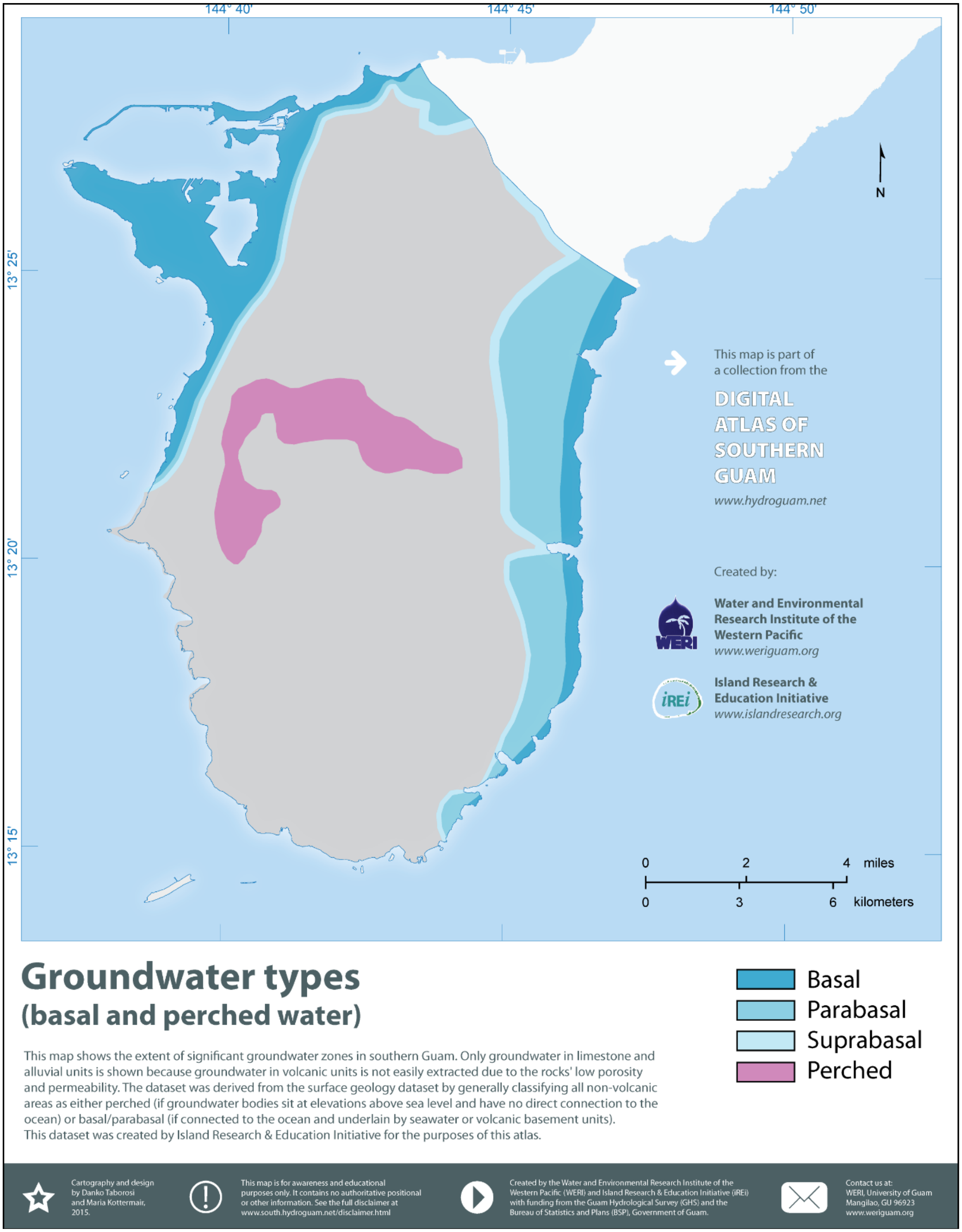
Groundwater in southern Guam is illustrated in Figure 5-6. Basal and parabasal water is found along the coasts where limestone formations and alluvial deposits are present (as illustrated in Figure 5-1). The low porosity and permeability of the volcanic deposits in the south and central highlands are not generally conducive for groundwater extraction, but inland limestone in the center of the region contains a perched water table which supplies springs and recharges the rivers and streams of the area.

Use of contents on this sheet is subject to the limitations specified at the end of this document.



Source: www.south.hydroguam.net

Figure 5-5. Southern Guam Drainage Basins



Source: www.south.hydroguam.net

Figure 5-6. Southern Guam Groundwater

Use of contents on this sheet is subject to the limitations specified at the end of this document.

5.2 Northern Guam Lens Aquifer

Prior to western colonization, most people on Guam lived in the south, where they obtained water from the many streams that form in the volcanic highlands. Habitable sites on northern Guam were confined mainly to coastal areas, where water was available from springs or shallow dug wells. The northern plateau has no inland sources of freshwater except for the modest spring flow issuing from the weathered volcanic rock of Mataguac Hill. With the advent of corrugated steel roofs, residents of Guam came to rely primarily on rooftop rainwater catchments for household water needs. Electrification following World War II, however, made it possible to install wells on the northern plateau, which now produces 80 percent of the island's drinking water and supports the vast majority of the population (Vann, 2014).

Forensic groundwater model simulations indicate that significant changes to the aquifer have occurred as a result of groundwater development. Most notably:

- Water levels are more than 5 feet lower and the fresh water lens is more than 50 feet thinner in the southern part of the Hagåtña basin.
- Water levels are up to 1 foot lower and the fresh water lens is thinner by 10–50 feet in most areas of the Yigo-Tumon basin.
- The zone of parabasal water (freshwater in the limestone above volcanic rocks) has shifted as much as 5,000 feet inland in the interior part of the Yigo-Tumon basin (Gingerich, 2013).

Today there are some 150 active water production wells in the NGLA being operated by GWA, the Navy, Air Force, and private businesses (Bendixson, 2013).

Table 5-1 outlines the history of water resource exploration, research, and development in northern Guam.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-1. History of Water Resource Development – Northern Guam

Timeline	Milestone	Details
1937	First hydrogeologic survey of the island	H.T. Stearns of the USGS creates a hydrogeological map.
1937	First drilling for potable water	Navy brings a drill rig to the island in May and exploration begins a month later.
World War II	Japanese occupation of Guam	No water resource development activities occur.
1944	First military wells developed in the North	MARBO series wells are developed in Yigo.
1947	Tumon Maui Well completed	Constructed in 1947, this relatively shallow well operates to skim underground freshwater from the thin basal layer. The well initially closed in 1995 because of chemical pollution. Last in service in 2003, the well was brought back online in 2016 and is now operated by GWA.
1947	ACEORP Well completed	A second Maui well was attempted at Tamuning (ACEORP, USGS No. 79) in 1947 but encountered brackish water and was abandoned as a water supply point. The tunnel was unfortunately sited within the salinized tongue of groundwater extending from the Ypao peninsula to Barrigada.
1950	Groundwater production in southern Guam investigated	Pacific Island Engineers investigates the possibility of developing groundwater resources in southern Guam but inadequate production from the volcanic bedrock limits large scale development viability.
1950s	Exploratory drilling in northern Guam	Exploratory wells confirm economical amounts of potable groundwater can be produced in northern Guam. Cloud (1951) expresses concerns about possible contamination from military and community sources.
1962–1965	Comprehensive Army-sponsored studies of the geology of Guam	Tracey, Ward et.al. build on previous works to produce more detailed geological information.
1965	First production well completed by Government of Guam	Government of Guam begins to develop the aquifer as the primary source of drinking water for Guam. Within 5 years, 33 wells are installed in the Hagåtña, Dededo, Mangilao, and Finegayan areas. Well sites are chosen based on availability of government-owned land, access, and proximity to successful wells.
1976	Publication of WERI Technical Report #1, Groundwater Resources on Guam: Occurrence and Development (Mink, 1976)	PUAG retains J.F. Mink to prepare a comprehensive report on the groundwater resources of Guam. The report includes recommendations for the successful exploration and proper management of the aquifer.
1982	Northern Guam Lens Study (NGLS)	Commissioned by the Guam EPA with federal support, Camp, Dresser & McKee (CDM) completes the 3-year, $1.2M NGLS. First detailed and state-of-the-art map of the basement topography prepared utilizing seismic surveys, supplemented by data from exploratory well logs and surface geology. Study includes construction of permanent observation wells, rain gauges, evaporation stations, continuous core sampling, seismic survey, recharge and hydraulic conductivity evaluations, and the first numerical modeling of the aquifer. More than 30 years later, the NGLS remains the most comprehensive study ever performed, and is the key reference and empirical tool for aquifer research, planning and development. The study is limited to non-military lands.
1990s	Installation Restoration Program (IRP)	Throughout the 1990s, DoD sponsors IRP projects on Guam military installations resulting in significant aquifer study.
1992	NGLS Update	New hydrologic data and modelling capabilities update the 1982 NGLS.
1992–2000	Drilling activity based on NGLS	68 boreholes are drilled, targeting the parabasal areas identified in the NGLS. 40 percent of these boreholes are dry.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-1. History of Water Resource Development – Northern Guam

Timeline	Milestone	Details
1994	Successful completion of Well Y-15	The well provides very high-quality water (<40 mg /L chloride) and 550-600 gallons per minute (gpm), in the suprabasal zone.
2000	Updated hydrogeological map produced (Vann, 2000)	Drilling data obtained on the military installations in the 1990s from the IRP, along with new borehole data from the aggressive exploration by PUAG in the 1990s, prompted WERI in 1998–2000 to produce an updated map, which includes military areas.
2010	Military buildup announced	Naval Facilities Engineering Command Pacific (NAVFACPAC) launches a new round of exploration in support of the anticipated military buildup on Guam. Intensive exploration (AECOM Technical Services Inc., 2011), focused exclusively on military lands, provides important new data precisely where the previous map had been least reliable and where new data were thus needed most.
2010	USGS Groundwater Availability Study	USGS conducts the $1.2M Groundwater Availability Study for Guam (Gingerich and Jenson, 2010). Components include: 1. NGLA database 2. Aquifer recharge study 3. Field study of regional hydraulic conductivity 4. Aquifer basement map update 5. Three-dimensional numerical model of the aquifer to help predict the response of the lens to anticipated development and natural changes in recharge
2013	NGLA declared Non-GWUDI	Issue of whether or not the NGLA is under the direct influence of surface water is resolved.
2015	Guam Drinking Water Source Assessment and Protection Program (DWSAP) and Wellhead Protection Plan (WHPP)	The DWSAP and WHPP lay the foundation for protection of GWA-supplied water quality from contamination in northern Guam.
2016	NGLA Monitoring System	Present monitoring system consists of seven deep monitoring wells installed in 1981–1982 (rehabbed in 2010), two test borings advanced in 2010, and four failed production wells converted to monitoring wells. Monitoring system to be expanded in 2017 with funding secured from the Economic Adjustment Committee Implementation Plan (EACIP).

5.2.1 Groundwater Under the Direct Influence of Surface Water

GWUDI is a regulatory designation of a groundwater source for which analytical tests indicate that there is a possibility that untreated surface water could infiltrate the groundwater near the source. An aquifer designated as GWUDI could potentially contain contaminants that may pose a risk to public health.

The high permeability of the limestone in northern Guam has the potential for rapid infiltration of rainfall, and the large pore size in the limestone formations may allow contaminants (if present in the surface water) to reach the groundwater aquifer. As a result, the NGLA was considered for designation as GWUDI.

In a December 2013 Formal Letter to GWA, Guam EPA declared that Guam's groundwater is not GWUDI of surface water and therefore is not subject to applicable local and federal Surface Water Treatment Rules. This declaration, based on a subsequently released study (Heitz, 2014), officially closed the issue. Water produced by both GWA and DoD from the NGLA are not GWUDI.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

5.2.2 Resource Supply and Quality

GWA owns and operates 124 deep wells (including Santa Rita Springs), 22 of which are either inactive, secured, on standby or not completed for production (wells Y-08, AG-10, and AG-12 have been drilled, but are not currently developed). All of the active and most of the inactive wells are in the Northern Public Water System, and there are two secured wells in the Southern System at Inarajan. A detailed listing of the wells, including production levels and permitted rates, is provided in Volume 2 of the 2016 WRMPU.

In July 2016, GWA began operating the Navy-owned Tumon Maui Well. Production from this relatively shallow well, inactive since 2003, should allow for several smaller wells currently experiencing high chloride levels or other contamination to be removed from service.

Groundwater quality is monitored by GWA according to the requirements of Guam Primary and Secondary Safe Drinking Water Regulations (GPSSDWR). A detailed discussion of compliance history was included in the 2006 WRMP, and updated in Section 6.2 in this Volume 1. Historically, wells have been vulnerable to contamination by underlying salt water, turbidity, and anthropogenic pollutants introduced into the aquifer by a variety of pathways. Threats to NGLA water quality are discussed more fully in Section 5.2.5.

5.2.3 Resource Demand

Withdrawals from the NGLA by GWA, the military, and privately-owned wells are presented in Table 5-2. The proportion of NGLA withdrawals attributable to GWA ranged between 86 and 90 percent between 2011 and 2015, underscoring the importance of the NGLA. Demand fluctuates from year-to-year depending on population and climactic conditions.

Table 5-2. NGLA Withdrawals (mgd)

Year	GWA [a]	Navy [b]	Air Force [b]	Other [c]	Total	Percent of Total Withdrawal by GWA
2011	37.7	1.68	2.37	1	**42.3**	89%
2012	35.6	2.05	2.64	1	**41.3**	86%
2013	33.3	2.07	2.12	1	**38.4**	87%
2014	34.9	2.16	2.00	1	**39.3**	89%
2015	35.0	1.98	2.09	1	**39.0**	90%

a. Source: GWA raw production data

b. Source: 2011–2012 BC, 2013–2015 Andersen AFB and Navy well production reports

c. Estimate

Although improved leak detection and implementation of the metering program are speculated to have contributed to an observed decrease in withdrawals between 2011 and 2015, the trend over nearly 70 years of NGLA usage has been upward. Table 5-3 lists production history since 1947. Figure 5-7 clearly shows the steady upward trend between 1947 and 2011, and the expected continuation through 2035.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-3. Production History – Northern Guam		
Year	Withdrawal (mgd)	Reference Source
1947	7	Sundstrom (1947)
1974	23	Mink (1974)
1996	35	U.S. Department of Agriculture (1999)
2011	42	GWA/DoD well production records
2015	39	GWA/DoD well production records
2035 (estimated)	47	Vann (2014) and GWA (2016)

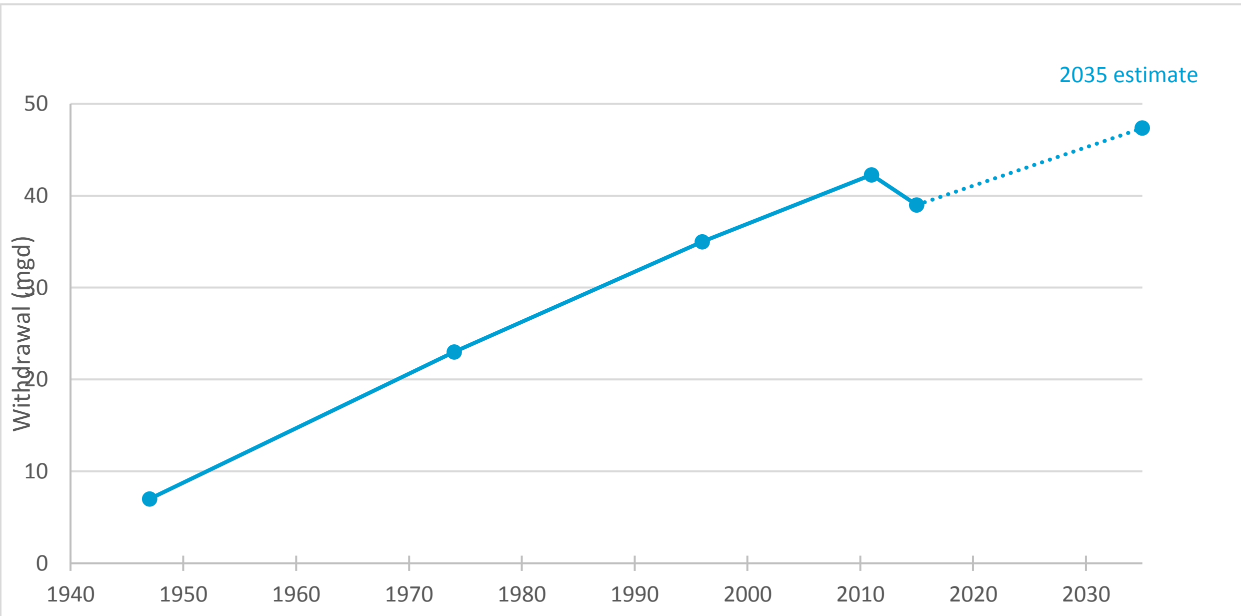


Figure 5-7. NGLA Withdrawals 1947–2035

Future GWA demands based on population growth are estimated in Volume 2 of the 2016 WRMPU. Even if the Air Force and Navy withdrawals do not change, annual withdrawal from the NGLA would be expected to increase to approximately 47 mgd by 2035 (42 mgd GWA, 4 mgd military, and 1 mgd private usage). Based on a historical ADD:MDD (average day demand to maximum day demand) ratio of 1:1.15, the required withdrawal to meet the MDD in 2035 is approximated at 55 mgd.

5.2.4 Sustainable Yield and Sustainable Management

Sustainable yield has been defined for Guam as the maximum amount of water that can be continuously withdrawn from the freshwater lens without impairing the integrity of the lens and the water quality (CDM, 1982). To sustain a groundwater resource in an ocean island setting, the rate of groundwater withdrawal would be significantly less than the rate of recharge because seaward flow of groundwater is required to maintain the freshwater lens (2010 EIS). Sustainable yield for the NGLA is estimated at approximately 80 mgd (Mink, 1991).

Table 5-4 (reprinted from the 2010 NAVFAC EIS) illustrates the available capacity of the NGLA subbasins. The table lists the subbasins, their sustainable yields, and total aquifer pumping rates as calculated in 2008 by NAVFAC.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-4. Sustainable Yield Estimates and 2008 Annual Average Pumping, NGLA			
Subbasin	1991 Sustainable Yield (mgd)	2008 Well Production (mgd)	2008 Estimated Available Yield (mgd)
Agana	20.5	10.9	9.6
Mangilao	6.6	2.5	4.1
Andersen	9.8	0.7	9.1
Agafa-Gumas	12.0	0.0	12.0
Finegayan	11.6	8.2	3.4
Yigo-Tumon	20.0	21.3	-1.3
Total	**80.5**	**43.7**	**36.8**

Notes: The current available yield is the difference between current well production and the 1991 sustainable yield.

Numbers may not add exactly due to rounding.

Sources: Mink 1991, USGS 2007, NAVFAC 2010

Based on these estimates, it is clear that from a sustainable yield perspective groundwater resources are underdeveloped within the Andersen and Agafa-Gumas subbasins, compared to the southern subbasins. A parabasal zone exists in both the Andersen and Agafa-Gumas subbasins, meaning that these subbasins have potential for increased development.

The sustainable yield approach is useful for providing a benchmark to managers and regulators and for keeping users aware that the resource is limited. This approach is restricted, however, by several factors (Gingerich, 2013):

1. The definition of impairment is largely subjective and may involve many criteria.
2. Sustainable yield estimates are based on the amount of acceptable quality water that might be obtainable from an ideal extraction system rather than based on the infrastructure in place. In principle, to achieve production at 100 percent of sustainable yield, some consumers would likely be getting water at a lower quality than others.
3. Sustainable yield estimates for Guam, which are based on some fraction of recharge, have traditionally not accounted for the dynamic responses of the aquifer system to withdrawal or natural changes in recharge (Bredehoeft, 2002).

Today, the concept of sustainable yield has been superseded by “sustainable management.” Sustainable management is a broader model which, in addition to looking at ways to improve the efficiency of production and delivery as resource use expands, also implies managing demand for the resource, supplying different levels of quality and quantity to meet different demands for different uses, and promoting conservation and efficiency of use (Gingerich, 2013).

Sustainable management of the NGLA is enhanced by advanced groundwater models developed by the USGS, WERI, and others, which enables analysis of the impact of different hypothetical withdrawal scenarios on water quality. This information, derived from research combined with a rigorous monitoring program and information database, will allow GWA and other policy-makers to know the volume of water that can be sustainably withdrawn from various parts of the aquifer, and how increased withdrawal will affect salinity and other contaminant transport. Production is not equal from all basins, and several basins (Finegayan at 95 percent utilization, and Agana at 92 percent, for example) have little reserve capacity that remains to be sustainably developed.

The extent to which quantity and quality might be optimized is ultimately constrained by the natural limits on aquifer recharge, storage, and water quality imposed by climatic and geologic conditions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Research is ongoing into the maximum natural capacity of the NGLA to provide a baseline against which to evaluate future proposals for holistic sustainable management approaches.

It is recommended that GWA continue to take a leadership role in the development of sustainable management practices for the NGLA. As part of this role, GWA should develop policy around supply-to-demand ratios and when planning for expansion of the source water supply network, consider both economic and sustainability factors.

5.2.5 Threats to Groundwater Supply and Quality in the NGLA

Ultimately, the amount of water required to be withdrawn from the NGLA depends on the number of people living on and visiting Guam, and how the land is utilized. As the rate of withdrawal increases, the aquifer becomes more vulnerable to contamination from salt water below and from human activities above. Supply is also influenced by recharge, drought, and seasonal climate fluctuations.

The following section outlines major threats to groundwater supply and quality.

Salinity

Salinity is one of the main factors controlling groundwater availability in the NGLA. The 2009 Guam EPA Annual Production Well Inspection Report required 13 of GWA's production wells to decrease production due to chloride levels and noted that 16 were approaching the chloride limit (GWA, 2010).

In general, the salinity of water withdrawn from wells increases with depth, proximity to the coast, and withdrawal rate. The wells producing the most saline water are generally closer to the coast, completed deeper in the fresh water lens, or pumped at the highest rates (McDonald and Jenson, 2003; Simard 2012).

Analyses of chloride concentrations revealed statistically significant upward trends in chloride concentration in 118 of the 153 production wells in the NGLA between 1973 and 2010 (Simard, 2012). Additionally, the chloride trends showed increased variability and cyclical patterns during the 1990s and 2000s when compared to earlier years. The cyclical patterns are most likely correlated with the fluctuations due to El Niño/La Niña episodes superimposed on a trend of rising sea level (Simard, 2012). Another observation has been increasing chloride trends in the suprabasal groundwater zone. This may indicate meteoric and/or man-made chloride sources other than over-pumped or over-deep wells (Simard, 2102). Dry salt deposited on the surface of the ground becomes entrained in water that percolates downward into the aquifer, adding another increment of salt to the groundwater.

McDonald (2003) characterized general patterns for wellhead chloride concentrations over three decades:

- Wells that start with good quality water and exhibit only gradual increases of relatively small magnitude have generally been constructed and managed according to design and pumping rate recommendations. Some general increase in chloride concentrations across well fields can be expected, as the portion of the lens from which water is being extracted equilibrates to the new water balance imposed by the extraction (Todd, 1980).
- Wells where chloride concentrations climb rapidly after the start of operation are almost certain to have been drilled too deep, pumped too hard, or both.
- Wells that maintain acceptable chloride levels for years but then exhibit sudden increases may have been designed and managed properly until the pumping rate was increased excessively or may have responded to interference from subsequent additional wells installed too close, or to some diversion of recharge that previously went to the well. Chloride levels may be brought down

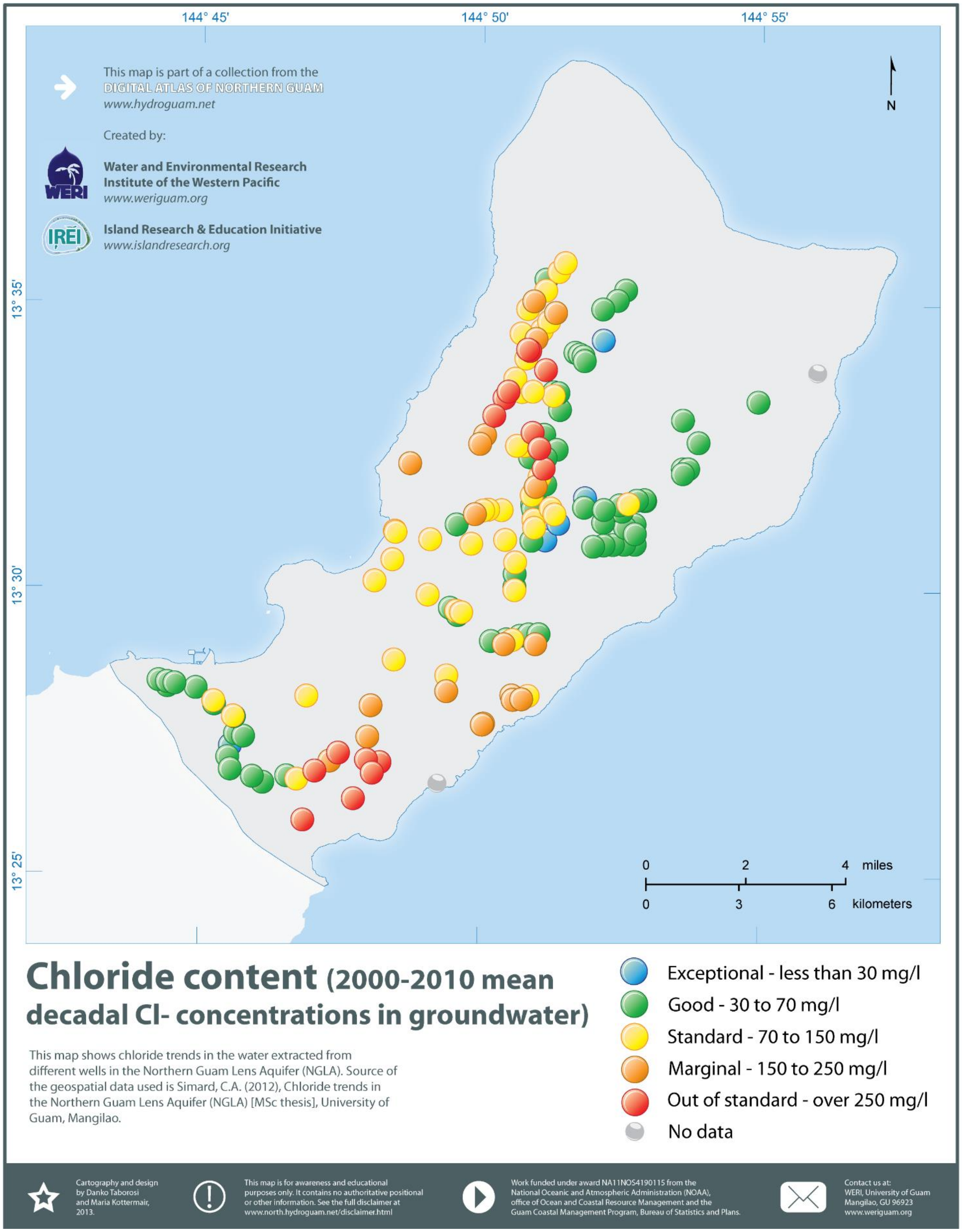
Use of contents on this sheet is subject to the limitations specified at the end of this document.

by reducing the pumping rate of the well or nearby wells or shutting the well or nearby wells down for long enough to allow the lens to recover. However, if the well has been drilled so deep that it penetrates into the transition zone, reducing the pumping rate may not suffice for long-term recovery.

- Wells that produce high chloride water from the start of their operations are almost certain to have been designed or installed improperly at the beginning. Such wells were probably drilled much too deep, terminating in the saltwater transition zone. For these wells, no pumping rate will be sufficiently low to obtain water with desired low chloride concentrations. The only remedy is to close the well and install a new well in an unaffected area.

Figure 5-8 illustrates the ten-year average chloride concentration in NGLA production wells between 2000 and 2010. In this figure, a concentration noted as “exceptional” corresponds to chloride levels in the parabasal zone, and “standard” to levels found in basal zone wells. Saltwater intrusion is inferred if the chloride levels increase above 150 mg/L (noted as “marginal” in the figure), and the Secondary Safe Drinking Water contaminant guideline for chloride is 250 mg/L. The chloride concentration found in pure sea water is 19,000 mg/L.

Use of contents on this sheet is subject to the limitations specified at the end of this document.



Source: www.north.hydroguam.net

Figure 5-8. Average NGLA Chloride Levels 2000–2010

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Impacts of withdrawal and drought on the groundwater availability in the NGLA were analyzed by the USGS in 2013 (Gingerich, 2013). The analysis included five withdrawal scenarios:

1. Future demands without the military buildup.
2. Future demands including the military buildup.
3. Scenario 2, with redistribution of withdrawal from DoD wells with poor chloride concentration to other DoD wells.
4. Scenario 3, with a 5-year drought (reduced recharge).
5. Scenario 2, with redistribution of withdrawal from GWA and DoD wells with poor chloride concentration to other GWA and DoD wells.

The results were classified by the amount of available withdrawal with “acceptable” chloride concentration (less than 200 mg/L), “cautionary” (200 to 500 mg/L), or “threatened” (greater than 500 mg/L). The model results are summarized in Table 5-5.

Table 5-5. USGS Analysis of Well Pumping Scenarios

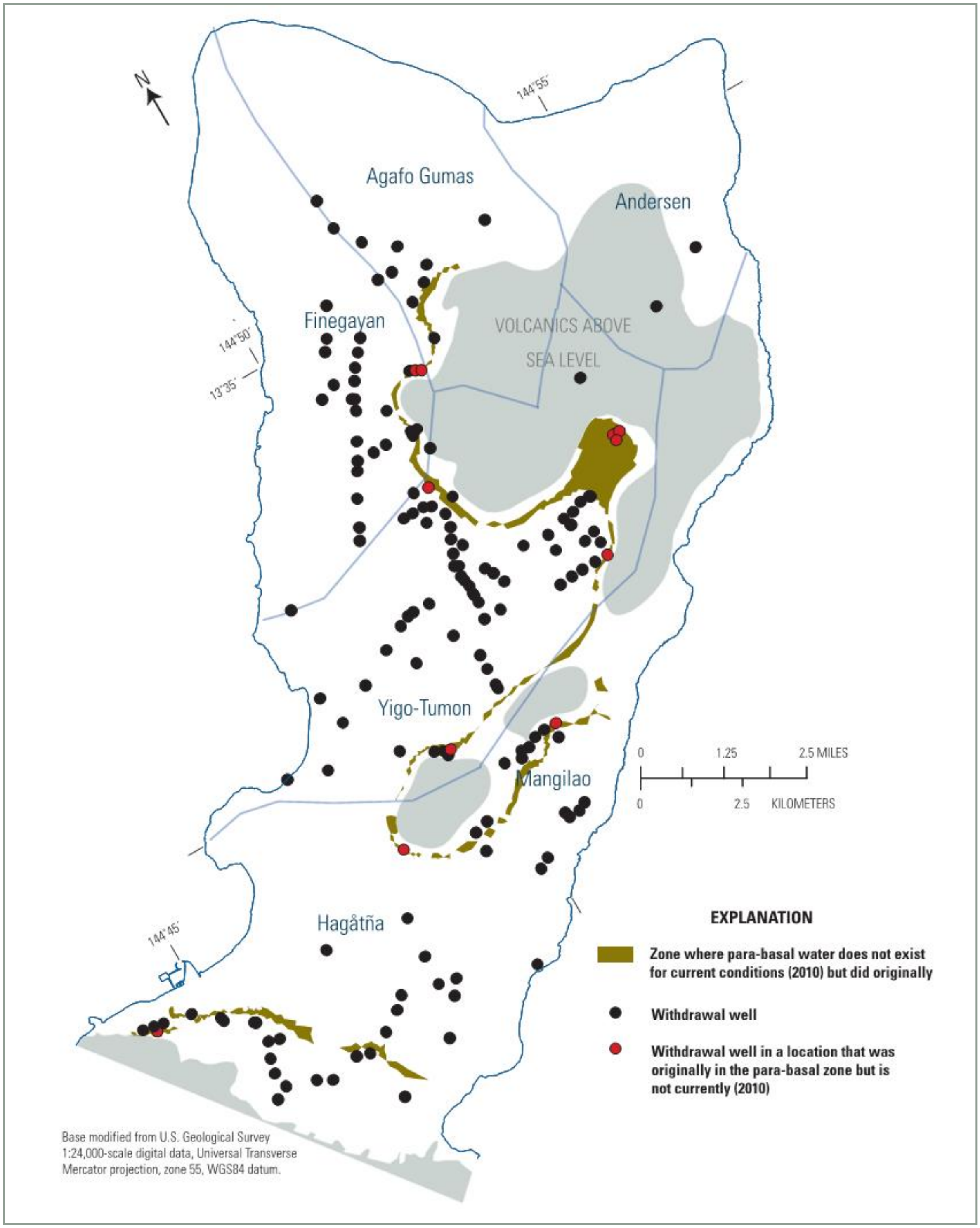
Pumped Well Yield (Chloride Concentration, mg/L)	Withdrawal for Each Scenario (mgd)				
	1	2	3	4	5
Acceptable (< 200)	38.5	39.9	40.2	14.9	41.4
Cautionary (200-500)	3.7	4.4	4.1	19.6	5.1
Threatened (> 500)	2.6	2.6	2.3	12.1	0
Total	**44.8**	**46.9**	**46.6**	**46.6**	**46.5**

Scenario 5 illustrates a maximum demand scenario with optimized withdrawal. The effect of redistributing withdrawal throughout the aquifer is that the number of wells classified as “threatened” decreases to zero, and a corresponding preservation of water quality and availability of water classified as “acceptable” takes place.

The current average production for GWA and DoD (2012–2015) of 38.99 mgd remains lower than the total future withdrawal predicted by this USGS study. The study illustrates how careful cooperation, integration, and balancing of well production levels by GWA and DoD can be utilized to sustainably manage chloride concentrations as demand increases.

The shape, thickness, and extent of the fresh water lens is not static over time. One of the scenarios looked at by Gingerich (2013) involves modeling the movement of the basal/parabasal interface in response to groundwater withdrawal. Figure 5-9 illustrates the findings.

Use of contents on this sheet is subject to the limitations specified at the end of this document.



Source: Gingerich 2013

Figure 5-9. Parabasal Water Relative to Pre-Development Conditions

Relative to predevelopment conditions (with zero withdrawal), the simulated fresh water lens for current conditions shrank in response to groundwater withdrawal. The greatest shift is in the northern part of the Yigo-Tumon basin, where the most seaward extent of the zone of parabasal water moved more than 5,000 feet inland. In ten locations, the parabasal zone is now landward of

Use of contents on this sheet is subject to the limitations specified at the end of this document.

wells that were originally drilled into the parabasal zone; therefore, the wells are now more vulnerable to salinity increases because pumping could induce flow from the saltwater that has encroached landward to lie below the well (Gingerich, 2013).

Unsewered Areas

Of the 55,567 housing units tabulated for the 2010 U.S. Census, only 36,624 were indicated as connected to the public sewer. In addition to the residential properties, many commercial and industrial operations are also not connected to the GWA collection network. These unsewered properties utilize septic or cesspool systems, and discharge from these systems can percolate down through the limestone of northern Guam towards the water table.

The extent of sewered and unsewered properties overlying the NGLA is illustrated in Figure 5-10 and Figure 5-11. Sewered customers are indicated by green markers. Proximity of the unsewered properties to wastewater collection mains is depicted by purple and gray markers—the properties closest to the mains have the darkest markers. Drinking water wells are also shown, with wellhead protection areas of 300 feet and 1000 feet diameter around the wellhead. Unsewered properties exist within the wellhead protection areas, and up-gradient of drinking water wells.

Properties unconnected to the sewer system have the potential to contribute nitrate-nitrogen to the NGLA. Other potential sources of nitrate-nitrogen include wastewater collection lines, golf courses, farms, piggeries, fish farms, pastures, and ponding basins. MacDonald (2002) analyzed 23 years of nitrate-nitrogen data from 147 water wells in northern Guam. Although concentrations did not exceed the GPSSDWR maximum of 10 mg/L, 39 wells indicated increasing nitrate-nitrogen trends. The results are included as Figure 5-12. The Mangilao sub-basin had the highest number of wells with statistically increasing nitrate-nitrogen concentrations. Although further testing would be required to definitively determine hydraulic relationships between potential nitrogen sources and downgradient sites, preliminary conclusions can be drawn from groundwater flow paths, well locations, nitrate-nitrogen concentrations, and overland activities. MacDonald recommended that wells identified as having increasing nitrate-nitrogen trends, or having average and/or maximum levels greater than or equal to 4 mg/L should be closely monitored. Areas of special concern should include the cluster of GWA wells and Mangilao Golf Course wells in the Mangilao sub-basin.

A model has also been developed to predict nitrogen transport through the NGLA (Habana et. al., 2013). Nitrogen contamination of the NGLA from septic effluent and sewer line discharge can be modeled. Results of the study can be utilized to analyze and prioritize septic connections and sewer main upgrades.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

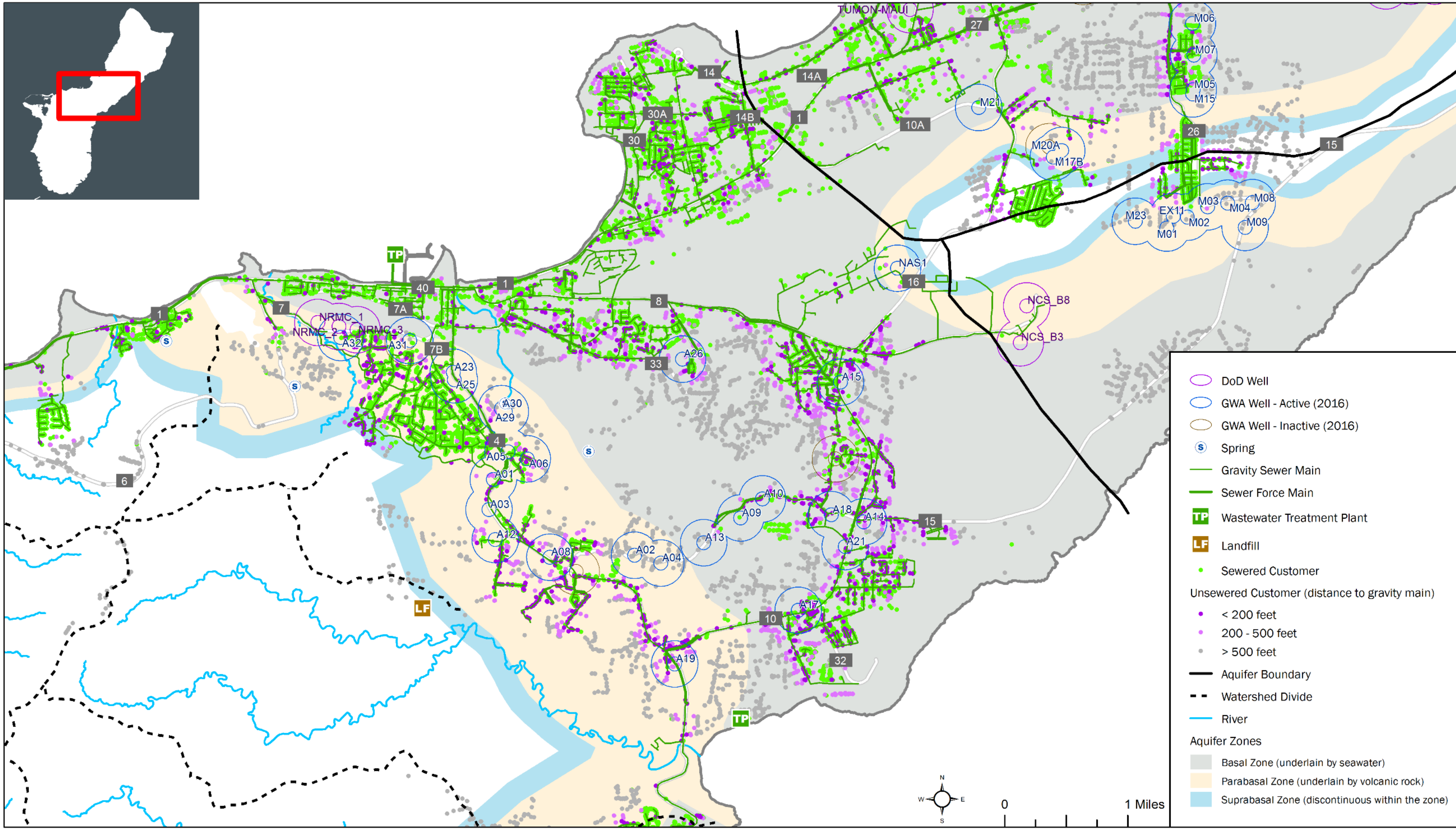


Figure 5-10. Wells, Septic Systems, and Groundwater (1)

Brown AND Caldwell

Use of contents on this sheet is subject to the limitations specified at the end of this document.

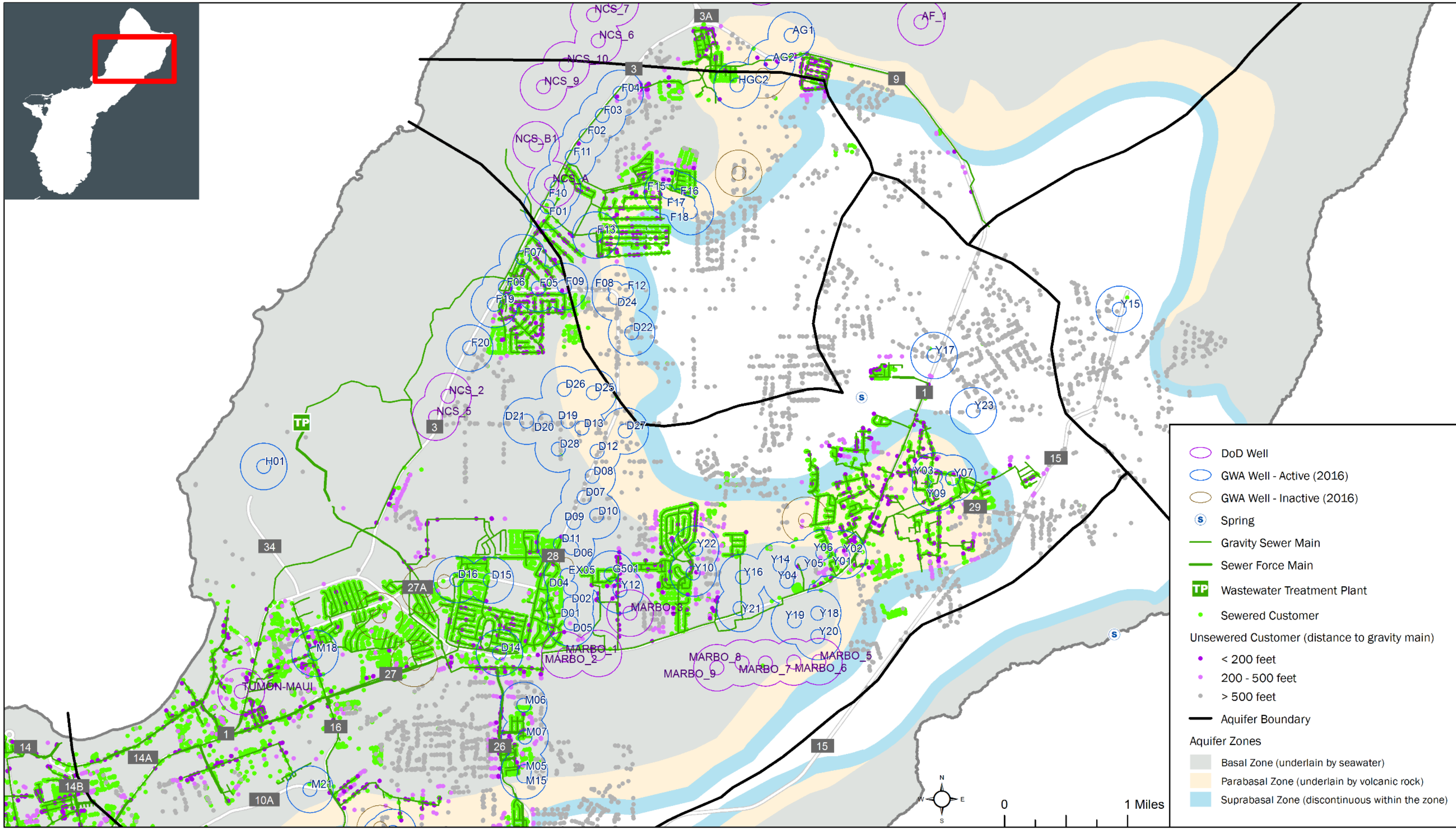
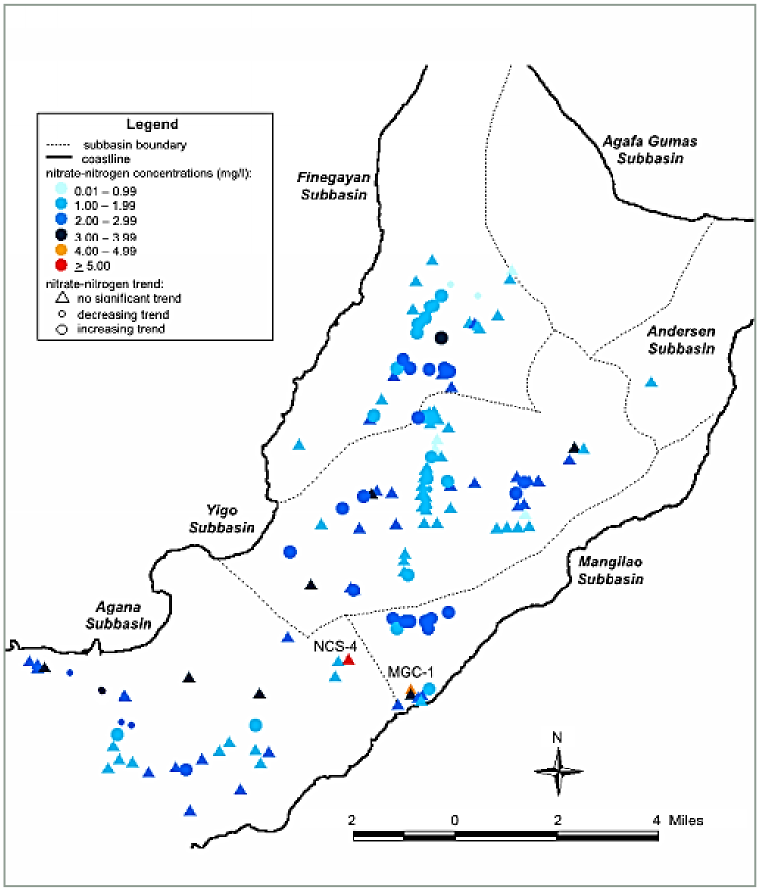


Figure 5-11. Wells, Septic Systems, and Groundwater (2)

Use of contents on this sheet is subject to the limitations specified at the end of this document.



Source: McDonald 2002

Figure 5-12. Trends and Average Concentration of Nitrate-Nitrogen

Connecting presently unsewered properties will increase GWA customer base and revenue and help protect the NGLA from contamination related to on-site disposal systems. GWA has established a goal to construct 5,000 feet of sewer line each year into developed areas that are currently unsewered (see Table 3-1). Because there are thousands of properties, a method of prioritization is recommended. Table 5-6 outlines the criteria to be considered.

Table 5-6. Non-Economic Prioritization of Septic Connections

Category	Criteria	Priority level		
		High	Medium	Low
System Conditions	Existing system	Cesspool	Septic	
	Age of system	More than 20 years	Between 5 and 20 years	Less than 5 years
	Gang system	More than one property connected		Single property connected
	Use	Institutional or Industrial	Commercial	Residential
	Distance to existing main	Less than 200 feet		More than 200 feet
	Volume of wastewater generated	Higher		Single family
Environmental Conditions	Proximity to groundwater supply well	Within 300 horizontal feet of deep wells, or underground Tumon Maui well collection tunnel	Within 300–1000 feet of deep wells, or underground Tumon Maui well collection tunnel	More than 1000 feet away from deep wells, or underground Tumon Maui well collection tunnel
	Proximity to groundwater supply well listed as vulnerable in WHPP	Yes		No
	Proximity to groundwater supply well with elevated nitrate concentrations	Within 1000 feet	1000–2500 feet	More than 2500 feet
	Upgradient of groundwater supply well	Yes		No
	Underlying geology [a]	Suprabasal zone	Parabasal zone	Basal zone
	Permeability of underlying rock	More permeable		Less permeable
	Proximity to any surface water, sink holes, stormwater injection wells	Within 300 feet	300–1000 feet	More than 1000 feet
	History of flooding or ponding in the area	Once per year or more	Less than once per year	Never
GWA Infrastructure	Cost of connection to GWA	Sewer main within 200 feet		New trunk main or lift station required
	Condition of existing GWA infrastructure	Area of known leaks, high infiltration and inflow (I/I), or overflow		No known issues with collection system
Surrounding Properties	Concentration of unsewered properties within area	Many		Few
	Average lot size in area	Small		Large
Other	Other public works projects (road upgrades, etc.) planned for the area	Yes		No

a. Refer to Section 5-2 for a description of the geology

Use of contents on this sheet is subject to the limitations specified at the end of this document.

To reduce the potential for contaminants entering the NGLA, creation of an On-Site Disposal System Reduction Strategy is recommended. The strategy should include:

- A 5-year plan to reduce or eliminate the construction of new septic systems over the NGLA.
- A 5-year plan to connect existing septic/cesspool properties currently located within 200 feet of a sewer main and/or within wellhead protection zones.
- A long-term strategy to connect all existing septic/cesspool properties overlying the NGLA to connect a portion of the unsewered customers. Section 4.3 in Volume 3 discusses a 20-year plan with the construction of 5,000 feet of new sewer lines per year. The section contains a map that shows that the 20-year plan would only connect a portion of the unsewered customers.

An On-Site Disposal System Reduction Strategy will require multi-agency coordination including GWA, the Department of Land Management, and Guam EPA. Reducing septic connections may necessitate consideration of regulatory requirements and enforcement, GWA policy, incentive programs, septic surveys, building permit processes, issuance of variances, subdivision development laws, a Land Use Master Plan, zoning regulations, and water quality monitoring.

Additional items to be considered in the planning section of an On-Site Disposal System Reduction Strategy include the diameter of newly-constructed gravity collection system mains, which should be large enough to facilitate the future connection of additional customers.

New water system piping construction should be coordinated with new collection system piping construction to minimize cost and disturbance. This should especially be considered when piping is constructed to connect to new water wells, such as the planned AG-2 and AG-10 wells.

Land Development

Land development can impact both groundwater supply and quality. Development alters the land surface, and the corresponding pathways for precipitation to reach the aquifer. If not managed properly, land use activities have the potential to introduce constituents into the underlying soil which may make their way into the groundwater. In addition, as new properties are developed, water system supply, storage, and delivery requirements change.

Additional information regarding planned land development is found in Section 4.5 (Planned Development). Two geographic areas of growth in particular have the potential to affect the availability of source water in northern Guam: development of the Chamorro Land Trust tracts (noted as numbers 3 and 8 on Figure 4-16) and the relocation of U.S. Marines from Okinawa, Japan to the island (numbers 1 and 2 on Figure 4-16).

Impacts to the NGLA associated with the military relocation are discussed in Section 6 (Enterprise Environmental Factors). Table 5-7 summarizes the impacts and mitigation of the buildup activities.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-7. Issues, Impacts, and Mitigation of Military Relocation Activities on the NGLA [a]			
Impact	**Issues**	**Concerns**	**Mitigation**
Increased wastewater flow through GWA interceptor sewer from Andersen AFB to Northern District WWTP during both construction and operations activities	• System spills exceed spill rate norms for similar wastewater systems	• Increased wastewater flows could lead to additional spill frequency and/or volume, with contaminants making their way into the aquifer	• EACIP outlines the need for federal assistance to complete refurbishment of the interceptor sewer between Andersen AFB and Northern District WWTP (value: $28.8 to $30.6 million)
Increased volume withdrawn from NGLA	• New wells will be installed at Andersen AFB to meet demand through NGLA withdrawal	• Additional withdrawal volumes could impact groundwater availability	• Sustainability and conservation measures such as low flow fixtures, Leadership in Energy & Environmental Design (LEED), and xeriscape may be utilized • The Guam Water Resources Development Group (GWRDG) will identify operational adjustments to be implemented during drought • Existing DoD water systems will continue to be improved to reduce leaks • Pumping rates from DoD wells will be adjusted • Use of surface water from Fena Reservoir will be increased to reduce withdrawals from NGLA • Tumon Maui well production (brought online in 2016) will reduce water drawn from other wells with high salinity
	• Overpumping could result in salinization	• Increased chlorides can result in aquifer contamination and decreased water quality	
	• Overpumping could result in reversal of groundwater flow gradient	• Reversal of groundwater flow could result in the migration of contaminants thought to be downstream of drinking water supply wells	
Increase in pollutants transported from ground surface to aquifer	• Topographical features at Finegayan and the LFTRC indicate the presence of sinkholes	• Sinkholes provide a direct pathway to groundwater from the surface for both recharge and introduction of pollutants	• A geotechnical study to determine the location of any sinkholes, and a hydrogeological investigation to confirm groundwater flow will be completed • Best management practices (BMPs) will include compliance with regulatory requirements
	• Location of new wells	• New wells drilled in the vicinity of known sources of contamination • Exploratory wells provide potential route for contamination to enter the aquifer • Development within vicinity of existing wells can affect local water quality	• New wells will be sited away from known sources of contamination • Exploratory wells not converted to production wells will be properly sealed and backfilled • Wells will be constructed in compliance with Guam EPA regulations • 1000-foot buffer and wellhead protection zones will be established around new production wells
	• Stormwater runoff generated during construction and operations	• Stormwater picks up pollutants such as sediment, nutrients, suspended solids, and	• Erosion and sediment control BMPs will be implemented during construction

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-7. Issues, Impacts, and Mitigation of Military Relocation Activities on the NGLA[a]			
Impact	**Issues**	**Concerns**	**Mitigation**
		heavy metals as it flows over developed areas • Infiltration of polluted water into the underlying aquifer	• Low Impact Development (LID) practices to manage runoff quality and quantity will be implemented in site design • Pre-development hydrology will be mimicked in site design by using stormwater control and treatment structures as necessary • Presence of pollutants in the environment will be minimized through integrated pest management, native plant landscaping, avoidance of pesticides and fertilizers, etc. • A Storm Water Management Plan (SWMP) and associated field monitoring program will be developed
Increased chlorides in aquifer	• Overpumping could result in salinization • Improper location or screen depth	• Increased chlorides can result in aquifer contamination and decreased water quality	• Water quality will be monitored during well completion • The GWRDG will identify operational adjustments to be implemented during drought • Pumping rates from DoD wells will be adjusted • Tumon Maui well production has been online to reduce water drawn from other wells with high salinity
New cantonment facilities may be within the wellhead protection zone of existing DoD wells at Finegayan and GWA wells along Route 3	• Proximity of existing wells to buildup-related development	• Groundwater contamination could result if construction or operations activities take place within the wellhead protection zone	• All construction and operation activities within the wellhead protection zone will be in accordance with Guam EPA regulations • GWA will monitor and implement Wellhead Protection Program for existing wells
Change in ground cover over NGLA	• 854 acres of secondary limestone forest is to be removed • Increase in impervious area (280 acres /24 percent) at Finegayan and decrease (40 acres/10 percent) at Andersen AFB	• Decreased groundwater recharge can affect supply • Potential for stormwater pollutant loading as a result of overall runoff increase during design storms	• Stormwater runoff protection measures will be implemented during construction • Environmental and hydrogeologic assessment for the selected alternative will be performed for sinkholes within the project development footprint to ensure adverse effects to groundwater resources would not occur • LID practices will be implemented to manage runoff quality and quantity • Project design will include vegetated swales for conveyance and treatment and

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-7. Issues, Impacts, and Mitigation of Military Relocation Activities on the NGLA[a]			
Impact	Issues	Concerns	Mitigation
			detention/retention ponds capable of capturing, storing, and treating additional runoff from the 25-year design storm • Groundwater pumping will be adjusted for changing recharge rates
Aquifer sustainability	• NGLA is the sole source water supply for more than 80 percent of Guam	• Monitor NGLA water quality.	• EACIP outlines the need for federal assistance to install additional NGLA monitoring wells (value: $2.2 to $3.7 million)[b]

a. Source: 2015 SEIS

b. Source: 2015 EACIP, estimates in 2016 dollars

Two large tracts belonging to the Chamorro Land Trust (CLT) are planned for development. Development of these properties are of particular concern to GWA because of the lack of existing services in the area and the manner in which development is occurring. Several issues were identified during a series of meetings with GWA and Department of Land Management (DLM) staff:

- Lessees are responsible to survey their own land within 60 days of their application being approved—the parcels have not been surveyed by CLT. Land necessary for water and wastewater infrastructure has also not been designated within the tracts.
- Leases are being issued for ½ acre lots because that is the size where the requirement for sewer connection can be waived and septic installed. The DLM would like to see smaller lots, which would result in the ability to issue more leases to more people, but they are limited by the lack of wastewater infrastructure to septic-sized lots.
- DLM would like GWA to develop water and sewer into the CLT areas. GWA would like to see the land serviced by the developing entity in the same manner as any other development. Neither the CLT nor GWA has funding readily available to construct the required infrastructure.
- One potential source of infrastructure funding is the Rural Utilities Service (RUS). RUS is a policy, planning, and lending agency of the U.S. Department of Agriculture (USDA). RUS is implementing the Substantially Underserved Trust Area (SUTA) provisions of the Food, Conservation & Energy Act of 2008 (2008 Farm Bill). The SUTA provisions give RUS new tools to finance improvements in electric, telecommunications, water, and sewer infrastructure in underserved tribal communities.
- This issue also affects the Department of Public Works, GPA, telecommunications services, etc.

The following actions are recommended:

- Conduct a review of current staff capabilities and capacity to address land development-related issues including utility verifications, building permit review, participation on land use committees and with urban planning initiatives, and proactive public outreach activities with development stakeholders (GEDA, realtors, and developers) and ancestral land recipients at the planning stage. Identify gaps in budget and staff.
- Work with Guam EPA to minimize approvals, especially variances, for new septic installations in northern Guam. Eliminate variances issued for new septic systems for homes within 200 feet of existing sewer line.
- Partner with CLT and other developers at the planning stage to ensure that easements exist, land for infrastructure is assigned, and the wellhead protection plan is adhered to.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

- Investigate servicing the CLT properties so that thousands of septic systems are not installed over the NGLA. As part of the investigation, consider assisting CLT in the development of preliminary engineering reports (similar to feasibility studies) required as part of the USDA funding application process.
- Formalize the initiative for water/sewer system analyses for new development as proposed by the Engineering Division. Develop policy to adequately service new areas of development, including financial arrangements.
- Update the sewer model to a level useful for planning scenarios.

Drought

In 2010, to aid in management of groundwater resources and to plan for sustainable growth on the island, the U.S. Marine Corps entered into a cooperative agreement with the USGS to study groundwater availability in northern Guam. The objective of this 3.5-year study was to estimate the effects of several hypothetical withdrawal scenarios on NGLA water levels, the transition zone between freshwater and saltwater, and salinity of pumped wells (Gingerich, 2013).

Key results of the study include the following:

- For a 5-year drought scenario in which recharge is reduced about 32 percent, wells throughout the NGLA get saltier and the amount of acceptable yield (salinity less than 200 mg/L) is reduced from about 34 mgd to 11.5 mgd. The Yigo-Tumon basin has the highest number of wells in the cautionary (salinity between 200 mg/L and 500 mg/L) and threatened (chloride levels greater than 500 mg/L) categories.
- These wells recover to pre-drought conditions within five years after the return of average recharge conditions. Reducing withdrawal at the wells with highest salinity by about 8 mgd during the drought scenario brought the acceptable yield to 13.3 mgd and eliminated all wells in the threatened category.
- Redistribution of withdrawals at both GWA and DoD wells to optimize aquifer response resulted in a complete elimination of threatened yield.
- In general, increased withdrawal will result in lower water levels and increased salinity in nearby and downgradient wells (Gingerich, 2013).

The following actions are recommended:

- Monitor drought conditions and adjust pumping with aquifer sustainability in mind, in addition to water supply.
- Combine DoD and GWA source water withdrawal systems to optimize source water quality during both regular operations and drought conditions.
- Support expansion of the groundwater model to analyze maximum demand withdrawal scenarios.

Operational Issues

GWA operational issues such as equipment breakdown and pumping rates outside of permitted values can affect source water availability. In addition, operations must be adjusted in response to an increase in chlorides, detection of contaminants in excess of GPSSDWR regulations, and turbidity.

It is recommended that a detailed operations strategy be developed in conjunction with a contingency plan—not just for emergencies, but also for the loss of critical well production.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Other Pollutants

Infiltration basins, injection chambers, and sinks exist throughout northern and central Guam. Most notably, the Harmon Sink, a large surface depression more than ten acres in area, receives stormwater runoff from much of the surrounding urbanized area including street drainage from a storm drain network and parts of the Guam International Airport (Johnson, 2012). Corridors located in the more urban areas of northern Guam convey flow directly to manmade infiltration devices or natural sinks generally through a storm drain network consisting of catch basins, pipelines, and outfalls. Stormwater discharge characterization studies conducted by the California Department of Transportation have shown that pollutants of concern generated from roadways within an environment similar to what is found in Guam (with land use designated as open space, residential or commercial) include suspended solids and metal particulate. Trash and debris are also considered pollutants of concern within urban areas. Hydrocarbons are of concern mainly at locations where vehicles idle for extended periods of time (California Department of Transportation, 2003).

A diverse array of surface contaminants can potentially be carried by recharging water including agricultural runoff, septic tank and sewage spills, industrial spills, stormwater, meteorological pollutants, and leachate from contaminated locations. Two sites on Guam have been identified as Superfund Sites under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA): Andersen AFB and the Ordot Dump. Long-term cleanup of Andersen AFB is ongoing, with contaminated groundwater detected and mitigation listed as “under control” according to the USEPA. For the Ordot site, insufficient data exists to determine groundwater status—in other words, due to uncertainty regarding contaminated groundwater migration, conclusions cannot be drawn as to whether the migration of contaminated ground water is stabilized (USEPA, 2016). However, the Ordot Dump was closed and covered in 2016.

GWA monitors drinking water according to the GPSSDWR. Where contaminants such as volatile organic compounds (VOCs), perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perchloroethylene (PCE), and chlordanes have been detected, wells have been shut off, treatment processes added, or water diluted to ensure safe drinking water levels are not exceeded.

5.2.6 Future of the Northern Guam Lens Aquifer

GWA has implemented a source water CIP program, which includes both the redevelopment of existing well sites and completion of new wells. Data is being collected in the NGLA Database, and the monitoring program will undergo a significant expansion as part of the pending military relocation. The NGLA is being studied and monitored extensively, with the goal of sustainably managing the resource now and into the future.

USGS/WERI Monitoring Programs

The following excerpt describing water resources monitoring on Guam is taken directly from the Guam Hydrologic Survey (GHS) & Comprehensive Water Monitoring Program (CWMP) FY 2014 Status Report (WERI, 2014):

> The GHS and CWMP were created in 1998 by the 24th Guam Legislature under Public Laws No. 24-247 and 24-161, respectively. WERI was charged with administering the annual legislative appropriations necessary to drive these two programs and facilitate, direct, and implement their primary objectives.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The purpose of the GHS is to consolidate Guam's hydrological data gathered over the years by local and federal government agencies and consultants, and to conduct research on water-related issues of local importance. The CWMP was created to collect data on saltwater intrusion and water lens thickness in Guam's sole source aquifer in the northern part of the island and stream flow and other parameters associated with surface waters in the south.

In 1998, the CWMP was made a permanent part of WERI's program when Governor Gutierrez signed PL 24-247. This resulted in the refurbishment of the old USGS deep monitoring wells and a renewed program of water resource monitoring on Guam. The intent of PL 24-161 was to restore, and then to expand, as needed, the discontinued monitoring program to help Guam manage and safeguard all of its freshwater resources, now and in the future. Under PL 24-161, WERI/UOG and the USGS entered into a memorandum of understanding to administer and fund this program on a 50/50 cost-sharing basis.

GHS and CWMP appropriations written into each public law are $204,200 and $173,948, respectively. Local budgetary constraints saw a 6% reduction in funding support for both programs in FY'09. An additional 5% reduction was levied against each account in FY'12, reducing the total awards to $182,694 for GHS and $155,626 for CWMP.

The current monitoring program consists of eight continuous-recording stream-flow gauges, nine continuous-recording groundwater wells, seven groundwater wells where the thickness of the freshwater lens is measured, and seven continuous-recording rain gauges. From a broad perspective, the program provides long-term information on the hydrologic cycle of Guam so that its water resources can be understood and sustainably managed. The bulk of the hydrologic data network on Guam is part of a cooperative data program that is funded by the USGS and WERI. Data from USGS stream gauges provide information needed by managers and engineers to properly manage the long-term sustainability of these water resources. Statistical analysis of long-term stream flow data is needed so the effects of abnormally wet or dry years can be understood and planned for.

The USGS, in cooperation with WERI, has proposed to expand the NGLA monitoring network. Major work elements include refurbishment of 12 existing monitoring wells, abandonment and closure of 1 existing monitoring well, and installation of 7 new monitoring wells. Funding was secured in July 2016 through the Economic Adjustment Committee (EAC) in support of the military relocation activities. Locations of existing and proposed wells are shown in Figure 5-13.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

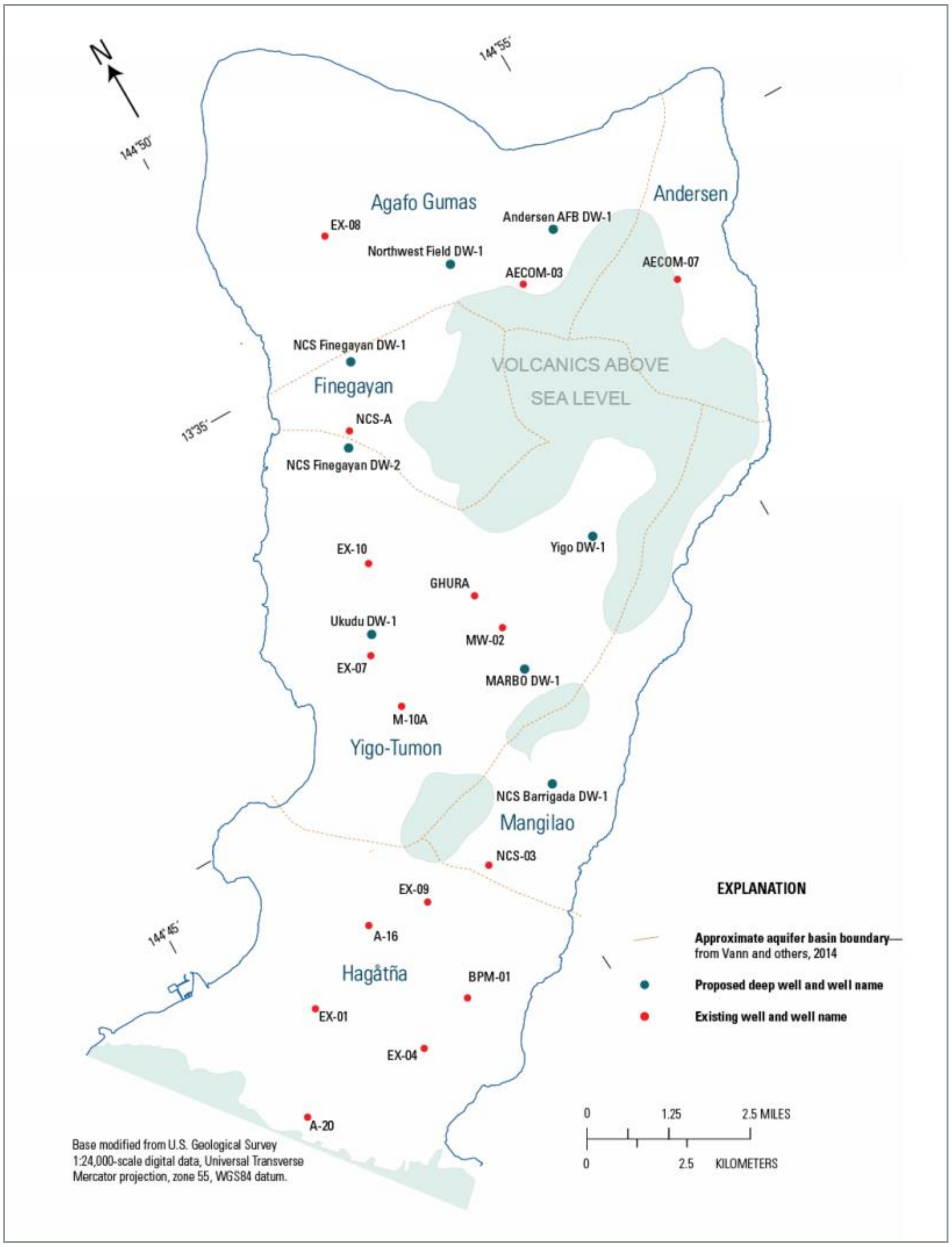


Figure 5-13. Current and Future NGLA Monitoring Wells

The following actions are recommended:

- Continue to provide financial, administrative, and organizational support for USGS and WERI monitoring programs as the main user of the NGLA and a significant beneficiary of hydrological data collected in southern Guam.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Wellhead Protection Program

A Drinking Water Source Assessment and Protection (DWSAP) Program and WHPP was completed in 2015. The DWSAP program was prepared in accordance with the 1996 reauthorization of the federal Safe Drinking Water Act (SDWA), which requires states and territories to develop comprehensive programs to assess sources of drinking water to determine system susceptibility to identified sources of contamination and ensure that related information is publicly available. The first step in developing a DWSAP Program involves completion of a source assessment, which includes delineation of the areas surrounding a drinking water source to identify and inventory activities that could lead to a release of potential microbial or chemical contaminants (EA, 2015).

GWA's DWSAP Program includes the 124 drinking water supply wells located on Guam and will be used to evaluate new sources as they are developed. The 124 drinking water supply wells include wells Y-08, AG-10, and AG-12 which have been drilled, but are not currently developed, as well as the Santa Rita Springs water supply source (EA, 2015).

The DWSAP Program includes guidance for protection of drinking water sources including:

- Identification of best management practices (BMPs) that can be used to protect the drinking water supply from contaminants associated with Potential Contaminating Activities (PCAs). These practices may include various control measures and public education efforts. BMPs that can be used to protect the drinking water supply are included in the WHPP.
- Development of a contingency plan that indicates the location and provision of alternate drinking water sources in the event that one or more of the normal water supply sources are lost. The contingency plan has not yet been completed.

For each of the 124 wells, the WHPP includes the following:

- Well assessment maps
- Inventory of PCAs in proximity to the well
- A vulnerability analysis

The vulnerability analysis revealed that 61 percent of GWA wells are highly vulnerable, 32 percent have medium vulnerability, and just 7 percent exhibit low vulnerability.

Recommended management practices were itemized for individual wells, including:

- Land purchase
- Frequency of groundwater monitoring/addition of monitoring wells
- Implementation of existing water resources protection codes and Regulations including applicable sections of the CWA (33 U.S. Code §1251 et seq. [1972]), Guam Water Resources Protection Act (10 Guam Code Annotated [GCA], Chapter 46), Guam Water Pollution Control Act (10 GCA, Chapter 47), Guam Water Resources Conservation Act (10 GCA, Chapter 46, as amended by P.L. 17-87), Guam SDWA (10 GCA, Chapter 53), and the Guam Water Resource Development and Operating Regulations
- Point source management/spill prevention/response (outreach to surrounding landowners and support for spill prevention/spill response)
- Well decommissioning consistent with requirements established in 22 GAR – Guam EPA – Division II-Water Control, Chapter 7, §7127(b) through (d) and §7128(a), (b) and (i)
- Land use planning
- Public education and outreach, postings, and signage identifying wellhead protection areas

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Ideally, the WHPP will be more than adequate to protect the groundwater supply. However, a contingency plan allows for rapid response to potential or actual contamination emergencies. The components of the contingency plan should include:

1. Description of the water system.
2. Identification of potential sources of supply disruption and vulnerabilities.
3. Identification of source deficiencies that could affect emergency response.
4. Water supply replacement and supplementation alternatives (both short term—bottled water, tanker trucks, water use restrictions, etc.—and long term—development of alternate sources, treatment, conservation).
5. Emergency response capabilities and resources (both logistical and financial).
6. Emergency response procedures and incident control.
7. Preventing emergencies.
8. Training local responders.
9. Public outreach and communication plan.
10. Procedure to review and update the plan.

The following actions are recommended:

- Create a strategy to implement WHPP recommendations:
  - Advocate for enforcement of existing zoning requirements that restrict location of new high risk PCAs, such as onsite sewage disposal systems or ponding basins within designated distances from a water supply.
  - Consider land purchase to control land use within the wellhead protection area of a well, as applicable.
  - Be actively involved in the development and permit review process to ensure that concerns involving the protection of the drinking water source well will be addressed prior to the permitting of new land uses within wellhead protection zones.
- Develop a contingency plan for both groundwater and surface water supply.
- Conduct an inventory of abandoned boreholes and wells to ensure all have been properly secured and decommissioned.

New Well Development

Recommendations for development of new wells in the basal, parabasal, and suprabasal zones of the NGLA have been developed by Vann et al (2014). The following excerpts are taken from the report *Topography of the Basement Rock beneath the NGLA and its Implications for Groundwater Exploration and Development*:

> **Exploration for Basal Water**
>
> The 2010 NAVFACPAC exploratory drilling program indicated promising prospects for further development of some basal water (particularly in the Agafa Gumas and Andersen basins), but it should be kept in mind that the risk of saltwater contamination is highest in the basal zone, and that basal water quality can be expected to deteriorate as upstream parabasal and/or suprabasal wells are installed. For this and the other two zones, other current research on local groundwater flow and quality should be considered as well before evaluating prospective effects of new wells on nearby current and planned production wells.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

In general, seek sites as close as possible to the parabasal zone, and where possible, along the axes of basement valleys, with the following qualifications:

- Finegayan Basin: High permeability and possibility that fresh water converges on regional-scale karst pathways suggest that basal wells here may be especially susceptible to saltwater contamination.
- Hagåtña Basin: Development should be avoided in the southeastern portion, which has historically contained high-salinity water, and shows strong seasonal variation in water quality.
- Mangilao Basin: Lacks such zones of possible higher-thickness basal water, except along the southeast flank of the Barrigada Rise.

Exploration for Parabasal Water

Given the important advantages of the parabasal zone, continuing investments should be made in more accurately and precisely determining its boundaries and in locating and developing productive well sites within it:

- The parabasal zone should continue to be the focus of exploration, particularly in the Agafa Gumas and Andersen Basins, where it remains relatively undeveloped. However, prospective sites are limited by current and planned land use.
- The northwest flank of the Mataguac Rise and head of the Yigo Trough contain shallow, extensive parabasal areas that may be relatively more vulnerable than elsewhere to landward migration of saltwater. This prediction is sensitive to the accuracy of the mapped topography in these areas—finer control on actual basement depths is advisable to support development in these areas.
- In the Hagåtña Basin, there may be some remaining potential along the flank of the Pago-Adelup Fault at the southwestern end of the basin.
- Focused study of the basement topography is also advisable here, although the current map is poorly constrained in this area. It should be noted that increased development of the parabasal zone in general may degrade the quality of water from basal wells downstream.

Exploration for Suprabasal Water

The suprabasal zone was generally regarded as unproductive until the discovery of what was initially called “perched” water in Andersen AFB Installation Restoration Program (IRP) wells during the 1990s:

- These discoveries were followed by the spectacular successes of a few exploratory production wells, notably Y-15, Y-17, and Y-23 (on the Santa Rosa Rise), which remain high-quality, large-capacity producers to this day.
- In summer of 2010, the latest attempt was made to locate suprabasal water. Although success was limited, insights gained from three of the wells drilled on Andersen AFB should improve the odds for future success.
- There are at least five positive reasons for pursing development of suprabasal water:
  - Given that the Santa Rosa-Mataguac-Pati Point complex occupies about 20 percent of the aquifer and nearly half of the Andersen Basin, it may be cost-effective to pursue development here.
  - It is immune to contamination by saltwater intrusion.
  - It lies at the headwaters of groundwater basins and upstream of most of the possible sources of surface contamination.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

  - The map shows prospective locations, with conditions that may be similar to those that provide the consistent high-quality water to Y-15.
  - Suprabasal wells might also be successful along the axes of the basement valleys.
- Continued improvements in the accuracy and precision of the basement map could be beneficial for supporting nearby residents and adjacent military activities.
- NOTE: Wells drilled in the suprabasal zone should be extended all the way to the basement contact. (Local regulations, which prohibit drilling more than 40 feet below static water level, should be adjusted accordingly.)

The following actions are recommended:

- Follow the guidance laid out by Vann et al (2013) when planning the expansion of the well network.
- Consider advanced acquisition of land and access to areas where exploration work is likely to occur in the future.
- Support studies that refine the NGLA basement map—more accurate mapping will assist with planning future exploration programs.
- Work with DoD to develop new wells at depths and in locations that minimize detrimental effects on the aquifer.

Existing Well Redevelopment

CIP projects are underway for the redevelopment of inactive wells to increase source water production. The D-series project involves four wells (D-03, D-17, D-18, D-22) to be taken down, new bore holes drilled and, if successful, new wells to be developed on these existing sites. Well M-09 will also be rehabilitated as part of this project. Estimated completion is December 2017.

The design phase for the A/F-series (A-02, A-07, A-12, D-05, F-03) project is scheduled to be complete by December 2017 with construction to follow.

Three wells (AG-10, AG-12, Y-8) have been drilled and are awaiting completion.

The Northern Guam Lens Aquifer Database

The NGLA Database is a comprehensive centralized database containing information on custodianship, function, operational status, and the geographical, hydrological, engineering, and geological attributes of each well installed in northern Guam for which records could be found. The database is integrated with current ArcGIS geospatial information visualization tools. Developed in support of the 2010–2013 Guam Groundwater Availability Study led by the USGS's Pacific Islands Water Science Center, with funding by the U.S. Marine Corps, and in conjunction with the 2010 NAVFACPAC Exploratory Drilling Program on northern Guam, its integration into WERI's Guam Hydrologic Survey Program will keep it up to date and make it permanently and readily accessible to professional and scientific users (Bendixson, 2013).

The 525 wells documented so far include 20 exploratory wells, one observation/monitoring well, 212 drinking water wells, 39 agricultural/industrial wells, and 104 stormwater management wells. Categories of data relevant to the NGLA database are summarized in Table 5-8.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-8. Data Relevant to the NGLA Database			
Geographical	**Hydrological**	**Engineering**	**Geological**
Watershed	Rainfall	Construction	Drill logs
Coordinates	Evapotranspiration	Data	Depth to basement
Elevation	Tidal influence	Well hydraulics	Depth of limestone
		Water quality	Sample collection
		Maintenance	Borehole video

The following action is recommended:

- Forward all relevant data to WERI for inclusion in the NGLA Database.

5.3 Water in Southern and Central Guam

Southern Guam is dominated by poorly permeable volcanic soil, and the majority of water occurs in streams and rivers on the surface. Two surface water treatment facilities provide water to GWA customers. GWA purchases water from the U.S. Navy's Fena WTP as needed to serve customers in the Central System. The Ugum SWTP is the major source of water supply for the Southern Public Water System and the only surface water treatment plant owned and operated by GWA.

Springs have historically played an important role in southern and central Guam. Today, Santa Rita Springs supplies water to the Central System. Water from Almagosa and Bona Springs is treated by the U.S. Navy at the Fena WTP and becomes a portion of the water supplied to GWA customers by the Navy. Other springs, draining the volcanics of southern Guam have in the past supplied nearby communities, but are not currently utilized by GWA. Use of these historical sources may have been discontinued for a variety of reasons, including inability to meet developing regulatory requirements, infrastructure condition, a deterioration of reliability/quality, and availability of alternate supply such as the Ugum SWTP. Figure 5-14 illustrates the major surface water, watershed boundaries, springs, and groundwater of southern Guam. The large body of the Fena reservoir can be seen near the center of the figure, in the Talofofo watershed. North of the reservoir is the Fena WTP. The Ugum SWTP is located near the eastern coast, at the outlet of the Ugum watershed. An overview of the drainage basins of southern Guam was presented in Figure 5-5.

Two inactive GWA wells, MJ-1 and MJ-5, are located in the parabasal limestone in Inarajan, south of the Ugum SWTP. The extent of limestone deposits in southern Guam was illustrated in Figure 5-1. Successful groundwater wells have been drilled over the years in this area, with productive sources found at Ylig, Togcha, Talofofo, and Malojloj. Many are still in use by private owners for irrigation, industrial, and potable water supply.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

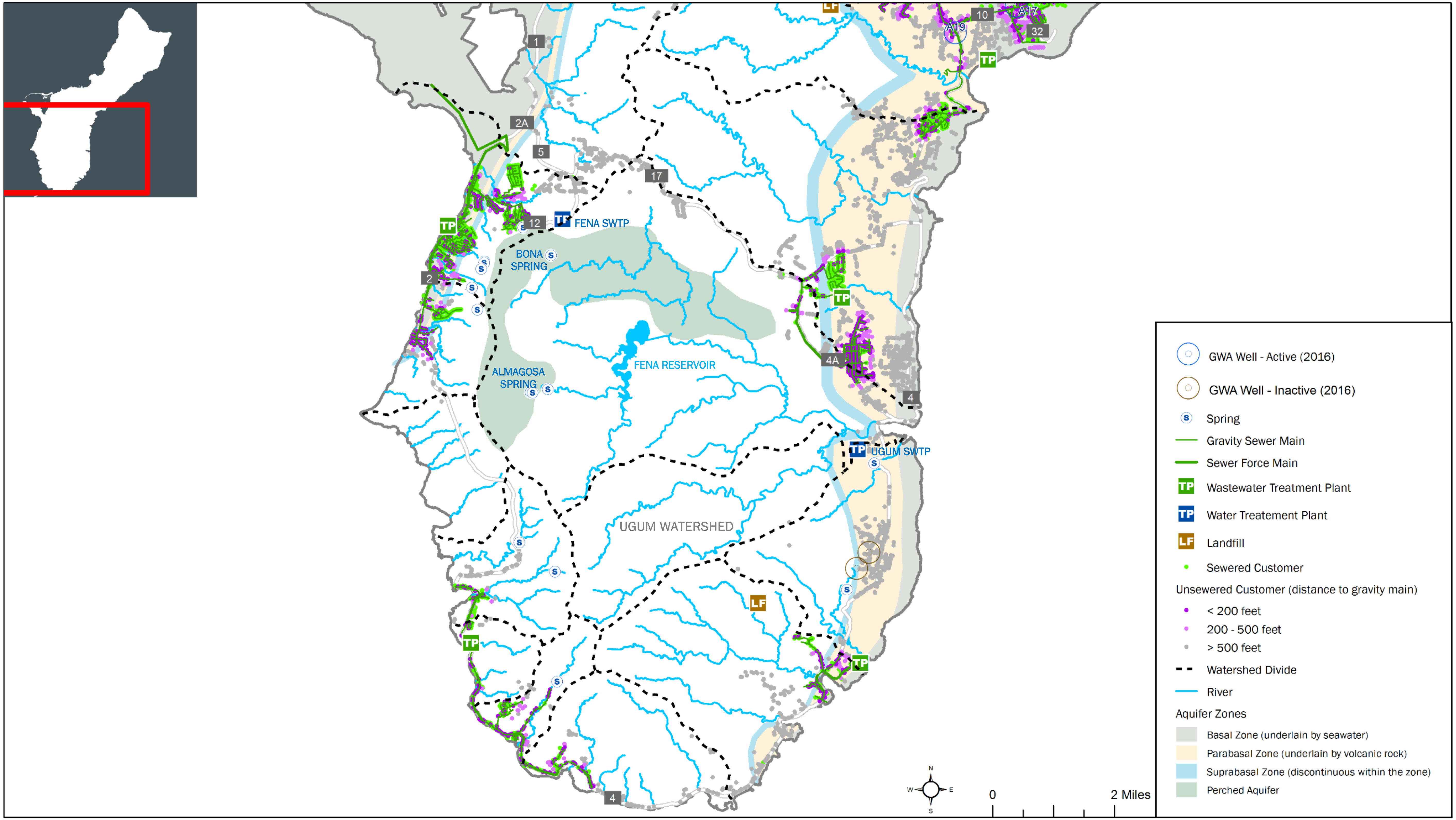


Figure 5-14. Water in Southern Guam

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-9 provides a partial listing of water resources developed in southern and central Guam. This is by no means a complete inventory, but a compilation of sources referenced in literature reviewed during the preparation of this report. Local memory and drilling records are imperfect, and even successful wells have been "lost" over the years. This table serves as an indication and reminder of the diversity and history of source water in the area.

Table 5-9. Surface, Spring, and Groundwater Supply – Southern and Central Guam

	Source	Location	Years in Operation	Comment
Currently in Use	Ugum SWTP	Talofofo	1992 to present	Designed for 4 mgd.
	Santa Rita Springs	Agat-Santa Rita	1929 to present	
	Fena Reservoir	Navy and Central Systems	1951 to present	1956 allocation to PUAG (now GWA), 4.25 mgd, 1991 allocation 4.39 mgd.
	Almagosa Springs	Agat	1941 to present	Belongs to the Navy, combined with Fena reservoir waters and treated at Fena WTP.
	Bona Spring	Agat		Belongs to the Navy, combined with Fena reservoir waters and treated at Fena WTP.
	Private Wells	Southern and Central Guam		Privately owned wells continue to provide irrigation, industrial, agricultural, and potable supply.
Awaiting Rehabilitation	Asan Springs [a]	Asan	1916 to 2003	Between 1937 and 1956, amount of water taken varied from 0.14 to 0.8 mgd. Use discontinued in 2003 due to coliform bacteria (and, anecdotally, access issues affected site maintenance could not be properly maintained). Rehabilitation being considered by GWA.
	Malojloj (MJ) Wells	Inarajan		Two GWA wells planned for rehabilitation.
Abandoned	Geus River Dam	Merizo	Abandoned in 1994	Water impounded behind the dam (100,000 gal) passed through a sand filter located in the dam structure before entering the transmission main to the Pigua Booster Station. Water highly turbid, especially during wet season and in the 1990s exceeded the maximum contaminant limit (MCL) for total coliform count. Guam EPA recommended permanent abandonment in 1994.
	Siligin Spring	Merizo	Abandoned in 1994	Located 3000 feet upstream of Geus Dam, water was collected in a 6- by 8-foot concrete structure and enters Geus Dam impoundment.
	Laelae (Piga) Spring	Umatac	Abandoned	No drawing available, but it is believed that perforated pipes exit the hillside one mile east of Route 4 (off Mandino Street) into an uncovered, 6- by 8-foot, two cell storage tank, then gravity flow to a 30,000-gallon steel reservoir.
	Alatgue Spring	Umatac	Unknown	Active in 1982 (Walski).
	La Sa Fua Intake	Umatac	Unknown	
	Fonte Dam [b]	Asan	1911 through World War II	Turbid during rain events, lower than anticipated river flow, resulted in low impoundment and eventual closure.
	Ma'ina Spring [b]	Agana	1937	Downstream of Fonte Dam, 190-foot elevation, connected to Asan Springs pipeline.
	Finile Creek area Springs	Agat	Abandoned after World War II	Four spring wells at Faata, Auau, and Mao Springs fed water to locations south of Agat.
	Laolao River Diversion	Inarajan	Through 1960s	Was used only for irrigation late in use period. Now abandoned.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-9. Surface, Spring, and Groundwater Supply – Southern and Central Guam				
	Source	Location	Years in Operation	Comment
	Fintasa Falls Diversion	Inarajan	Through 1960s	Included a small treatment facility. Now abandoned.
	Masso Reservoir	Piti	Early 1940s to 1951	Early water supply for the Navy was abandoned due to siltation.

a. Source: Asan Spring Reservoir HAER No. GU-10

b. Source: SWDS p. I.4-6

5.3.1 Ugum River Supply

The Ugum Watershed stretches from Mount Bolanos (elevation 1,241 feet) in the west to the Talofofo River in the east. Mount Bolanos includes the headwaters of the Atate and Bubulao river systems, which combine and flow into the Ugum River. The watershed has an area of 4,672.6 acres (7.3 square miles) of rolling hills with areas of very steep slopes. The 23 miles of rivers and streams in the Ugum Watershed spread from the mountains to sea level where the Ugum River drains into the Talofofo River and then into the Talofofo Bay (Khosrowpanah, 2005).

Seventy percent of the basin is privately owned, and the remaining 30 percent is owned by the Government of Guam and the U.S. Navy. The publicly owned land encompasses the headwater area of the watershed, and has been designated by the Division of Aquatic and Wildlife Resources as a conservation area (Khosrowpanah, 2005).

USGS maintains stream gauging station 16854500 on the Ugum River above Talofofo Falls, approximately 1.5 miles upstream of the Ugum SWTP intake. Historic 7-day minimum average flows are presented in Figure 5-15. Daily stream flow records for the years 1978 through 2015 are presented in 5-16.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

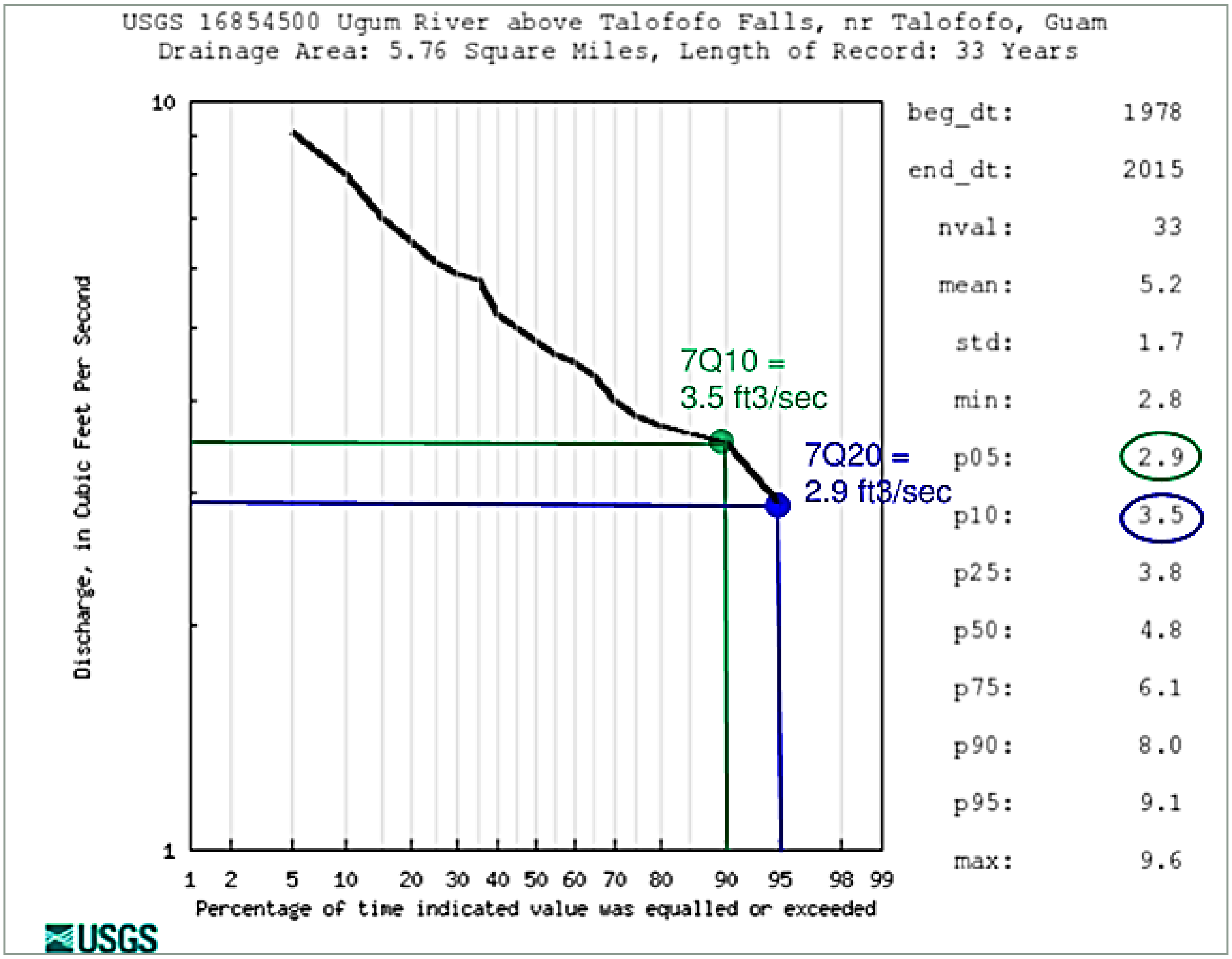


Figure 5-15. Ugum River 7-day Minimum Average Flows (1978–2015)

Withdrawal from the river to supply the facility is contingent on maintaining minimum stream flows to support aquatic life. There is some uncertainty regarding the minimum environmental flow that must remain in the stream after withdrawal for the Ugum SWTP:

- The requirement is variously stated in the literature as “2 ft^3/second during the dry season” (GWA, 2006 WRMP; USDA, 1995) and “2 mgd” (3.1 ft^3/sec) (Khosrowpanah, 2007, referencing a 1989 EIA). Unfortunately, the original EIA/Guam EPA-permitting documentation was unavailable during preparation of this report and this number could not be confirmed.
- The minimum flow ever recorded at the upstream USGS gauge is 2.5 ft^3/sec.
- The calculated 7Q10 flow (7-day average low flow occurring once in 10 years) at the USGS gauge, based on data recorded from 1978 to 2015, is 3.5 ft^3/sec (USGS, 2016).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The total stream flow necessary to maintain minimum environmental flow under various withdrawal scenarios is summarized in Table 5-10.

Table 5-10. Ugum River Minimum Stream Flow Requirements and Production

Minimum Environmental Stream Flow ft³/s (mgd)	Total Minimum Stream Flow Required for Production Withdrawal [a] ft³/s (mgd)				Source for Minimum Environmental Stream Flow
	6.1 ft³/s (4 mgd)	4.6 ft³/s (3 mgd)	3.1 ft³/s (2 mgd)	1.5 ft³/s (1 mgd)	
2.0 (1.3)	8.1 (5.3)	6.6 (4.3)	5.1 (3.3)	3.5 (2.3)	GWA (2006), USDA (1995)
2.5 (1.6)	8.6 (5.6)	7.1 (4.6)	5.6 (3.6)	4.0 (2.6)	USGS minimum flow on record (1977–2016) [b]
3.0 (1.9)	9.1 (5.9)	7.6 (4.9)	6.1 (3.9)	4.5 (2.9)	EIA/Guam EPA requirement for Ugum SWTP [c]
3.5 (2.3)	9.6 (6.3)	8.1 (5.3)	6.6 (4.3)	5.0 (3.3)	7Q10 (2016)

a. Total minimum stream flow is equal to minimum environmental stream flow added to Ugum SWTP production of 4, 3, 2, or 1 mgd.

b. USGS stream gauge 16854500 1.5 miles upstream.

c. Original documentation could not be located, this number is unverified.

It is important to note that the 7Q10 numbers presented here are for the stream gauge station 1.5 miles upstream, where the drainage catchment area is 5.76 square miles (mi^2). Both the stream flow and the minimum required flow numbers at the location of the Ugum intake would theoretically be higher, as the drainage catchment area at the point of withdrawal is larger (approximately 7.3 mi^2). However, tidal influence immediately downstream of the Ugum SWTP intake, combined with a lack of data quantifying groundwater flow into the lower reaches of the Ugum River Basin, preclude a simple linear extrapolation of the stream flow data. It is recommended that stream flows be measured regularly (ideally, daily) both upstream and downstream of the diversion structure, and that a permanent stream flow gauge be installed downstream of the diversion structure.

Figure 5-16 illustrates the ability of the Ugum River to meet the flow scenarios outlined in Table 5-10. On any given day, Ugum River flows will meet or exceed 9.6 ft^3/sec—the flow necessary to leave 3.5 ft^3/sec in the river, while withdrawing 4 mgd or 6.1 ft^3/sec for water supply—approximately 65 percent of the time. In contrast, if only 2.0 ft^3/sec is required to maintain aquatic life and 1 mgd for water supply, the river flow will almost always meet or exceed the 3.5 ft^3/sec total flow required (99 percent of the time).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

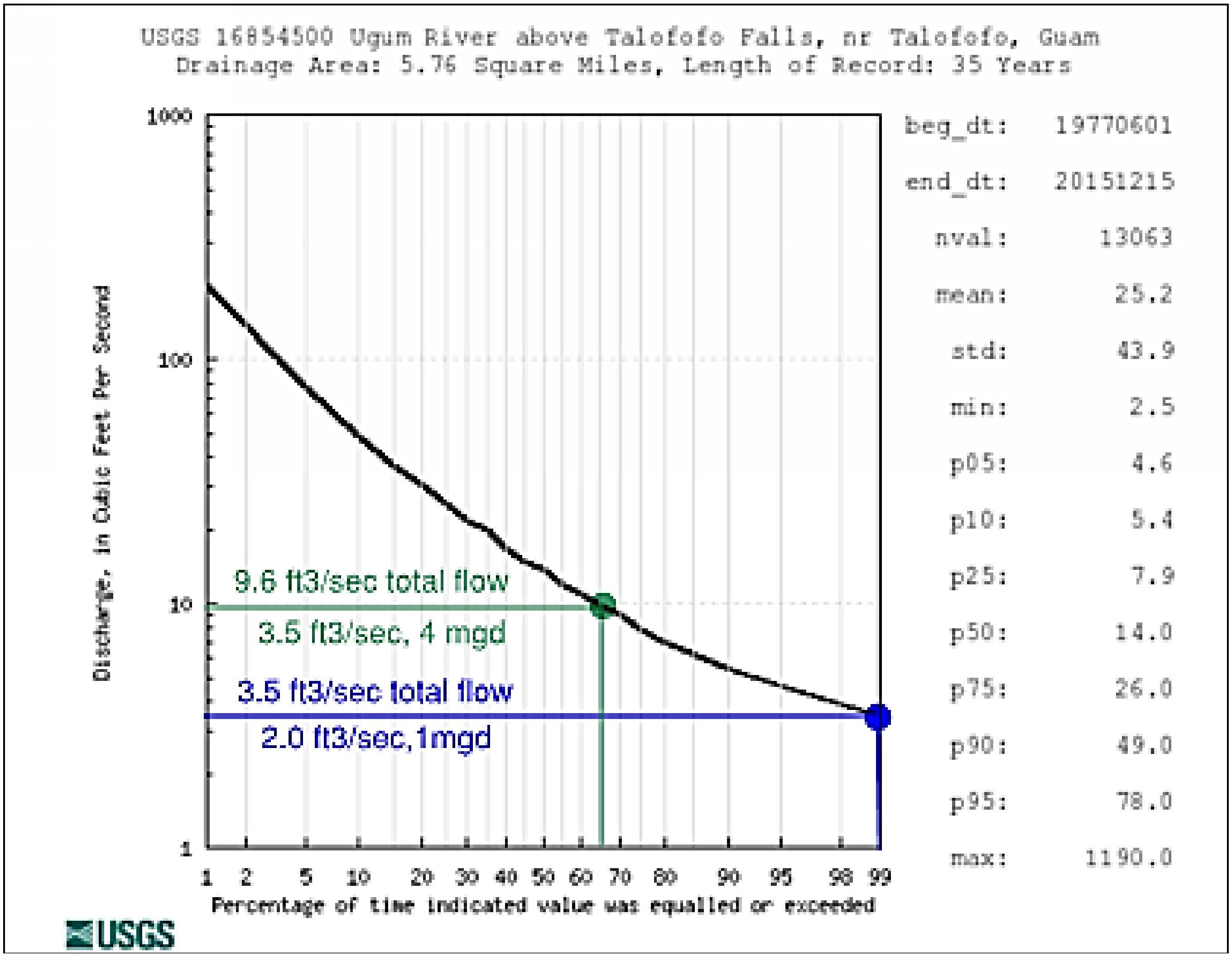


Figure 5-16. Ugum River Daily Flows (1977–2015)

Because the Ugum River flows are highly variable between the wet and dry season, monthly average flows were examined to investigate the ability of the Ugum SWTP to withdraw the necessary volume of water while maintaining minimum environmental flows.

Figures 5-17 through 5-22 illustrate, by month, the likelihood that the required stream flows can be maintained under the varying withdrawal scenarios for the Ugum SWTP outlined in Table 5-10.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

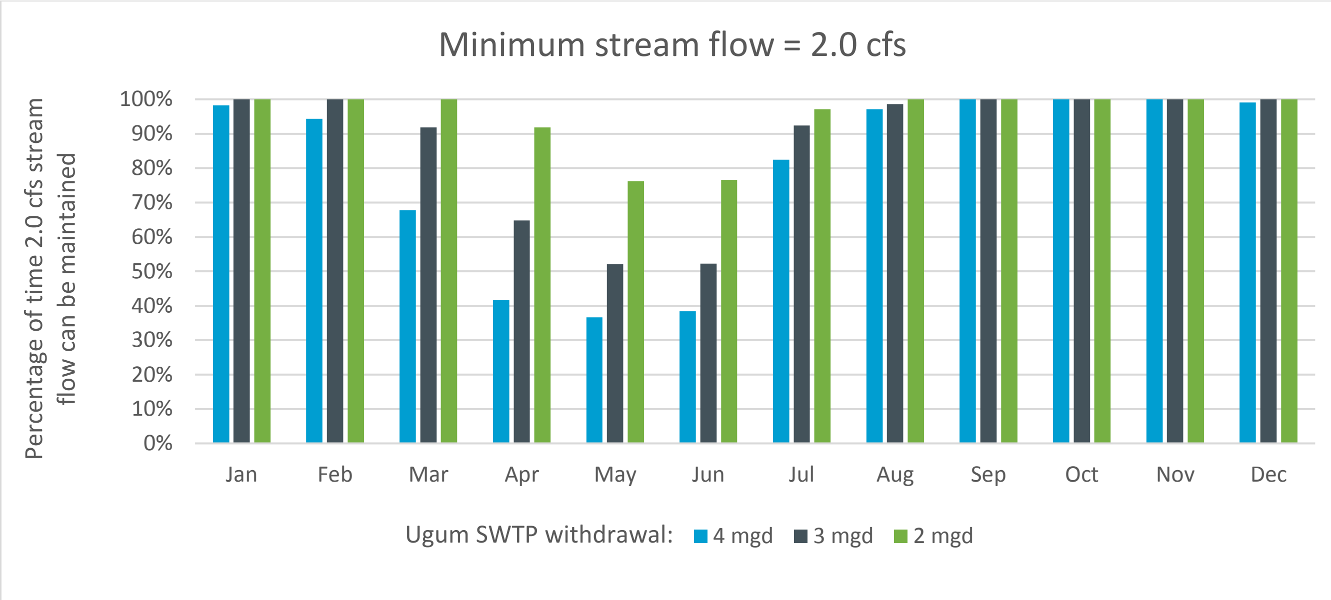


Figure 5-17. Ugum River Supply – 2.0 ft³/sec Minimum Stream Flow

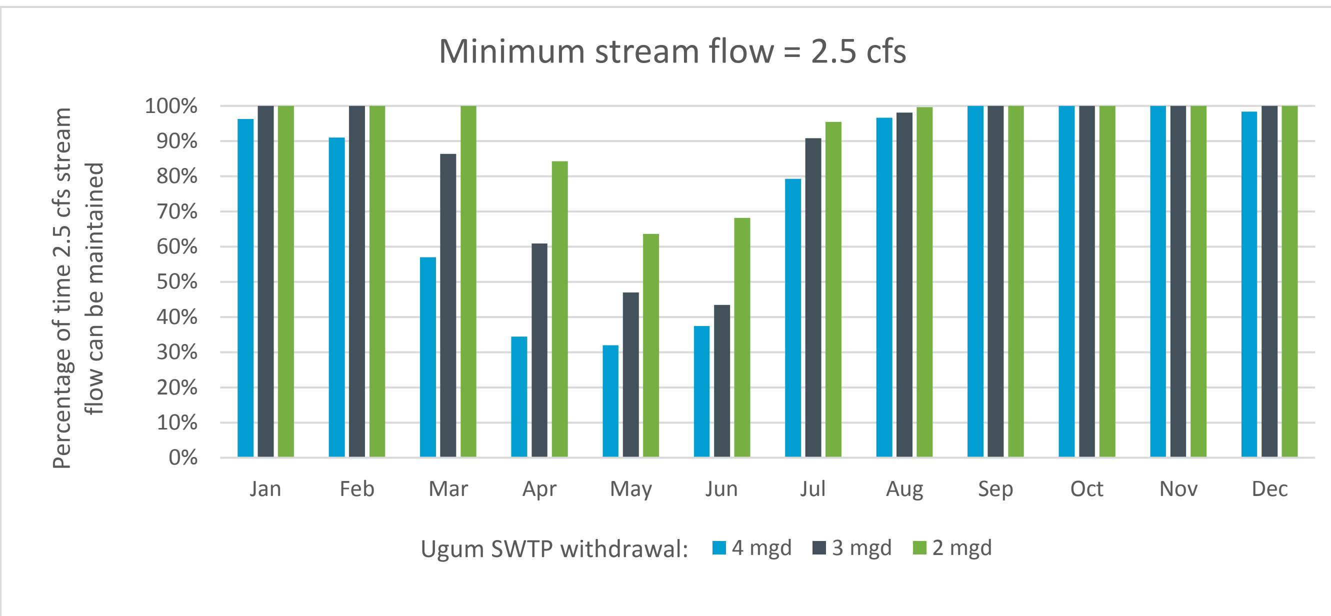


Figure 5-18. Ugum River Supply – 2.5 ft³/sec Minimum Stream Flow

Use of contents on this sheet is subject to the limitations specified at the end of this document.

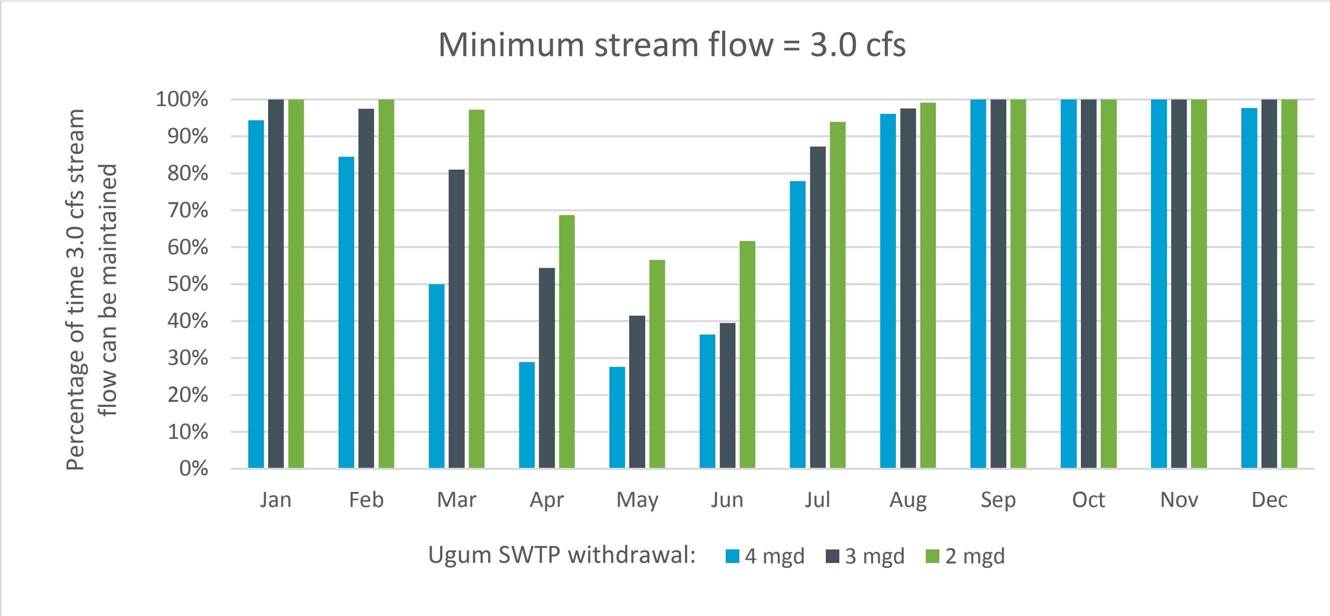


Figure 5-19. Ugum River Supply – 3.0ft³/sec Minimum Stream Flow

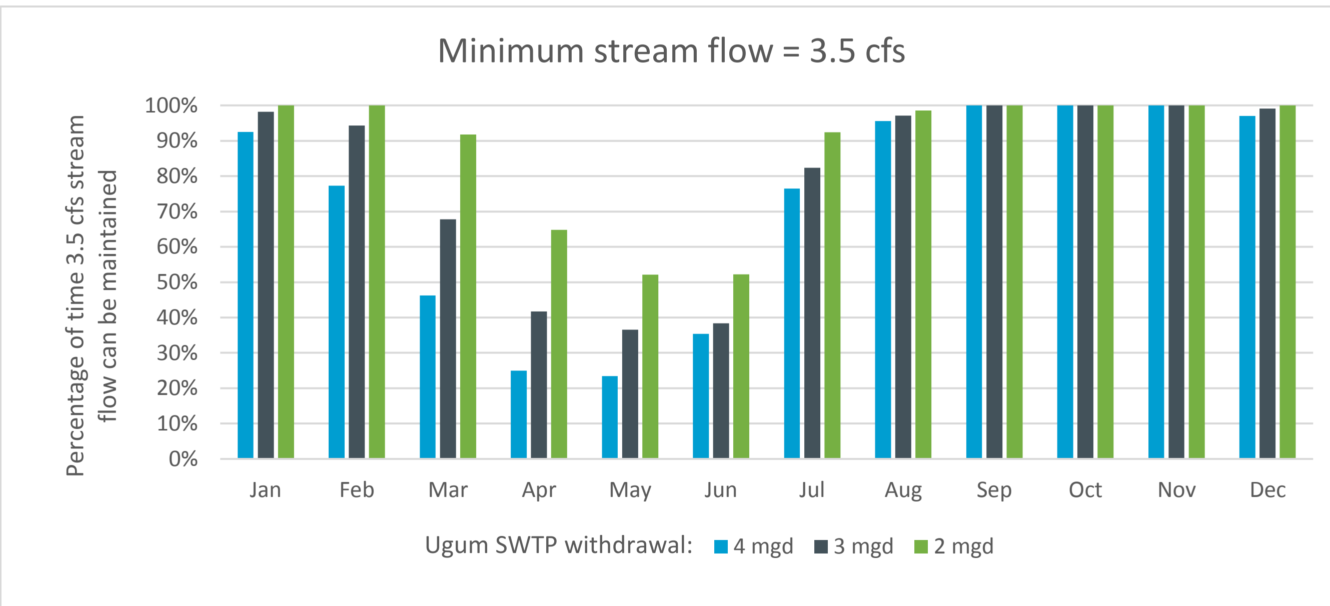


Figure 5-20. Ugum River Supply – 3.5 ft³/sec Minimum Stream Flow

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The following conclusions can be drawn when looking at Figure 5-19, which corresponds to 3.0 ft^3/sec (2 mgd) minimum environmental flow:

- There is sufficient flow in the Ugum River to supply up to 4 mgd, more than 90 percent of the time, 6 months of the year, from August through January. If only 2 mgd is withdrawn for potable water production at Ugum SWTP, sufficient flow is present more than 90 percent of the time nine months of the year.
- In May, which is historically the month with the lowest stream flow, withdrawal of 4 mgd can be accommodated only 23 percent of the time. In other words, for three years out of four, 4 mgd cannot be removed from the Ugum River during the month of May while maintaining a 2 mgd stream flow. Similarly, 2 mgd can only be withdrawn about half of the time.

Figure 5-17, which illustrates a minimum flow requirement of 2 ft^3/sec, rather than 2 mgd, shows the following:

- There is sufficient flow in the Ugum river to supply up to 4 mgd, more than 90 percent of the time, seven months of the year—August through January. If only 2 mgd is withdrawn for potable water production at Ugum SWTP, sufficient flow is present more than 90 percent of the time 10 months of the year.
- In May, withdrawal of 4 mgd (Ugum SWTP design capacity) can be accommodated only 37 percent of the time. However, 2 mgd can be withdrawn more than 75 percent of the time.

From a source water supply and quality perspective, Ugum SWTP experiences operational challenges when there is:

- Too much water flowing in the Ugum River (during the wet season and periods of flooding).
- Too little water flowing in the Ugum River (during the dry season and periods of drought).
- Too much turbidity in the raw water (at any time).

The Ugum River contains high turbidity. As raw water turbidity increases, plant efficiency decreases due to membrane fouling and increased need for backwash. There comes a point where the volume of treated water required for backwash operations equals or exceeds the amount of water that can be produced by the plant (GWA interview, May 17, 2016).

There is a disconnect between the design of the facility and the actual operational capability. The plant has a theoretical design capacity of 4 mgd, but typically produces 2.5–2.8 mgd. Operationally, production higher than 3.2 mgd is difficult to maintain for any length of time. Historically, the plant has been able to produce 2 mgd even under drought conditions. The original operations plan called for a reduction in productivity to 2 mgd when turbidity levels reached 200 nephelometric turbidity units (NTU), with a plant shut down at 300 NTU. Currently, a turbidity reading of 200 NTU requires plant shutoff (Guam EPA restrictions). However, the plant is capable of operating to 600 NTU and should have the ability to produce potable water at 2 mgd even when turbidity levels exceed 200 NTU.

Summary

There is uncertainty regarding the required minimum stream flow in the Ugum River downstream of the SWTP intake, but it is unlikely that the minimum flow required to remain in the river to support aquatic life would be less than the minimum flow on record of 2.5 ft^3/sec. Therefore, the minimum stream flow should be maintained at least 3 ft^3/sec (2 mgd) per the EIA/Guam EPA reference. BMPs would limit withdrawal by the Ugum SWTP to maintain a 7Q10 stream flow of 3.5 ft^3/sec (2.3 mgd).

As discussed in Volume 2, Ugum SWTP's maximum capacity is 3 mgd under current operating conditions. To accommodate a 3 mgd withdrawal, the total stream flow required upstream of the diversion is between 5 and 5.3 mgd (7.6 and 8.1 ft^3/sec).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Supply volume from the Ugum River is not limited between the months of June and February. However, based on historical USGS stream flow data (Figures 5-19 and 5-20), during the dry season:

- The Ugum River is unable to reliably provide the flows necessary to withdraw the design capacity of 4 mgd March through June while maintaining the minimum stream flow required to support aquatic life. The driest month is May, during which flow can be maintained only 23–28 percent of the time while withdrawing 4 mgd.
- The Ugum River is unable to reliably provide the flows necessary to withdraw the maximum operational capacity of 3 mgd April through June while maintaining the minimum stream flow required to support aquatic life. The driest month is May, during which flow can be maintained only 37–42 percent of the time while withdrawing 3 mgd.
- The Ugum River can provide the flows necessary to withdraw the average operational capacity of 2 mgd during dry season months (April through June) while maintaining the minimum stream flow required to support aquatic life 52–69 percent of the time.

Greatest demand generally occurs during the months of the least supply. There are several possible options for water to be reliably provided to southern Guam while maintaining minimum stream flows during the dry season:

- Supply can be supplemented with existing sources from the north—by pumping water from either the northern wells or Fena WTP.
- Additional water sources can be developed in southern Guam—by creating additional raw water supply for the Ugum SWTP (for example, via a second diversion on the nearby Talofofo River) or by redeveloping other sources such as the MJ wells at Inarajan or spring water in the southern communities.
- System storage can be increased—creating raw water storage or increasing treated water storage throughout the distribution system can buffer short-term shortages.
- System losses can be minimized. Non-revenue water (NRW) has been estimated as high as 75 percent in the southern system. Any effort that reduces NRW will effectively decrease demand.

Recommendations

The following actions are recommended:

- Ugum SWTP operators should read and record Ugum River stream flows upstream and downstream of the diversion to ensure minimum flow remains in the river during operation of the Ugum SWTP.
- It is recommended that a water supply policy be established for southern Guam and a study be performed to determine the most viable options to achieve water supply goals for the area. Water supply policy should address issues such as the level of acceptable service, and establish a contingency plan for when the Ugum SWTP is offline.

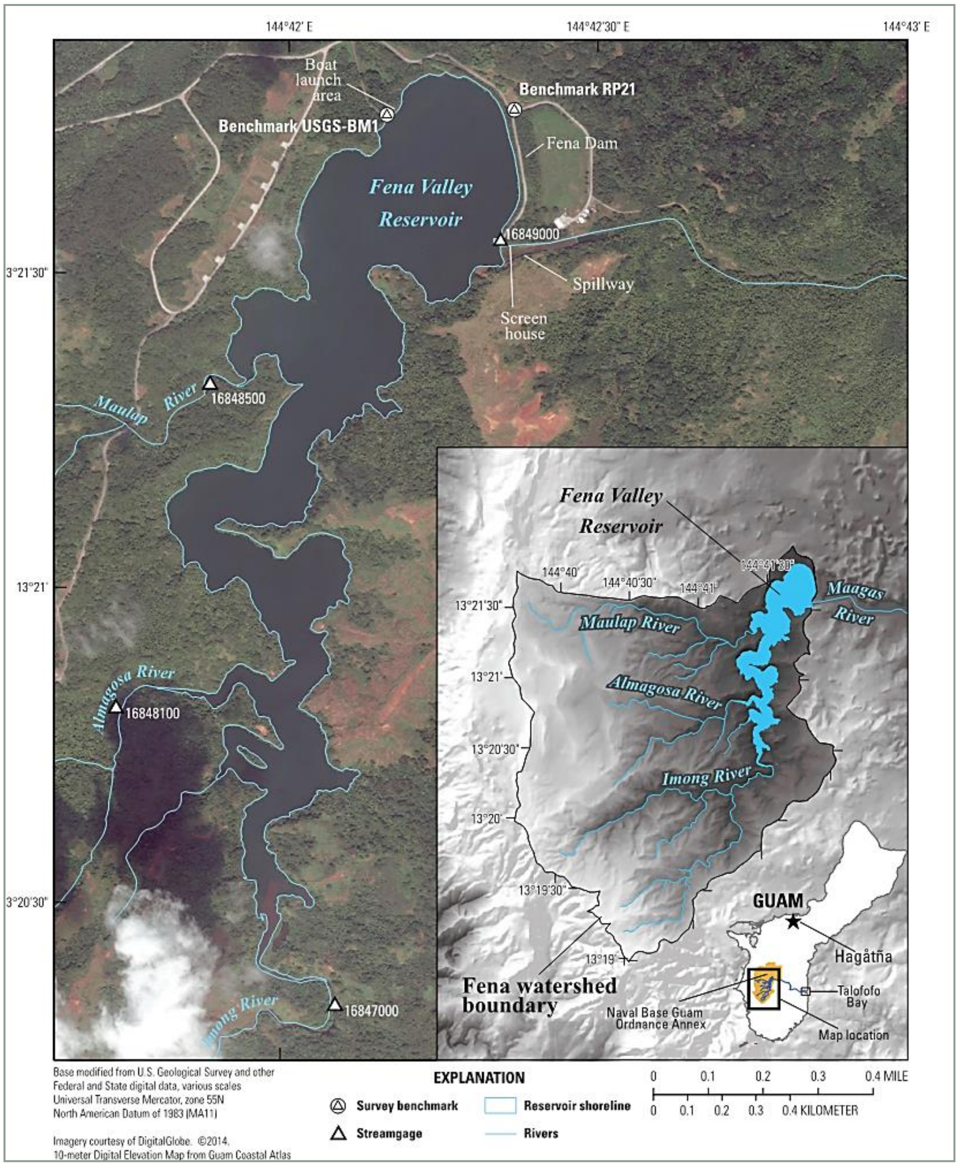
5.3.2 Fena Reservoir

The Fena WTP receives its source water from Fena Lake, Almagosa Springs, and Bona Springs. The capacity of these raw water sources is 8.5 mgd (low lake level), 3 mgd and 2 mgd, respectively (BC, 2014). The location of the Fena WTP and springs can be seen in Figure 5-14.

The WTP is a conventional surface water treatment plant which can produce approximately 13.5 mgd. A 1956 agreement between the U.S. Government and the Government of Guam commits 4.25 mgd of Navy water for GWA's use. A memorandum of understanding (MOU) developed in 1991 increased the Navy's commitment to GWA to 4.39 mgd (WRMP 2006). Supply from the Fena WTP may be restricted by the Navy due to mission support needs.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The Fena reservoir currently has a total storage capacity of 6,915 acre-feet (acre-feet). The live-storage capacity was calculated as 5,511 acre-feet (Marineau, 2015). The original capacity of the reservoir as constructed in 1951 was estimated to be 8,365 acre-feet, and the live-storage capacity was estimated to be 5,900 acre-feet. The location of the Fena Reservoir is shown in Figure 5-21.



Source: Marineau 2014

Figure 5-21. Fena Watershed

5.3.3 Threats to Surface Water Supply and Quality

Surface water supply and quality in southern Guam is ultimately tied to climactic factors and land use within the watershed. Watershed health is affected by drought, flooding, use by people and animals, and terrestrial land cover.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Watershed Health

The Ugum River is impaired due to turbidity, and in 2007 USEPA approved a total maximum daily load (TMDL) for sediment. The TMDL established daily and annual load allocations for the sediment and an instream turbidity target to address sediment impairment in the Ugum Watershed (NPDES, 2016).

Turbidity in the Ugum River occurs due to the introduction of sediment into the stream by upland soil erosion. Intense rain events, steep terrain, narrow river cross sections, changes in river direction, areas of existing bank erosion, and mass wasting all increase the potential for sediment to be introduced to and carried by the river. Poorly vegetated regions in the watershed are highly susceptible to erosion processes. These areas include badlands, jeep trails, ungulate habitat, and land destabilized by wildfires (Khosrowpanah et. Al, 2005, 2015).

In addition to negative impacts on biota in the watershed and nearshore coastal waters, turbidity in the river affects the ability of the Ugum SWTP to supply drinking water to southern Guam. As turbidity levels increase, the process efficiency of the plant decreases. When the volume of water required to backwash (clean) the microfiltration systems is equal to the amount of treated water production, the plant must be taken offline until raw water turbidity subsides.

Upland restoration in southern Guam is ongoing. Mitigation measures include streambank restoration and ungulate control. The Guam Coastal Nonpoint Pollution Control Program (in accordance with the requirements of Section 6217 of the 1990 Coastal Zone Act Reauthorization Amendment) requires the development of watershed restoration strategies. The Guam Water Planning Committee recommended the Ugum Watershed for a comprehensive assessment. In 2011, Guam EPA was tasked with the review, revision, and update of the 1996 Ugum Watershed Management Plan. This plan should provide a road map to help the Watershed Planning Committee (WPC) identify the problems, set goals, and implement solutions in the Ugum Watershed. Work was scheduled to be complete in 2012.

It is strongly recommended that GWA continue to take a leadership role in the protection and restoration of the Ugum Watershed, with the ultimate goal of increasing Ugum River water quality through cooperative efforts with other stakeholders. Legislative changes may be required to support watershed protection and could include the establishment of river buffer zones and clarification of surface water-related issues on Guam. GWA has committed $50,000 and data provision to the WPC, and it is recommended that support continue. Restoration of the Ugum Watershed should result in an overall decrease in sediment loading to the river, with a corresponding reduction in turbidity and increase in water quality for the Ugum SWTP.

Ugum SWTP Intake

The intake facilities at the Ugum SWTP are in poor condition, affecting the quality and quantity of raw water available to be processed. The condition of the overall plant is discussed in Section 5.3 of WRMPU Volume 2.

Long term, it is recommended that options for decreasing turbidity at the intake be investigated. Permanent silt curtains, an increase in diversion height, installation of settling basins, raw water storage, or a diversion channel or infiltration system could all improve the raw water quality prior to the water entering the plant. The benefit of reconstructing or relocating the entire intake structure should also be considered.

When the sediment is removed from the diversion pond, a volume-over-time accumulation profile should be calculated, and a sediment management program implemented, including funds to dredge at intervals appropriate for replenishment of impoundment volume and intake maintenance.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

During the dry season, water does not overflow the diversion structure. It is therefore important that data regarding the transmissivity of the underlying and surrounding soils be examined in conjunction with repairs to ensure minimum stream flow requirements continue to be maintained downstream of the intake.

5.3.4 Future of Water Supply in Southern and Central Guam

The Fena Reservoir remains the largest and most reliable water source in southern Guam. While the reservoir and associated treatment facility are controlled by the Navy, supply necessary to support the Defense mission in Guam will always take priority over GWA requirements. Although an annual allotment from the reservoir has been made to GWA, the DoD has, at times, restricted water delivered to GWA. In addition, although the DoD is mandated to run the facilities on a “break-even” basis, the rate structure of water purchased from the Navy is not sustainable for a public utility—GWA cannot resell the Navy water for as much as it costs to purchase, and the contract has historically not been negotiable. For this reason, purchases of the Navy water have dramatically decreased over the past five years.

As a matter of long-term policy, GWA should decide whether to pursue operation and/or ownership of the Fena Reservoir and treatment facilities as part of the OneGuam initiative to combine DoD and GWA systems.

Relatively small groundwater, surface water, and springs sources were historically developed to provide local supply to the remote communities of southern Guam. Today, a single line supplies water from Ugum to these same communities. Outages are common, and although there is storage, it is an unlooped, dead-end system. With the abandonment of the spring sources, there is no longer any secondary redundant supply in the area to provide resiliency. As part of the creation of a Water Resource Policy, it is recommended that security of service to these communities and options for supply redundancy be analyzed.

Groundwater and Springs

Groundwater sources and springs in southern and central Guam are described below.

Asan Springs

Although currently inactive and in a state of disrepair, Asan Springs has provided water to the people of Guam for a century. Records indicate that the amount of water extracted varied from 0.14 to 0.8 mgd. First developed in 1916, its use was discontinued in 2003 due to the presence of coliform bacteria (and, anecdotally, access issues which affected site maintenance). Rehabilitation is being considered by GWA to supplement supply to central Guam and should be pursued as a viable source water option.

MJ Series Wells

The two MJ series wells in Inarajan were secured due to high chlorine residuals reported in the system. Permitted for 56 and 58 gpm, the wells are planned to be reactivated to supplement water supply in southern Guam.

Santa Rita Springs

Santa Rita Springs is currently operational and contributing to GWA supply.

Other Springs and Groundwater Sources

Privately owned wells continue to provide irrigation, industrial, agricultural, and potable supply to southern and central Guam. It is recommended that GWA investigate the viability of acquiring any of those sources for public use.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Springs were utilized to supplement supply in southern Guam as recently as 2006. The Siligin Spring and associated Geus River source were abandoned in 1994. If studied, the springs would likely be determined as GWUDI, but rehabilitation of these sources may be possible with the addition of treatment to meet SDWA standards.

Valley Fill Aquifers

In 1983, a feasibility study investigating the development of alluvial (river valley) aquifers to augment village water supplies in southern Guam was completed (Ayers, 1983). Test wells were drilled in the lower reaches of the Inarajan river near the outflow at Inarajan Bay. The results of the study indicated the presence of fresh water-bearing sediments overlying a partially weathered volcanic basement. Potential extraction methods for these shallow deposits included interception trenches for seepage-type areas and well points where the hydraulic conductivity warranted. Further study of the geology and additional water quality testing of these valley-fill aquifers, was recommended to determine the suitability and treatment requirements for potable use.

Guam Surface Water Development Study

In the early 1990s, concern over withdrawals from the NGLA approaching the aquifer's sustainable yield resulted in the completion of the Guam Surface Water Development Study (SWDS) in 1994. The purpose of the study was to determine the feasibility of developing surface water sources and other alternative water supply options to supplement NGLA groundwater production.

This comprehensive study identified 18 of the 40 watersheds in southern Guam as having some potential for development as a water resource. The three primary structures considered for use were dams, diversions, and infiltration galleries. A total of 30 options were identified for further study—15 potential reservoir sites and 15 diversion sites. The general location of these sites is shown in Figure 5-22.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

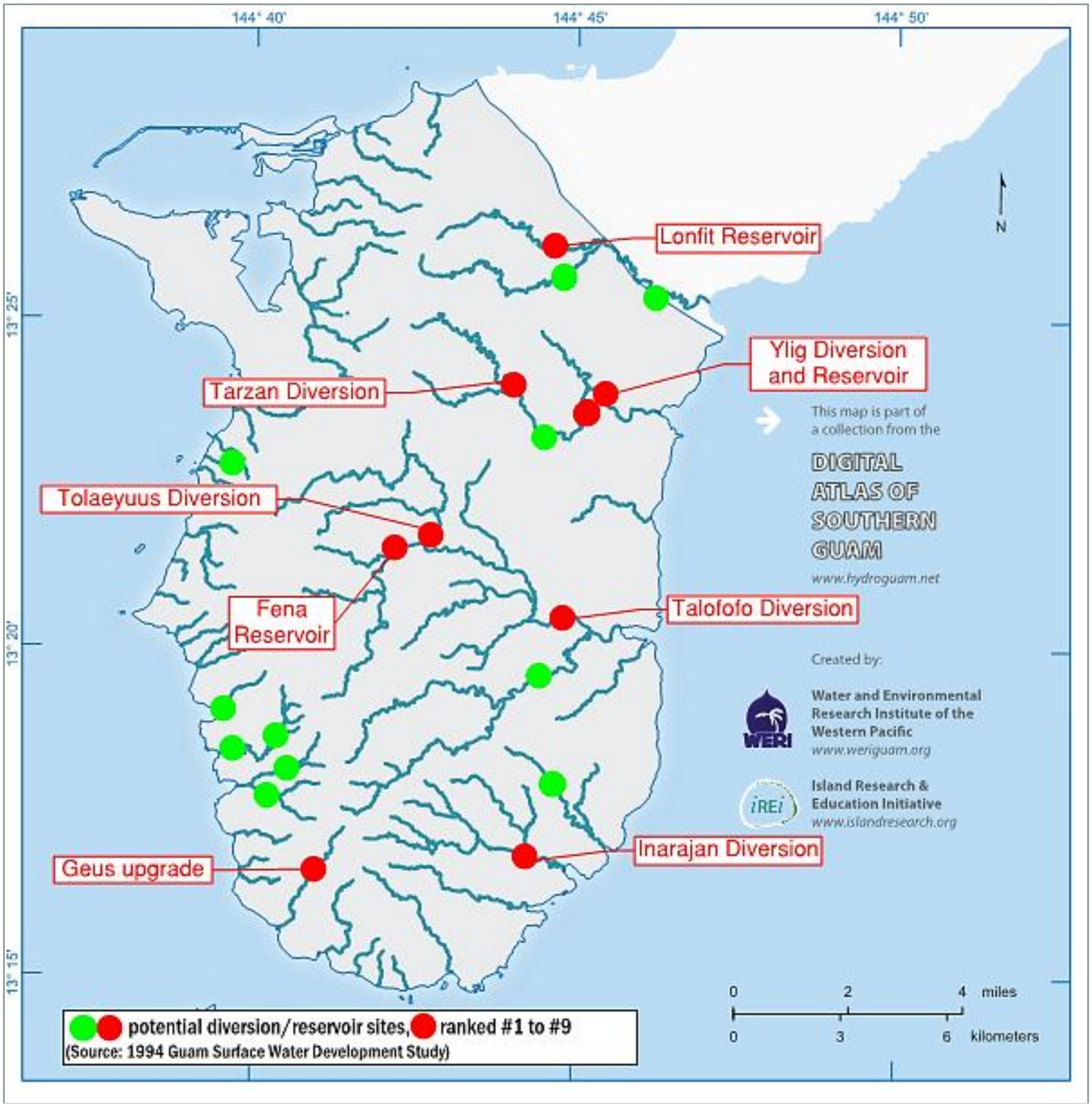


Figure 5-22. Potential Water Resource Development Sites

Five of the 30 options initially identified were determined to be unfeasible either due to water quality concerns (such as the Pago River) or sediment storage requirements (in the case of proposed reservoirs on Finile Creek and the La Sa Fua, Umatac, and Geus Rivers). The remaining 25 options were ranked using a weighted matrix screening method. Included in the analysis were parameters relating to archaeological, environmental, human life quality, and economic impacts. A sensitivity analysis was also performed to confirm the results. The top nine ranking alternatives are listed in Table 5-11.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-11. SWDS Alternatives and Rankings				
Rank	Alternative	Estimated Yield (mgd)	1994 Conceptual Cost ($Million) [a]	Adjusted 2016 Conceptual Cost ($Million) [b]
1	Ylig Treatment Plant Rehabilitation	2.0	4.5	7.3
2	Talofofo Diversion	2.0	6.3	10.3
3	Tolaeyuus Diversion/Fena Reservoir Recharge	0.9	0.9	1.5
4	Inarajan Diversion	2.0	5.7	9.3
5	Geus Treatment Plant Upgrade	0.15	0.6	1.0
6	Tarzan Diversion	1.0	4.1	6.7
7	Ylig Reservoir	11.4	52.8	86.1
8	Fena Reservoir Modification	4.0	5.9	9.6
9	Lonfit Reservoir	3.3	19.7	32.1

a. Construction cost. Source: 1994 Surface Water Development Study.

b. $1.00 (1994) = $1.63 (2016) www.bls.gov. Conceptual cost components were not re-estimated as part of the 2016 WRMPU.

Several general conclusions were drawn from the results:

- Larger diversion projects ranked highest. The environmental and archaeological impacts of these diversions are offset by the benefit to human life quality and lower economic costs per mgd when compared to smaller diversion projects and reservoirs.
- Four of the top ranked alternatives (Ylig rehabilitation, Geus upgrade and the two Fena projects) utilize existing facilities and/or access.
- Smaller diversion projects generally ranked lowest, with none ranking in the top nine. The cost of gaining access and construction is relatively high for the small quantity of water developed.

The two alternatives on the Ylig River (diversion and reservoir) are mutually exclusive. In addition, the Tarzan diversion is further upstream on the same river. Construction of any one of the three projects would therefore have a major impact on the viability of the others.

Viability of the two projects involving Fena (Tolaeyuus diversion and Fena Reservoir modification) is dependent on GWA gaining access to the additional volume of water created by these projects and impounded by the reservoir. The nature and limitations of the current agreement in place between GWA and DoD was not explicitly considered in this analysis, and access rights would have to be negotiated.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The order of implementation recommended in the SWDS is presented in Table 5-12 along with a description of each alternative.

Table 5-12. SWDS Recommended Implementation

Order	Alternative	Project Description
1	Ylig Treatment Plant Rehabilitation	Replace the existing (abandoned) sheet pile diversion with a concrete structure, replace existing inlet pipes, construct a new water treatment facility on site.
2	Talofofo Diversion	Construct a concrete diversion structure, pump to a new elevated storage tank, gravity feed to Ugum SWTP, upgrade Ugum to accommodate additional flow.
3	Tolaeyuus Diversion/Fena Reservoir Recharge	Repair the existing (abandoned) concrete diversion, clean out the accumulated sediments, replace existing intake and cleanout pipes, construct a new pump station to transport raw water into the Fena Reservoir.
4	Inarajan Diversion	Construct a concrete diversion structure, pump to a new water treatment facility.
5	Fena Reservoir Modification	Increase the dam height by 20 feet by constructing a steep-sloped, reinforced soil system “cap” on top of the existing 85 feet tall structure.

It is important to note that in 1994 when the SDWS was completed, facilities were contributing to water supply in southern and central Guam which are no longer in service today. These sources include the Geus River dam, Siligin Spring, and Laelae (Piga) Spring. Although an upgrade to the Geus was included in the SWDS, sources in operation at the time were excluded from the analysis.

Although the key assumptions of an 80 mgd sustainable yield for the NGLA hold true today, the projected 2015 population of 263,744 was overestimated in the SDWS. At that time, there was a very real concern that the NGLA would be unable to supply all of the water needed by the population.

It is recommended that, should surface water development be identified as a priority for GWA, the SWDS be updated to reflect current conditions.

5.4 DoD and GWA System Integration – “OneGuam”

As part of the 2006 WRMP, the Stipulated Order required exploration of consolidation opportunities with the U.S. military. During the planning process, both privatization and consolidation with other public entities were added to the WRMP scope of work. That analysis can be found in Chapter 16 of the 2006 WRMP document.

Today, integration of DoD and GWA water resources is being actively pursued as the “OneGuam Vision.” In 2010, DoD and GWA signed a MOU, and agreed to evaluate opportunities towards integrating military and civilian water systems on Guam. The original intent of the MOU was to address expected water and wastewater needs for the proposed military buildup.

Building on the MOU, a *Framework for an Integrated Water System for Guam* has been created as a living document to capture progress and forecast planned initiatives that support an integrated water system. The framework provides a strategy to move from two separate utilities to a single water utility that can service both the military population and the civilian population. The long-term vision is to provide for uninterrupted supply of potable water to all of Guam through the consolidation of GWA and DoD systems (Draft Framework, 2016).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

As stated in the framework document, for integration to occur steps must be taken by GWA to prove the ability to provide uninterrupted water service to all customers. An agreement will be drawn up which provides for a gradual turnover of control from the DoD to GWA. This agreement will include benchmarks that demonstrate GWA's ability to be reliable, sustainable, and compliant. These benchmarks are outlined in Table 5-13.

Table 5-13. Benchmarks for System Integration

Reliability	Sustainability	Compliance
Constant operating pressure in the system of 20-90 psi for each customer	DoD and GWA determine acceptable water and pressure reserve levels system-wide	Completion of all 2011 USEPA Court Order projects
An established periodic preventative maintenance program	Robust modernization program	Completion of all 2011 NEIC Significant Findings for water
An established computerized maintenance management system	Budgeted funding for wellhead protection	Completion of USEPA NEIC Significant Findings
Emergency recovery plan	Continued aquifer modeling refinement and data fidelity	Sampling results consistent with USEPA regulations
Sustained funding for system maintenance	Establish safe yield for each well and tank	Operator certification
Budgeted funding for CIP: • Number of miles of pipe replaced • Well service life extension program • Reservoir recapitalization and expansion program		
Operator training		
Water loss management program		
Capacity for fire flow throughout the island		

Strategies and milestones have been identified to work toward system integration. Near-term activities include conducting appropriate studies, collecting data, and identifying achievable projects for the Northern Guam Water System. During this phase, GWA will explore opportunities to operate selected DoD facilities such as the Tumon Maui Well, enhance areas where there are connections between GWA and DoD systems, and complete a WRMP that supports redundancy in the system. During this phase, water exchange will be explored as a mechanism for compensation with water services. Specific milestones are summarized in Table 5-14.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-14. System Integration Action Plan – Near-Term Activities

Action	Milestone	Outcome
Identify issues, risks, and opportunities. Evaluate combined DoD and GWA existing water infrastructure.	• Print a map with DoD and GWA facilities for northern Guam. • Receive letter from Navy to GWA/BC releasing system data. • Determine areas of consideration for potential interoperability. • Review inventory of existing GWA and DoD assets in northern Guam. • Determine major water resources infrastructure projects and sharing water resources based on current assessment of the NGLA.	Develop strategies for each issue, risk, and opportunity.
Identify facilities and projects that can easily be integrated.	• Review location of existing and proposed wells and reservoirs as potential shared resources. • Review feasibility of GWA operating Tumon Maui Well. • Review performance work standards. • Identify funds to support the operation of Tumon Maui Well by GWA. • Identify water connections between water systems that can be easily connected.	Review draft license for GWA to operate Tumon Maui Well. Draft template for agreements for future collaborative projects.
Conduct a feasibility study to determine potential for a singular, unified water utility.	• Identify funds for the feasibility study. • Determine all costs including staff and maintenance requirements.	Finalized strategic plan for combined water utility.
Ensure data coordination and sharing for NGLA.	• Draft a MOU between GWA and WERI, which can be used as a template. • Complete MOU between GWA and WERI.	Database for all data associated with the NGLA that is accessible to critical stakeholders.
Model proposed combined water system.	• Identify funding for project. • Obtain existing data. • Identify data gaps.	Combined hydraulic model.
Update GWA WRMP.	• Ensure GWA's updated master plan includes the combined water utility as an option. • Utilize information from hydraulic model to determine new water service areas.	Improved master plan activities.
Determine research projects critical for improved management of the NGLA.	• Work with WERI, UOG, and USGS to identify critical research necessary for the management of the NGLA. • Additional USGS monitoring wells to support increased water demand as proposed by USGS.	Improved management of the NGLA.
Evaluate applicable laws, service rules, and contracts.	• Work with appropriate stakeholders including CCU, GWA Legal, DoD Legal, USEPA, Guam EPA, Guam Legislature, etc. to determine if any laws need to be updated or created.	
Develop performance standards of delivery of the system.	• DoD and GWA to develop performance work standards.	Consistent performance standards for water delivery.
Review impact to water rates for Navy water purchase.	• Fund a rate study based on combined utility.	Potential rate structure.
Review water exchange for Navy water purchases.	• Fund a feasibility study for a water exchange program.	

Mid-range goals include conducting appropriate studies, collecting data, and identifying achievable projects for the Central Guam Water System. The long-term goal is full integration of the two systems into one consolidated utility. Specific mid- and long-range actions are included in Table 5-15.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-15. System Integration Action Plan – Mid- and Long-Term Activities	
	Action
Mid-range	Determine if new wells will be needed to supply both DoD and GWA needs. Coordinate selection of well sites.
	Evaluate consolidation of water infrastructure for central Guam.
	Develop plan for consolidation of central Guam water service areas.
	Develop appropriate plans for integration of new water production and distribution infrastructure in central Guam water service areas.
	Develop common standards related to security, reliability, interoperability, construction, and performance.
	Determine where replacement lines can be directed for service areas that enable consolidated systems.
Long-range	Develop appropriate plans for the integration of new water production and distribution infrastructure in southern Guam water service areas.
	Complete pipe replacement to accommodate shared service areas.
	Evaluate appropriate rate structures.

Both DoD and GWA are committed to a long-term sustainable management of the NGLA. The Technical Expert Group identified in the MOU meets quarterly to ensure Guam's water resources are well managed and protected in an effort to continue fostering cooperation and sharing information with GWA partners and critical stakeholders. The group is charged with the following objectives:

- Develop and maintain a database and technical tools needed to monitor and assess the health of the NGLA.
- Develop a process for sharing information and making resources and infrastructure decisions, with the ultimate goal of joint management of the NGLA and protection of water resources on Guam.
- Develop permanent drinking water supply sufficient to meet:
  - The requirements of DoD on Guam
  - The requirements of Guam's projected civilian growth and development
  - Future requirements of the people of Guam extending beyond DoD, and its related impacts
- Improve the overall quality, reliability, and availability of the water supply for all of Guam.
- Provide the framework for subsequent agreement for the transfer, exchange, and cost recovery of water resources between DoD and GWA.
- Coordinate efforts to resolve the challenges of providing water treatment for military and civilian populations.
- Provide the opportunity to assess and mitigate adverse impacts to the NGLA.
- Promote the long-term viability of the NGLA.

The technical experts working on NGLA issues include GWA, DoD, Guam EPA, USEPA, USDA, USGS, UOG-WERI, NOAA, and private consulting companies.

These technical experts provide recommendations to the Working Group whose members include a GWA engineer, NAVFAC Marianas UEM Production Line Coordinator, and a Guam EPA representative; and to the Senior Advisory Group, whose members include the GWA General Manager, NAVFAC Marianas Commanding Officer, CCU, Guam EPA, and UOG-WERI.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

5.5 Additional Source Water Issues

Additional source water issues in Guam are described below.

5.5.1 Water Resource Policy

As GWA takes an active role in sustainable management of the water resources of Guam, formalization of GWA Water Resource Policy is necessary to guide water resource development, use, and management by GWA into the future. Planning principles such as:

"Withdraw only to sustainable yield of NGLA"
"Conserve before adding supply"
"Develop new sources for system resiliency"
"Protect surface and groundwater quality"
"Develop and maintain a 1.2 supply:demand factor"
"Combine military and civilian water resource infrastructure into a single utility"

should be discussed and, if agreed upon, entrenched in the culture of the organization. It is recommended that a stakeholder workshop be conducted to identify and formalize GWA water resource policy. Developing source-water related policy will create a roadmap for critical water supply decisions to be made over the next 20 years and beyond.

5.5.2 Supply-to-Demand Ratio

A supply:demand ratio of 1:1.2 (20 percent excess supply) was proposed in the 2010 GWA Potable Water Production Enhancement Plan (PWPEP). Excess supply ensures GWA's ability to provide adequate quantity and pressure to its customers in the event of a source water interruption or emergency. It is recommended that the 2010 PWPEP be updated to establish a strategy to achieve and ultimately maintain this ratio as demand increases.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

5.5.3 Climate

Table 5-16 outlines potential climate-related impacts for GWA source water.

Table 5-16. Climate-Related Impacts for GWA Source Water

Climate-Related Event	Result	Potential Impact	Source
Rising sea level	Increase in elevation of the fresh water lens and fresh to salt transition zone	May raise the freshwater lens above well screen and put saltier transition water at the screen elevation, increasing chlorides.	Australian Bureau of Meteorology & CSIRO, 2011
ENSO-related drought	High inter-annual rainfall variability	Prolonged and extended dryness occurring in the year following El Niño.	
Increase in number of heavy and extreme rain days	Larger volume of runoff and/or infiltration over a shorter period	Increased potential for pollutant transport into aquifer with runoff infiltration. Increased sediment transport and resultant turbidity and pollution into surface water.	Australian Bureau of Meteorology & CSIRO, 2011
Increase in evapotranspiration	Less infiltration	Decrease recharge, well water levels drop.	Australian Bureau of Meteorology & CSIRO, 2011
Tidal fluctuations		In wells closest to the coast, water levels fluctuate daily as much as 0.5 feet in response to ocean tides. Wells in the high-hydraulic-conductivity limestone in the island's interior typically show much smaller daily fluctuations.	
Climate change in the South Pacific	Climate-related migration	People displaced by rising sea levels may migrate to Guam, adding to infrastructure requirements.	

ENSO = El Niño–Southern Oscillation

The source of all fresh water on Guam is rainfall, and water availability is highly vulnerable to changes in precipitation. Seasonal differences in rainfall and wind define distinct wet and dry seasons on the island. Mean rainfall ranges from about 84 inches per year near Apra Harbor to about 116 inches per year in the southern highlands (Daly and Halbleib, 2006). The largest deviations from mean rainfall conditions are related to tropical cyclones and El Niño/La Niña-Southern Oscillation events (Lander and Guard, 2003). Some of the wettest years have been during years when typhoons pass nearby or directly over the island (Lander and Guard, 2003). Rainfall during a year with El Niño conditions tends to be above average, while some of the driest years occur during the year following an El Niño event (Lander 1994; Guard and others, 1999).

Small islands such as Guam are well below the resolution of global climate models, which model macro-level climate changes. A 4-year USGS study is underway to evaluate potential adverse climate-change impacts on DoD installations which rely on Guam's surface-water and groundwater resources. For a range of climate-change scenarios on Guam, the study will:

- Evaluate how stream flow, sediment loads, and turbidity will be modified and affect surface-water availability.
- Assess how groundwater recharge and salinity will be modified.
- Define impacts to DoD infrastructure supplying surface water and groundwater and highlight adaptive strategies to maximize the water resources.
- Evaluate and implement effective communication strategies to inform water managers about potential impacts and adaptive strategies.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

To meet the objectives of this study, the research team will:

1. Develop regional and local climate projections.
2. Develop a southern Guam watershed model.
3. Recalculate Fena Valley Reservoir capacity.
4. Investigate groundwater geochemistry and refine recharge estimates
5. Apply the northern Guam groundwater model.
6. Assess adaptive strategies.
7. Communicate the results.

The study is scheduled to be complete in 2017. Impacts identified for DoD installations will almost certainly be applicable to GWA infrastructure. Monitoring the progress and results of this study will provide insight into the effects of climate change on all Guam water resources.

5.5.4 Reducing Demand

Potable water availability can be achieved via both supply-side enhancements and demand-side reduction, as described below.

Non-Revenue Water

The difference between water production and the billed water use is referred to as NRW. NRW includes “unbilled authorized consumption (water for firefighting, flushing, etc.) plus apparent losses (customer meter inaccuracies, unauthorized consumption, and systematic data handling errors) plus real losses (system leakage and storage tank overflows)” (AWWA, 2012).

Table 5-17 compares the water production to the average billed water use for March 2015 through February 2016. NRW accounted for 57 percent of water produced by GWA over this period with 56 percent in the north and 75 percent in the southern systems. Efforts made to reduce NRW will have the effect of either conserving supply (in the case of leaks and overflows), or increasing revenue (for apparent losses).

GWA should continue efforts to reduce NRW through meter replacement, leak detection and repair, and overflow reduction programs. Additional detail is provided in Section 11.5, Volume 2 (Water Loss Control).

Table 5-17. Water Production Versus Billing Data

Area	2015 Production (mgd)	2015–2016 Average Billing Data (mgd)	Non-revenue Water (mgd)	Notes
North (supplied primarily by wells)	33.91	14.46	19.46	Production includes wells
Central	2.28	0.97	1.31	Production includes wells, Santa Rita Spring, and Navy Water
South (supplied by Ugum SWTP)	2.11	0.53	1.58	Production includes Ugum SWTP
Nimitz pressure zones	0.20	0.09	0.11	Production includes Navy meters 109, 110
Total	**38.51**	**16.05**	**22.46**	

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Conservation

Options for water conservation on Guam were presented in Volume 2, Chapter 5 of the 2006 WRMP. Implementing this strategy, which includes education, a fixture retrofit program, pricing adjustments for high users, and an extensive leak detection program, is recommended. Water demand that is reduced through conservation can delay the necessity for new supply development.

Reuse

The limited options for water reuse on Guam were analyzed by wastewater facility in Volume 3, Chapter 7 of the 2006 WRMP. The recommendations identified remain valid and include:

- Development of water reuse regulations.
- Identification and evaluation of reuse markets.
- Reuse for agricultural, golf course, and landscape irrigation (new and existing development).
- Reuse for toilet flushing (new development).
- Exploration (in coordination with the Guam Department of Public Works) into reuse of recycled stormwater.

5.6 Recommendations

Table 5-18 summarizes the recommendations made throughout this section.

Table 5-18. Summary of Recommendations – Source Water		
Section	**Topic**	**Recommendation**
5.2.4	NGLA sustainable management	• It is recommended that GWA continue to take a leadership role in the development of sustainable management practices for the NGLA. As part of this role, GWA must develop policy around supply:demand ratios and when planning for expansion of the source water supply network, consider both economic and sustainability factors.
5.2.5	NGLA nitrogen contamination	• Wells identified as having increasing nitrate-nitrogen trends, or having average and/or maximum levels greater than or equal to 4 mg/L, should be closely monitored. Areas of special concern include the cluster of GWA wells and Mangilao Golf Course wells in the Mangilao sub-basin. • Investigate the applicability of the WERI-developed groundwater model for nitrogen transport through the NGLA to source water protection.

5.2.5	Elimination of septic systems and cesspools
	Construction of new sewer lines
		• Prioritize the connection of unsewered properties according to criteria outlined in Table 5-6.
		• To reduce the potential for contaminants entering the NGLA, create an on-site disposal system reduction strategy. The report should include:
		  • A 5-year plan to reduce or eliminate the construction of new septic systems over the NGLA.
		  • A 5-year plan to connect existing septic/cesspool properties currently located within 200 feet of a sewer main and/or within wellhead protection zones.
		  • A 20-year plan to connect existing septic/cesspool properties in conjunction with construction of new sewer lines at the rate of 5000 feet per year.

5.2.5	Land development	• Review current staff capabilities and capacity to address land development-related issues including: utility verifications, building permit review, participation in land use committees and urban planning initiatives, and proactive public outreach activities with development stakeholders (GEDA, realtors, developers), and ancestral land recipients at the planning stage. Identify gaps in budget and staff. • Work with Guam EPA to minimize approvals, especially variances, for new septic installations in northern Guam. Eliminate variances issued for new septic systems for homes within 200 feet of existing sewer lines. Partner with CLT and other developers at the planning stage to ensure that easements exist, land for infrastructure is assigned, and the wellhead protection plan is adhered to. • Investigate servicing the CLT properties so that thousands of septic systems are not installed over the NGLA. As part of the investigation, consider assisting CLT in the development of preliminary

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-18. Summary of Recommendations – Source Water		
Section	Topic	Recommendation
		engineering reports (similar to feasibility studies) required as part of the USDA funding application process. • Formalize the initiative for water/sewer system analyses for new development as proposed by the Engineering Division. Develop policy to adequately service new areas of development, including financial arrangements. • Update the sewer model to a level useful for planning scenario analysis.
5.2.5	Drought	• Monitor drought conditions and adjust pumping with aquifer sustainability in mind in addition to water supply. • Combine DoD and GWA source water withdrawal systems to optimize source water quality during both regular operations and drought conditions. • Support expansion of the groundwater model to analyze maximum demand withdrawal scenarios.
5.2.5	Contingency planning	• Develop a detailed operations strategy in conjunction with the WHPP contingency plan.
5.2.6	Water resources monitoring	• As the main user of the NGLA and a significant beneficiary of hydrological data collected in southern Guam, continue to provide financial, administrative, and organizational support for WERI and USGS monitoring programs island-wide.

5.2.6	Source water protection - WHPP	• Create a strategy to implement WHPP recommendations:
		  • Advocate for enforcement of existing zoning requirements that restrict location of new high-risk PCAs, such as onsite sewage disposal systems or ponding basins within designated distances from a water supply.
		  • Consider land purchase to control land use within the wellhead protection area of a well as applicable.
		  • Be actively involved in the development and permit review process to ensure that concerns involving the protection of the drinking water source well will be addressed prior to the permitting of new land uses within wellhead protection zones.
		• Develop a contingency plan for both groundwater and surface water supply.
		• Conduct an inventory of abandoned boreholes and wells to ensure all have been properly secured and decommissioned.

5.2.6	New well development	• Follow the guidance laid out by Vann et al (2013) when planning the expansion of the well network. • Consider advanced acquisition of land and access to areas where exploration work is likely to occur in the future. • Support studies that refine the NGLA basement map, as more accurate mapping will assist with planning future exploration programs. • Provide financial, administrative, and organizational support for WERI and USGS initiatives to quantify remaining withdrawal capacity for NGLA basins. • Work with DoD to develop new wells at depths and in locations that minimize detrimental effects on the aquifer.

5.2.6	Existing well redevelopment	• Complete ongoing CIP projects to rehabilitate and construct wells to increase supply:
		  • PW-05-13 Deep well rehabilitation
		  • PW 05-14 New deep wells at down hard sites
		  • PW 09-02 Construction of new production wells (5–7 mgd)

5.2.6	NGLA database	• Continue to contribute to and support expansion of the NGLA Database.
5.3.1	Ugum SWTP	• Ugum SWTP operators should monitor the Ugum River stream flows to ensure adequate minimum flow remains in the river. • A water supply policy should be established for southern Guam and a study undertaken to determine the most viable options to achieve the area's water supply goals. Water supply policy should address issues such as the level of acceptable service, and establish a contingency plan for when the Ugum SWTP is offline.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 5-18. Summary of Recommendations – Source Water		
Section	**Topic**	**Recommendation**
5.3.3	Ugum Watershed	• It is strongly recommended that GWA continue to take a leadership role in the protection and restoration of the Ugum Watershed, with the ultimate goal of increasing Ugum River water quality through cooperative efforts with other stakeholders. • Legislative changes necessary for watershed protection should be pursued as needed. • Continue the monetary and in-kind commitment to the WPC. Restoration of the Ugum Watershed should result in an overall decrease in sediment loading to the river, with a corresponding reduction in turbidity, and increase in water quality for the Ugum SWTP. • Assist Guam EPA with the preparation and review of the updated Ugum Watershed Plan.
5.3.3	Ugum SWTP intake	• Complete required intake repairs. • When the sediment is removed from the diversion pond, a volume-over-time accumulation profile should be calculated, and a sediment management program implemented, including funds to dredge at intervals appropriate for replenishment of impoundment volume and intake maintenance. • When the diversion impoundment structure is repaired, data regarding the transmissivity of the underlying and surrounding soils should be examined to ensure that minimum stream flow requirements are maintained in the Ugum River. • Undertake a study to investigate long-term options to decrease turbidity of the raw water quality prior to the water entering the plant, increase safety, and guarantee maintenance of minimum flows in the Ugum River. In addition to existing intake enhancements, reconstruction or relocation of the entire structure should be considered. • Determine with certainty the flow required to remain in the Ugum River downstream of the Ugum SWTP intake, and implement a program to ensure daily withdrawal does not cause river levels to drop below minimum flow including regular flow measurement upstream and downstream of the diversion structure.
5.3.4	Fena	• As a matter of long-term policy, decide whether to pursue operation and/or ownership of the Fena Reservoir and treatment facilities as part of the OneGuam initiative to combine DoD and GWA systems.
5.3.4	LOS for southern Guam	• As part of the creation of a GWA water resource policy, analyze security of service and options for supply redundancy in southern Guam communities.
5.3.4	Other sources for southern Guam	• Investigate the viability of acquiring any private wells for public use. • Investigate the feasibility of rehabilitating Asan Spring. • Rehabilitate MJ wells.
5.3.4	New surface water development	• If surface water development is identified as a priority during the creation of a GWA water resource policy, update the SWDS to reflect current conditions.

5.4	OneGuam	• Achieve all benchmarks required in pursuit of DoD and GWA system integration.
		• Identify funding and complete studies as outlined in the 2016 Framework and Section 4. Specifically:
		  • Conduct a feasibility study to determine the potential for a singular, unified water utility.
		  • Combine the DoD and GWA hydraulic models to plan for a combined water system.
		  • Evaluate applicable laws, service rules, and contracts.
		  • Fund a rate study based on a combined utility.
		  • Fund a feasibility study for a water exchange program.
		  • Create a strategic plan for a combined water utility.

5.5.1	Water resource policy	• Conduct a stakeholder workshop to identify and formalize a GWA water resource policy. Developing source water-related policy will create a roadmap for critical water supply decisions to be made over the next 20 years and beyond.
5.5.2	Supply-to-demand ratio	• Update the 2010 PWPEP to establish a strategy to achieve and ultimately maintain a 1.2 supply:demand ratio as demand increases.
5.5.4	Demand reduction	• Reduce NRW through meter replacement, leak detection and repair, and overflow reduction programs.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 6
Enterprise Environmental Factors

Every organization exists in an environment that can greatly influence—positively or negatively—the ways in which decisions are made and projects are managed. Different approaches are needed to deal effectively with the cultural, economic, logistical, regulatory, and political environment. Enterprise Environmental Factors (EEFs) include the policies, practices, procedures, and legislation that exist both inside and outside of an organization that impact the way business is done (Siegel 2012).

Identification of EEFs is critical to the master planning process. These realities need to be considered and contingencies developed to account for their influence on future performance. Beyond the master planning effort, knowledge of constraints and environment provides context for decision making and focus for change and improvement.

A selection of EEFs affecting GWA is presented in Table 6-1. Although not necessarily an exhaustive list, the table illustrates the diversity of the environment in which GWA operates, and the importance of considering EEFs in the planning process.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 6-1. Selected GWA Enterprise Environmental Factors		
	Factor	Examples
External Factors	Economy	Labor market conditions Interest rates Energy availability and cost
	Politics	Political stability CCU and PUC elections Water rights Military influence
	Security	Cyber Physical
	Laws, Regulations, Industry Standards, and Codes	Regulatory and judicial actions (i.e. 2011 Court Order and NEIC reports) Occupational health and safety legislation NPDES permits Drinking water quality standards Guam EPA programs Fire code pressure and minimum flow requirements Building codes and permits
	Climate and Environment	Extreme weather events such as drought and typhoons Natural disasters such as earthquakes and tsunami Climate change
	Geography	Land use and development policies Island isolation
	Culture	Demographics Service expectations
	Competition	Contract operators for Navy water and wastewater facilities
	Stakeholders	DoD agencies OneGuam Rate payers
	Water Supply	Watershed health Aquifer sustainable yield Availability of Navy water
Internal Factors	Organizational Culture and Structure	Risk tolerance Internal policies CCU outlook on utilizing Navy water Governance
	Resources	Availability of trained operators and tradespeople Physical resources
	Information Management Systems	SCADA and GIS Work authorization process Asset management systems
	Financial Stability	Cash flow Borrowing capacity

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The purpose of this section is the following:

- Identify EEFs with the potential to impact GWA operations
- Analyze three of the most important of those factors. These were identified as:
    - The upcoming relocation of U.S. Marine Corps forces to Guam from Okinawa.
    - The current regulatory environment affecting GWA planning and operations.
    - Security-related issues, both physical and virtual, with the potential to impact GWA.

Additional factors listed in Table 6-1 will be addressed within other sections of this WRMPU. These include SCADA, water supply, labor market conditions, culture, land use, and climate change. Although useful from an organizational standpoint, additional factors such as a detailed analysis of Guam's economy and politics, and GWA organizational structure are beyond the specific scope of this planning document.

6.1 Military Buildup

The following section describes EEFs related to the upcoming military buildup on Guam with the potential to impact GWA operations.

6.1.1 Background

Since the end of World War II, Guam's economy has been heavily influenced by the presence of the U.S. military. Defense commitments and international treaty obligations of the United States require ratification and funding by the federal government, leaving Guam in the unique position of having to react to decisions often made far beyond the geographical and political reach of the territory. These decisions can have a significant influence on the population, tax base, infrastructure needs, and land use planning.

For more than a decade, the proposed relocation of military personnel from Okinawa to Guam has been expected to have a major impact on the island. The projected size and composition of the forces have changed over time, making planning for the relocation a challenge for territorial agencies.

Table 6-2 details the timeline of the major decisions and reports leading up to the relocation. Key events from the timeline are discussed further in following subsections.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 6-2. Military Buildup Timeline

Date	Event	Discussion [a,b]
2002–2005	Integrated Global Presence and Basing Strategy (IGPBS) and Quadrennial Defense Review (QDR) initiatives Defense Policy Review Initiative (DRPI) talks	IGPBS and QDR initiatives included reduction of overseas forces as well as locating forces to support flexibility and speed of response. The DPRI focused on alliance transformation at the strategic and operational levels, with particular attention on the posture of U.S. and Japanese forces in Japan, as well as transforming capabilities in the Western Pacific around the U.S.-Japan alliance.
October 29, 2005	Alliance Transformation and Realignment Agreement (ATARA) Report	The DRPI talks resulted in the ATARA, in which the U.S.-Japan Security Consultative Committee (SCC) approved recommendations for realignment of U.S. forces in Japan in their document, “U.S.-Japan Alliance: Transformation and Realignment for the Future.” SCC staff was directed to finalize these initiatives and develop plans, including implementation schedules.
May 1, 2006	U.S.-Japan Roadmap for Realignment Implementation (the “Roadmap”)	The “Roadmap” outlined details of realignment initiatives, including cost sharing arrangements with the Japanese government and relocating approximately 8,000 Marines and 9,000 dependents from Okinawa to Guam with a target completion date of 2014.
February 17, 2009	Guam International Agreement	The Guam International Agreement outlined financial contributions to be made by Japan for the relocation of Marines from Okinawa and the responsibilities of both the U.S. and Japan to construct the infrastructure necessary to complete the relocation.
July 2010	EIS Report	In accordance with the National Environmental Policy Act (NEPA), the Navy prepared an Environmental Impact Statement (EIS) to assess the potential environmental effects associated with the proposed “Roadmap” activities and identify preferred alternatives.
September 2010	2010 ROD	In September 2010, the military issued a ROD for “The Guam and CNMI Military Relocation: Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Air and Missile Defense Task Force.”
April 27, 2012	2012 Roadmap Adjustments	On April 27, 2012, the SCC issued a joint statement announcing its decision to adjust the plans outlined in the May 2006 Realignment “Roadmap.” These “2012 Roadmap Adjustments” included reducing the force to 5,000 Marines and approximately 1,300 dependents on Guam. This decision prompted the Navy’s review of the major actions previously planned for Guam and approved in the September 2010 ROD.
July 2015	SEIS Report	In July 2015, the Navy published a SEIS that assessed the potential environmental consequences of establishing a LFTRC, cantonment area, family housing area, and associated infrastructure on Guam in accordance with the “2012 Roadmap Adjustments” and identified preferred alternatives.
August 28, 2015	EAC Implementation Plan [c]	Recognizing that Guam lacks the ability to finance the public infrastructure improvements on the schedule necessary to support the SEIS preferred alternative, the Economic Adjustment Committee (EAC) detailed that Federal assistance and investment in Guam’s civilian infrastructure of between $196.6 and $218.0 million is needed to address and mitigate the unavoidable impacts attributable to the relocation of Marine Corps forces to Guam. The EAC Implementation Plan (EACIP) contains detailed descriptions of work, costs, and schedules for completion of construction, improvements, and repairs to Guam public infrastructure affected by the realignment. This includes the refurbishment of the GWA interceptor sewer from Andersen AFB to the Northern District WWTP, expansion/rehabilitation of the NGLA monitoring network, and upgrade of the Northern District WWTP.
August 29, 2015	2015 ROD	The Navy released the ROD for relocating Marine Corps forces to Guam, selecting the preferred alternatives as described in the 2015 SEIS: cantonment/family housing Alternative E and LFTRC Alternative 5. The cantonment is to be located at Navy Computer and Telecommunications Station – Guam (Finegayan), and family housing at Andersen AFB. The LFTRC will be located at Andersen AFB Northwest Field, with a stand-alone hand grenade range at Andersen South.

a. Source for information 2002-2010: 2010 EIS.

b. Source for information 2010-2027: 2015 SEIS, except EACIP.

c. Source: 2015 EACIP.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The Roadmap and Roadmap Adjustments

An execution plan for the Defense Policy Review Initiatives (DPRI) was presented in the 2006 U.S.-Japan Roadmap for Realignment Implementation. The "Roadmap" outlined details of realignment initiatives, including cost-sharing arrangements with the Japanese government and relocation of approximately 8,000 Marines and 9,000 dependents from Okinawa to Guam with a target completion date of 2014. Over the following years, the 2010 EIS was developed by the Navy for the Roadmap activities, public input was received, and support for the relocation was sought from the U.S. and Japanese governments.

In 2012, the U.S.-Japan Security Consultative Committee (SCC) issued a joint statement announcing its decision to adjust the plans outlined in the 2006 Roadmap. These "2012 Roadmap Adjustments" included reducing the force to 5,000 Marines and approximately 1,300 dependents on Guam and extending the target completion date for the relocation to 2028. This decision prompted the Navy's review of the major actions previously planned for Guam. The review concluded that while some actions remained unchanged as a result of the smaller force size, others, such as the main cantonment and family housing areas, could significantly change due to the modified force.

2015 Final Supplemental Environmental Impact Statement

The Navy prepared the 2015 Final SEIS to evaluate potential environmental consequences of alternative locations for the cantonment, housing, community facilities and LFTRC needed to support the military relocation to Guam as outlined in the 2012 Roadmap Adjustments. Impacts were assessed for the following resource areas: geological and soil resources, water resources, air quality, noise, airspace, land and submerged land use, recreation, terrestrial biological resources, marine biological resources, cultural resources, visual resources, ground transportation, marine transportation, utilities, socioeconomics and general services, hazardous materials and waste, public health and safety, and environmental justice/protection of children.

The SEIS identified the preferred alternative as cantonment at Naval Computer and Telecommunications Station Finegayan, family housing at Andersen AFB (Alternative E in the 2015 Final SEIS), the LFTRC at Andersen AFB NWF (Alternative 5 in the 2015 Final SEIS) and a stand-alone hand grenade range (HGR) at Andersen South.

Economic Adjustment Committee Implementation Plan

The Economic Adjustment Committee (EAC) was convened to "consider assistance, including assistance to support public infrastructure requirements, necessary to support the relocation of Marine Corps forces to Guam (SS 2822 9d) FY2014 NDAA)." As part of the EAC Implementation Plan (EACIP), GWA systems were assessed by an interagency water and wastewater working group with subject area experts from the USEPA, the Guam Office of the Governor, the Navy, GWA, and CCU.

Three projects were recommended:

1. Upgrade the Northern District WWTP treatment systems ($134.3 to $139.6 million).
2. Refurbish the GWA interceptor sewer from Andersen AFB to Northern District WWTP ($28.8 to $30.6 million).
3. Update and expand the NGLA monitoring well network ($2.2 to $3.7 million).

The EACIP includes detailed descriptions of work, costs, and schedules for construction, improvements, and repairs to Guam public infrastructure affected by the realignment. The limited capacity for Guam to fund these necessary upgrades was recognized by the EAC. As a result, the DoD sought $173.9 million to complete the projects. $106.4 million of was appropriated in July 2016, and in August of 2016, $55.3 million in funding was released to GWA for obligations related to the Northern District WWTP, the interceptor sewer line refurbishment, and the monitoring well network.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

In November 2017, the U.S. Department of Defense Office of Economic Adjustment awarded GWA a further $117.9 million for construction of upgrades to the Northern District WWTP.

2015 Record of Decision

On August 29, 2015, the Navy released the ROD for the relocation of U.S. Marine Corps forces to Guam from Okinawa, Japan. The Navy selected the preferred alternatives as identified in the 2015 Final SEIS. Figure 6-1, reprinted from the SEIS, illustrates the locations of the expected development.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

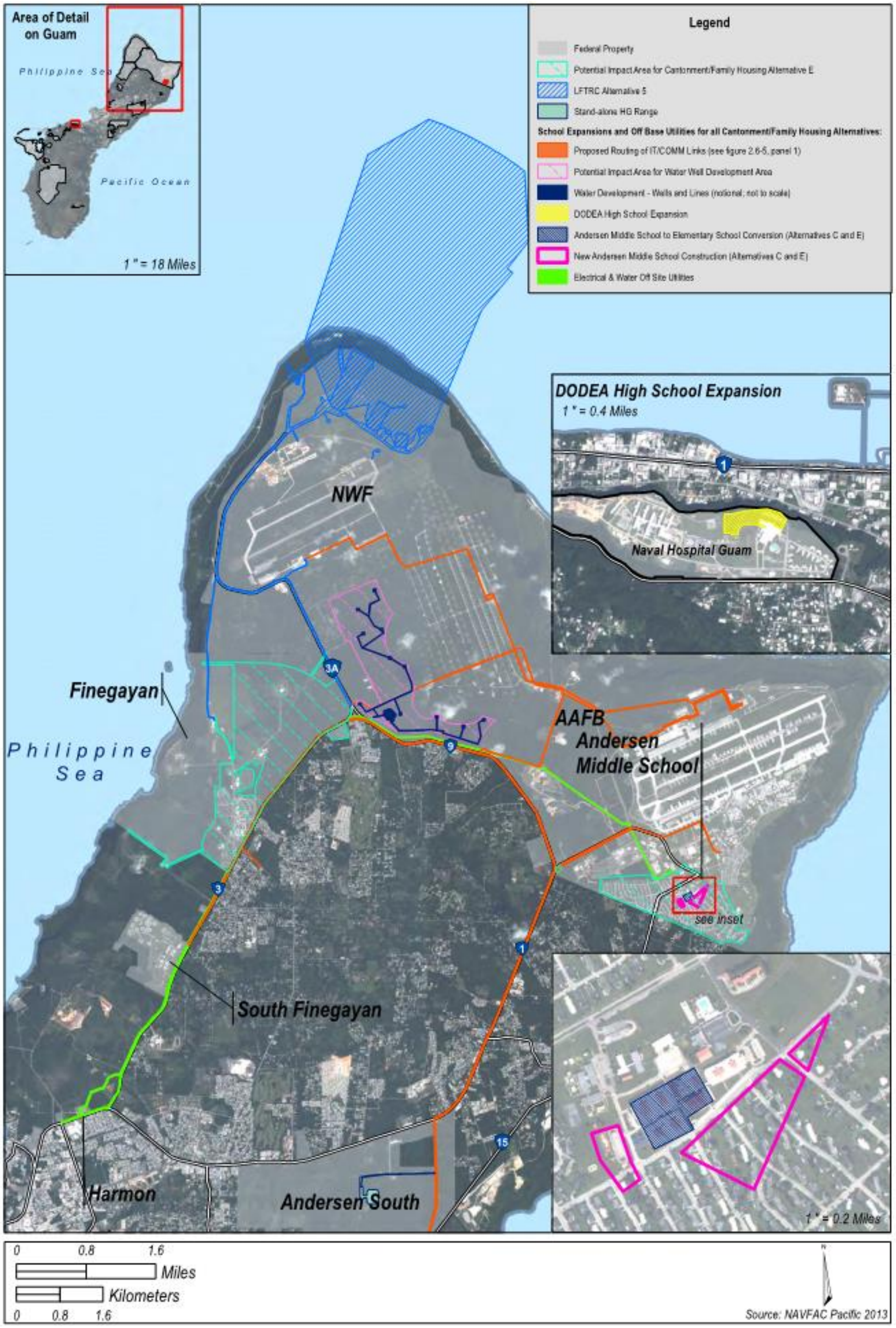


Figure 6-1. Development for Military Relocation

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The Finegayan cantonment area will consist of six functional areas: Command Core, Unit Operations, Base Operations, Bachelor Quarters, Community Support, and Training. The family housing area on Andersen AFB will include family housing units (single-family residences, duplex residences, and fourplex residences), community center, elementary school (converted from the existing Andersen Middle School), child development center, temporary lodging facility, youth center, and a base exchange. A new middle school will be constructed at Andersen AFB, and the Department of Defense Education Activity (DODEA) High School in Agana Heights will be expanded. Infrastructure will be expanded both on and off base to accommodate the new facilities and personnel.

Table 6-3 provides a summary of buildup-generated projects with the potential to impact GWA systems.

Table 6-3. Buildup-Related Projects

Project	Location
Finegayan Cantonment	Finegayan
Andersen Family Housing	Andersen AFB
LFTRC	Andersen AFB NWF
HGR	Andersen South
Construction of new water supply wells, piping, and storage	Andersen AFB
Construction of new monitoring wells	Andersen AFB
Off-base road widening and intersection improvements	Routes 1, 3, 16, and 28
Off-base utility construction	Routes 3 and 9
DODEA High School expansion	Agana Heights
Andersen Middle School to elementary school conversion	Andersen AFB
Andersen Elementary School construction	Andersen AFB

GWA services will be affected directly and indirectly by increased wastewater generation and potable water demands of the relocated troops, dependents, and support workers. The DoD has put significant effort into planning for the relocation, including identifying options to mitigate impacts to Guam's infrastructure and water resources. The balance of this section details those impacts, as well as the upgrades and mitigation proposed to accommodate the buildup.

6.1.2 Wastewater Systems

This section outlines the impact of the military relocation on GWA wastewater systems. A discussion of specific impacts is presented first, followed by details of DoD-generated flow estimates.

Impacts and Mitigation

Table 6-4 details the impacts to GWA wastewater systems anticipated as a result of the relocation. Issues and concerns associated with those impacts are presented, as well as proposed mitigation measures.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 6-4. Issues, Impacts, and Mitigation – GWA Wastewater Assets

Impact	Issue	Concern	Mitigation
Increased wastewater flow through GWA interceptor sewer from Andersen AFB to Northern District WWTP during both construction and operations activities	CCTV data has shown the reinforced concrete pipeline to be in an advanced state of deterioration.	Increased wastewater flows have potential to accelerate pipeline deterioration.	The EACIP outlines the need for federal assistance to complete the refurbishment of the interceptor sewer between Andersen AFB and Northern District WWTP (value: \$28.8 to \$30.6 million).[a]
	System spills exceed spill rate norms for similar wastewater systems.	Increased wastewater flows could lead to additional spill frequency and/or volume.	
Increased effluent production from Northern District WWTP	Northern District WWTP is non-compliant with the 2013 NPDES permit. The CWA waiver from secondary treatment was denied by USEPA in 2011.	Additional wastewater flow to an already noncompliant treatment plant will have a significantly adverse impact on the environment [b]	EACIP outlines the need for federal assistance to upgrade Northern District WWTP to secondary treatment. (value: \$134.3 to \$139.6 million).[a]
Increased influent at Northern District WWTP	Long-term operational impacts.	Increased sludge production.	The Marine Corps will pay a system development charge and as a rate-paying customer contribute revenue to GWA for O&M.
		Increased power demands.	GWA will require additional personnel and O&M budget for an expanded facility.
		Increased requirements for operations personnel and training.	
		Depreciation, compliance, and facility maintenance costs.	GWA will require additional budget for an expanded facility. Increased revenue from DoD customer accounts will help offset costs.
		Increased industrial wastewater and FOG content.	BMPs such as an on-base program to control FOG and pretreatment of industrial wastewater with oil-water separators will be incorporated in facility design.
Risks to existing assets during construction	Short-term construction impacts.	Increased service outages.	BMPs such as coordination with GWA and permitting agencies, pre-construction utility location, constructing wastewater lines during low-flow periods, bypass pumping, and standby pump trucks will be utilized during construction.
		Increased wastewater spills.	
Increased influent at other island wastewater facilities	Hagåtña WWTP is non-compliant with the 2013 NPDES permit. Island-wide, wastewater facilities and collection systems have had operational issues requiring compliance actions.	Additional wastewater flow to noncompliant treatment plants will have a significantly adverse impact on the environment. [b]	Northern District WWTP will treat all direct wastewater flows from on-base facilities. Impacts from indirect wastewater flows generated by temporary construction workforce and civilian population increase outside of the Northern District wastewater service area are considered less than significant. [b] Compliance issues at Agat-Santa Rita WWTP, Baza Gardens WWTP, and Umatac Merizo WWTP will be addressed by 2018.
Increased operations costs at upgraded Northern District WWTP	A more complex plant will incur additional O&M costs.	Additional trained personnel are required to operate and maintain the plant.	The Marine Corps will pay a system development charge and as a rate-

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 6-4. Issues, Impacts, and Mitigation – GWA Wastewater Assets			
Impact	Issue	Concern	Mitigation
		Depreciation and an increase in maintenance costs.	paying customer contribute revenue to GWA for O&M.

a. Source: 2015 EACIP, estimates in 2016 dollars

b. Source: 2015 SEIS

CCTV = closed-circuit television

FOG = fats, oils, and grease

The significant impacts to wastewater systems associated with the military relocation result from increased flows into the collection system and through the Northern District WWTP. As discussed in Section 6.2.1, the EACIP identified that federal support is needed to address these impacts. The two EACIP recommended projects are discussed below.

Upgrade of Northern District WWTP to Secondary Treatment

All wastewater from the cantonment at Finegayan and additional family housing at Andersen AFB will be processed at the Northern District WWTP, which is not in compliance with the secondary treatment requirements for the current (2013) NPDES permit. Additional wastewater flow to an already noncompliant plant will have a significantly adverse impact to the environment due to increased effluent leaving the outfall in the Philippine Sea (2015 SEIS). To mitigate the impacts, the DoD is contributing to upgrade the Northern District WWTP processes to both meet its design capacity of 12 mgd and provide secondary treatment. The upgraded plant is scheduled to be in operation by 2021. Major components of the project will include:

- Alteration to the preliminary treatment.
- Construction of new secondary treatment components.
- Upgrade of the solids management and disinfection systems.
- Installation of the outfall diffuser.

GWA Interceptor Sewer Refurbishment

The existing GWA interceptor sewer line from Andersen AFB to the Northern District WWTP will convey wastewater generated by buildup activities. Closed-circuit television (CCTV) footage from 2014/2015 shows substantial deterioration and pipe wall corrosion of the reinforced concrete pipe. Repair is required prior to the addition of flows to prevent further damage, potential loss of service to both civilian and military facilities, and leakage into the underlying aquifer. To mitigate potential impacts, the DoD has proposed funding a cured-in-place pipe rehabilitation program. A phased approach is planned, with the northern half of the line completed by 2019 and the southern half by 2021.

Wastewater Flows

DoD estimates for wastewater flows to the Northern District WWTP are presented in Table 6-5. Direct wastewater flows include all wastewater flows that would be generated by active duty personnel and their dependents, the on-base civilian workforce, and industrial flows from on-base facilities. Indirect wastewater flows include increased flow from induced civilian population growth resulting from the military relocation, increased construction workforce, and all other anticipated DoD projects. The forecasted organic Guam civilian population growth will also contribute to the increase in future wastewater flow to the plant.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 6-5. DoD Northern District WWTP Wastewater Flow Estimate – 2028 [a]			
Wastewater Impact	Average Flow (mgd)	Maximum Flow (mgd)	Increase from Baseline
Baseline	5.1	11.48	N/A
Direct increase	1.23	2.08	24%
Indirect increase	0.61	0.81	12%
Projected civilian growth to 2028	0.84	1.88	16%
Total future flows (2028) [b]	**7.78**	**16.25**	**53%**

a. Source: 2015 SEIS, Table 4.1.14-1.

b. Total may not add due to rounding.

As shown in Table 6-5, the total future flow at the steady state year 2028, including the flow from the proposed action and Guam civilian growth, is estimated by DoD to increase the average baseline flow by 53 percent at the Northern District WWTP. The estimated direct and indirect wastewater flows specifically attributed to the build-up represent a 36 percent increase from the baseline.

Flows produced at the LFTRC and HGR are not considered significant. According to the SEIS, wastewater flows generated at these two locations will be less than 0.01 mgd, and serviced by a combination of portable toilets and a septic tank/effluent disposal basin system.

6.1.3 Northern Guam Lens Aquifer

The NGLA is the sole source of drinking water for more than 80 percent of Guam residents. Both military and civilian populations are served by water drawn from the aquifer. In general, wells located on Andersen AFB supply DoD requirements, while GWA wells located off-base provide water for civilian use.

The proposed Marine Corps relocation to northern Guam will require additional production wells to support increased water demand. The additional demands on the NGLA will begin during construction, but most of the increase will start in 2021 when the relocated Marines and their families start arriving on Guam. In addition to impacts associated with withdrawing drinking water from the aquifer to supply the new facilities, construction and operational activities associated with the buildup also have the potential to affect the subsurface water quality.

Impacts and Mitigation

Impacts to and mitigation proposed for the NGLA for the buildup activities are detailed in Table 5-7 of this report.

NGLA Monitoring System Expansion and Rehabilitation

A comprehensive NGLA monitoring program is critical to ensure the sustainability of the resource and supply quality water to all users. The EACIP outlines the need for federal assistance to expand the NGLA monitoring program. Major work elements include:

- Refurbishment of 12 existing monitoring wells.
- Abandonment and closure of one existing monitoring well.
- Installation of 7 new monitoring wells.

Live-Fire Training Range Complex

Figure 6-1 shows the general location of the LFTRC. Figure 6-2, reprinted from the 2015 SEIS, provides additional detail of the project area over the NGLA. Of note is the proximity of the range to the northernmost active groundwater wells, the prevalence of sinkholes, and the general direction of groundwater flow.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

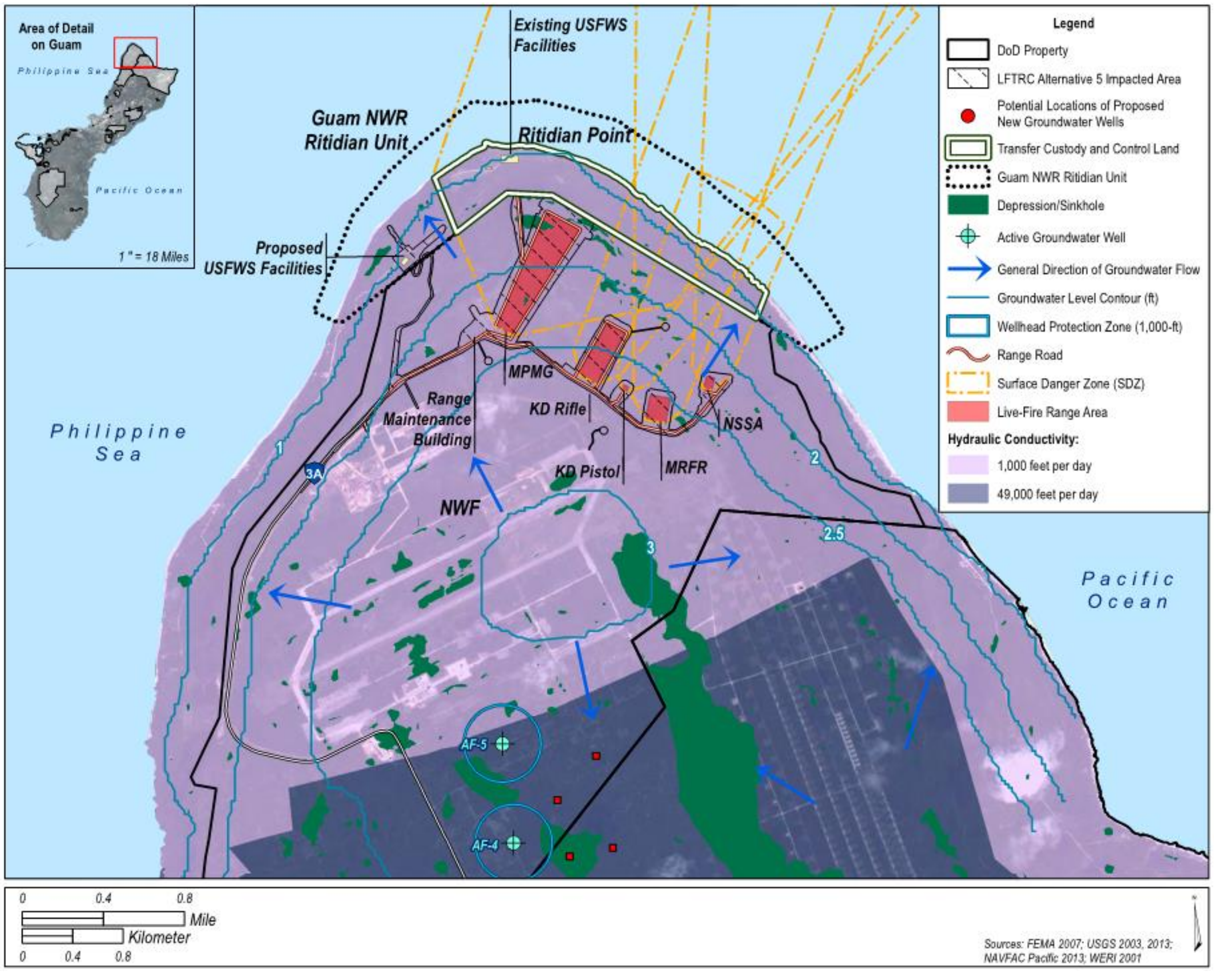


Figure 6-2. LFTRC – Surface and Subsurface Details

Prior to construction, site-specific data will be collected to assess the potential for lead and other munitions constituents to migrate into the surrounding environment. Monitoring wells are proposed throughout the range area. According to DoD, a mitigation plan will be created to ensure there is no impact on the underlying groundwater, and that the direction of groundwater flow away from drinking water wells is maintained.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Potable Water Demand

Potable water demand estimates for the military buildup at Finegayan and Andersen AFB are outlined in Table 6-6.

Table 6-6. DoD Water Demand Estimate – 2028

Average Day Demand (mgd)	Maximum Day Demand (mgd)	Assumptions
1.7	2.6	Steady state operations. All housing units fully occupied.

Source: 2015 SEIS.

According to the SEIS, potable water demand for the LFTRC is estimated at 0.03 mgd, and the HGR does not require water service. Therefore, these facilities will have minimal impact on water supply.

It was estimated that the proposed action would require installation of approximately 11 new wells at Andersen AFB to meet the maximum day demand (2015 SEIS). However, representatives from GWA and DoD have been in discussion since 2010 to identify opportunities to collaborate, share resources where appropriate, and identify steps toward the integration and consolidation of water delivery to the island community. This vision of an integrated water system is referred to as OneGuam. The first OneGuam pilot project is the operation of the DoD Tumon Maui Well by GWA, which was rehabilitated in preparation for the military buildup. The facility became operational in July 2016 and is currently providing up to 1.3 mgd of supply to the GWA system. Operation of this well, combined with water sharing agreements between GWA and DoD, will decrease the need for some of the new wells planned for Andersen AFB and allow for reduced pumping from nearby GWA wells with higher salinity. A portion of water for the new cantonment and housing facilities will instead be supplied by GWA via the Potts Junction interconnection point. OneGuam is discussed in Section 5.4.

6.1.4 Other Impacts

The following section describes other potential impacts to GWA operations related to the upcoming military buildup.

Population

In 2014, active duty military personnel numbered 6,006 (Guam Statistical yearbook, Table 8-02). There were an additional 6,648 family members, for a total military population of 12,654, or 7.9 percent of the population of Guam. The SEIS indicates that by 2026, an additional 5,000 Marines and 1,300 dependents will arrive, increasing the military population by nearly 50 percent over 2014 levels.

In addition to the increase in active duty military and dependents, Guam's population is expected to fluctuate due to construction activity related to the military buildup and civilian jobs created by buildup activities. It is expected that temporary foreign workers (such as those on "H2-B" visas) brought to the island for military projects will transition from project to project during the 13-year construction period, resulting in a shortage of construction workers on the island. Although these workers will leave the island after the completion of buildup-related construction, their departure will be offset by the arrival of military personnel and dependents.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Additional details regarding population growth and labor market concerns are presented in Section 4. Table 4-2 shows population impacts related to the proposed military buildup over the period of 2015 to 2028. Figure 4-11 illustrates the cumulative expected population growth (including the military buildup as outlined in Table 4-2) to the year 2050.

The population growth presented in Table 4-2 does not include additional construction personnel required for the $179M EACIP projects discussed in Section 6.2.1.

The DoD has committed to support the efforts of the Civilian Military Coordination Council (CMCC) to develop recommendations, as appropriate, regarding adjustment of construction tempo and sequencing to directly influence workforce population levels and indirectly influence induced population growth before infrastructure capabilities are exceeded. Such support may include providing project-related employment and population forecasts, participating in the identification of shortfalls in Guam public services, and assisting in the identification of federal programs and funding sources that may help the Government of Guam to address shortfalls (2015 SEIS).

Road Improvements

The roadway widening and intersection improvement projects in Table 6-7 were identified in the SEIS to address impacts to Guam roadways resulting from the relocation. GWA should plan for these upgrades in conjunction with the Department of Public Works and DoD to take advantage of the opportunity to inspect and/or upgrade utilities exposed as a result of the road projects.

Table 6-7. Proposed Road Projects

Road	Widening	Intersection Improvements
Route 1	From Route 3 to Route 34 From Route 34 to Route 16	Route 1/Route 3 Route 1/Route 27 Route 1/Route 26 Route 1/Route 14A Route1/Route 10A
Route 3	From Route 3A/9 to Finegayan Main Gate From Finegayan Main Gate to Finegayan Residential Gate From Finegayan Residential Gate to Route 28 From Route 28 to South Finegayan Main Gate From South Finegayan Main Gate to Route 1	Route 3/3A/9 Route 3/Royal Palm Drive
Route 28	From Chalan Balako to Route 3	-
Route 16	-	Route 16/Route 27 Route 16/Route 10A

Impact on Rate Payers

Expanded DoD water facilities will in general be operated separately from the system operated by GWA. Any integration of the two systems, such as those proposed through the OneGuam initiative, will result in mutual benefit to both GWA and DoD. Therefore, no impacts to Guam rate payers are expected as a direct result of the buildup.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

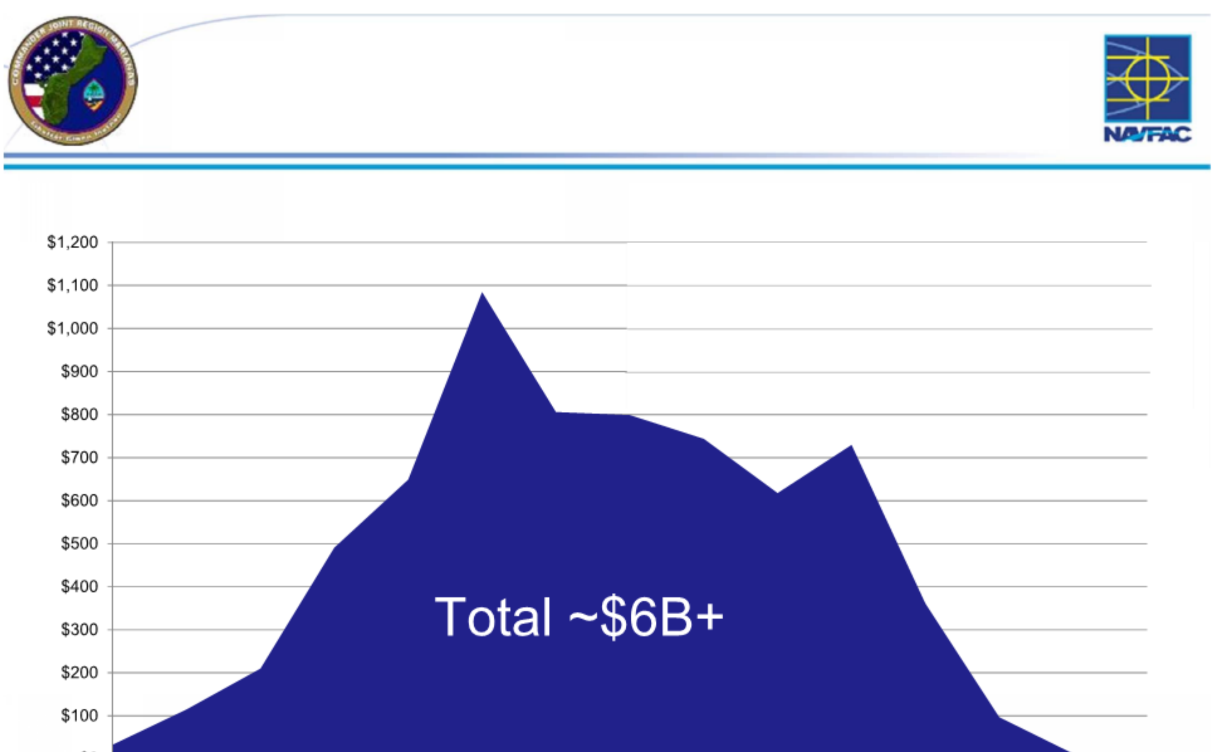
Upgrades to treatment at the Northern District and Hagåtña WWTPs and sewer collection system improvements are required whether or not the Marines relocate. Identification of federal funding sources could offset potential rate increases that might otherwise be charged to rate paying customers on Guam. Further, the proposed action will result in an increased customer base by the addition of Marines as new rate paying customers. There may also be impacts to the GWA wastewater systems in southern Guam that are not used by the DoD but would service additional civilian populations from induced growth. These systems require ongoing maintenance and upgrades, although the projected buildup-related population increase for the southern parts of Guam is minimal.

6.1.5 Schedule for Implementation of Impact Projects

The following section summarizes the schedule for implementation of projects related to the military buildup.

Overall Buildup Schedule

Construction activity required to implement the proposed military buildup is underway. The work is expected to peak between 2017 and 2025 and taper off until the final year of construction in 2027. Figure 6-3, reprinted from the NAVFAC Marianas website, details the estimated value for each year of construction.



	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
Proj.	3	8	13	17	36	39	42	33	33	28	18	13	3	1	0

Source: www.navfac.navy.mil.

Figure 6-3. Estimated Construction Workload by Year as of October 2015 (DPRI Program)

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Marine Corps Base Guam is planned to be operational in January 2022. Marines and their families will need civilian wastewater improvements in place prior to the start of their arrival in 2019.

Schedule for Implementation of Impact Projects

Implementation schedules for the Northern District WWTP upgrades, effluent diffuser installation, interceptor sewer refurbishment, and NGLA monitoring expansion were developed as part of the EACIP. These schedules have since been refined and updated by the Program Management team.

Table 6-8 illustrates key milestones for the Northern District WWTP design-build project.

Table 6-8. Northern District WWTP Treatment Upgrades Project Schedule

Milestone	Anticipated Completion Date [a]
Project funds available	August 2016 (Grant 1) January 2018 (Grant 2) [b]
Land acquisition	December 2017 [c]
NTP PMCM firm	February 2017
NEPA process and documentation	Per EPA schedule
100% design submittal and bid documents	January 2019
NTP construction contractor	May 2019
Construction completion	December 2021

a. As of 9/22/2017

b. Anticipated date of fund release

c. Land appraisals completed as of report writing, purchase not yet complete

PMCM = program management/construction management

NTP = notice to proceed

The availability of funding initiated several key tasks including the formal start of the land acquisition process and the procurement of a design firm for the project. The NEPA process is anticipated to occur concurrently with the design phase. The design and construction schedule is conservative and allows for additional time for project delays associated with work in Guam's remote location.

Table 6-9 illustrates key milestones for the installation of the effluent outfall diffuser.

Table 6-9. Northern District WWTP Effluent Outfall Diffuser Project

Milestone	Anticipated Completion Date [a]
Project funds available	August 2016
NTP PMCM firm	February 2017
100% Design Submittal/Bid Documents	November 2017
NTP to Contractor	February 2018
Construction Complete	June 2018

a. As of 9/22/2017

PMCM = program management/construction management

NTP = notice to proceed

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 6-10 illustrates key milestones for the interceptor sewer project.

Table 6-10. Interceptor Sewer Refurbishment Project Schedule

Milestone	Anticipated Completion Date [a]
Project funds available	August 2016
NTP PMCM firm	February 2017
Bid step 1 – Technical Offer	October 2017
Bid Step 2 - Pricing	December 2017
NTP design build contractor	March 2018
90% design submittal	November 2018
Construction complete	June 2020

a. As of 9/22/2017

PMCM = program management/construction management

NTP = notice to proceed

Table 6-11 illustrates key milestones for the NGLA monitoring project. Additional project details can be found in Section 5.2.

Table 6-11. NGLA Monitoring System Expansion and Rehabilitation Project Schedule

Milestone	Anticipated Completion Date [a]
Project funds available	August 26, 2016
NTP to PMCM firm	February 10, 2017
100% Rehabilitation Wells Design Submittal/Bid Documents	January 2018
NTP to Rehabilitation Wells Contractor	April 2018
Rehabilitation Wells Construction Complete	July 2019
100% New Wells Design Submittal/Bid Documents	April 2018

a. As of 9/22/2017

PMCM = program management/construction management

NTP = notice to proceed

6.2 Regulatory Requirements

The GWA Compliance and Safety Division ensures adherence to all applicable regulatory requirements. GWA must comply with territorial and federal regulations for both water and wastewater treatment and services. Water standards are based on the requirements established by the SDWA, while wastewater treatment and disposal is governed by the CWA. USEPA issues NPDES permits for GWA facilities when required, and is responsible for monitoring compliance. Guam EPA is the territorial agency in charge of monitoring GWA operations and monitoring for SDWA compliance.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Guam EPA oversees three programs that relate to drinking water protection: the Safe Drinking Water Program, the Water Resources Management Program, and the Water Pollution Control Program. The primary goal of the Safe Drinking Water Program is to ensure that potable water on Guam meets local and national standards. The purpose of the Water Resources Management Program is to protect and manage groundwater resources. Through the Water Pollution Control Program, Guam EPA enforces the provisions of the Guam Water Pollution Control Act and follows the mandates of the CWA with the goal of protecting surface water resources.

Guam regulations governing water resources, drinking water and wastewater are found in the Guam Administrative Rules and Regulations (GAR) Title 22. A summary is presented in Table 6-12.

Table 6-12. GARR Title 22 Regulations

Regulation	Title
Division 2, Chapter 5	Water Quality Standards [a]
Division 2, Chapter 6	Safe Drinking Water Regulations
Division 2, Chapter 7	Water Resource Development and Operating
Division 2, Chapter 8	Sewer Connection
Division 2, Chapter 9	Underground Injection Control
Division 2, Chapter 10	Soil Erosion and Sediment Control
Division 2, Chapter 11	Water and Wastewater Operator Certification
Division 2, Chapter 12	Individual Wastewater Disposal Systems
Division 5, Chapter 22	Connection to Public Sewer
Division 9, Chapter 45	Soil Erosion and Sedimentation Control

a. The 2001 Guam Water Quality Standards are currently undergoing revision.

The status of GWA regulatory compliance for water and wastewater systems is discussed in the following section.

6.2.1 Background

The current major compliance requirements for GWA are covered under a 2011 Court Order, significant findings for water from a USEPA NEIC inspection conducted in 2012, and 2013 NPDES permits requiring treatment upgrades for the Northern District WWTP and Hagåtña WWTP.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

2011 Court Order

On November 10, 2011, the U.S. District Court of Guam issued the 2011 Court Order. The 2011 Court Order establishes deadlines for completing outstanding projects that were identified in a previous Stipulated Order originally issued in 2003, and subsequently amended in 2004 and 2006. The 2011 Court Order supersedes the requirements of all previous orders. Table 6-13 provides a brief summary of the 2011 Court Order, and GWA's status meeting the deadlines. As shown in the table, GWA has successfully met most deadlines. The missed deadlines have generally been because of unavoidable construction delays. USEPA has not fined GWA for missed deadlines since the 2011 Court Order was issued, a testament to GWA's success in meeting the challenges to date. GWA remains on track to be in compliance with the scheduled requirements of the 2011 Court Order by 2021. Other requirements of the 2011 Court Order related to improved utility management practices are on-going, such as implementation of an asset management process, and will continue beyond 2021.

Table 6-13. Summary of 2011 Court Order and Status

Project Name	Deadline Status [a]				
	Total	Completed	Missed but Since Completed	Missed: Pending Completion	Ongoing or Pending
Northern District WWTP Interim Primary Treatment Upgrades	10	9	1	0	1 [b]
Hagåtña WWTP Interim Measures	13	13	1	0	0
Infiltration and inflow (I/I) and SSES Work Plan	8	7	0	0	1 [c]
Agat-Santa Rita WWTP Projects	10	6	1	1	4 [c]
Baza Gardens WWTP Projects	8	5	0	1	3
Umatac-Merizo WWTP Projects	4	1	0	0	3
Sewer Cleaning	1	0	0	0	1
Hot Spot Plan	1	0	0	0	1 [c]
CCTV Inspection Program	3	1	0	2	2
Groundwater Chlorination	1	1	0	0	0
Chlorine Residual Monitors	4	3	0	1	1
Water Metering	3	2	0	1	1 [d]
Ugum SWTP	5	5	0	0	0
Sinajana Water Transmission Line	7	6	0	1	1
Storage Tank/Reservoir Rehabilitation and Replacement Program	10	5	0	0	5
Totals	**88**	**64**	**3**	**7**	**24**

a. As of October 29, 2015.

b. Construction complete, continued monitoring and reporting only.

c. USEPA requested additional information, project reopened.

d. Approximately 80 meters out of the original 41,300 meters need to be replaced, which includes meters that are the most difficult to replace.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

2012 USEPA Findings of Significant Deficiencies: Water

On November 1, 2012, USEPA issued a notice that significant deficiencies were found in the GWA water systems pursuant to the SDWA, based on inspections and sanitary surveys conducted by the USEPA NEIC during April and May 2012. The NEIC report identified deficiencies in water sources, treatment systems, finished water storage, distribution systems, BPSs, water quality monitoring, reporting and verification, SDWA compliance, water system management, operations and administration, and operator compliance with licensing requirements. GWA submitted a response plan in December 2012 and its formal response in April 2013. The formal response led to a Corrective Action Plan that was adopted by GWA and USEPA in 2014. The significant deficiencies have either been completed as part of the 2011 Court Order, or will be addressed via a long-term planned approach by GWA. Table 6-14 provides the current status of GWA's performance addressing USEPA's findings. The current CIP includes projects to address the USEPA findings of significant deficiencies in the water system.

Table 6-14. GWA Status Addressing USEPA Findings of Significant Deficiencies – Water

Corrective Action Plan Status	Number of Items
Completed: no further action	26
Interim completion: next step(s) scheduled	0
2011 Court Order-managed items	10
On schedule: next step(s) scheduled	0
In progress: continuous (long-term commitment)	4

2013 USEPA Request for Information – Wastewater

On May 30, 2013, USEPA issued a request for information to GWA under Section 308 of the CWA. The NEIC inspected GWA's NPDES permitted WWTPs, pump stations, and collection systems in April and May 2012, and documented its findings and observations in a report on the wastewater collection and treatment systems. GWA issued a response to USEPA's request for information indicating that out of 72 findings and 16 sub-findings, for a total of 88, GWA has completed 37. Another 28 are included in the 2011 Court Order projects. The remaining 23 are ongoing, or undergoing continuous monitoring and maintenance. No corrective action plan is being developed at this time.

Groundwater under the Direct Influence of Surface Water

GWUDI is a regulatory designation of a groundwater source for which analytical tests indicate that there is a possibility that untreated surface water could infiltrate the groundwater near the source. An aquifer designated as GWUDI could potentially contain contaminants that may pose a risk to public health.

The high permeability of the limestone in northern Guam has the potential for rapid infiltration of rainfall, and the large pore size in the limestone formations may allow contaminants (if present in the surface water) to reach the groundwater aquifer. As a result, Guam's NGLA was considered for designation as GWUDI.

In a December 2013 Formal Letter to GWA, Guam EPA declared that Guam's groundwater is not GWUDI of surface water and therefore is not subject to applicable local and federal surface water treatment rules. This declaration, based on a subsequently released study (Heitz, 2014), officially closed the issue. Water produced by both GWA and DoD from the NGLA are not GWUDI.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

6.2.2 Water

Public water supply systems on Guam are regulated by the Guam EPA Safe Drinking Water Program through an operating permit issued by the program. There are currently 11 permitted public water supply systems on Guam, three of which are operated by GWA: the Northern System (GU00000006), Central System (GU00000003), and Southern System (GU00000001). Additional details regarding the systems and operator certification requirements are detailed in Section 2.2 of the 2006 WRMP.

Regulatory Environment

Table 6-15 summarizes the USEPA Primary and Secondary Safe Drinking Water Regulations (USPSSDWR). The USPSSDWR were adopted by the Guam legislature in 2006, giving Guam EPA primacy over the regulations in place (up to and including the Long Term 2 Enhanced Surface Water Treatment Rule) as the Guam Primary and Secondary Safe Drinking Water Regulations (GPSSDWR). Since that time, Guam EPA has acquired delegated enforcement authority for the Stage 2 Disinfection Byproducts Rule, GWUDI, revised Ground Water Rule, Revised Total Coliform Rule, and the Lead Ban Rule by letter of delegation from Region 9 USEPA.

Table 6-15. USEPA Regulations Timeline

Regulation	Year
SDWA	1974
National primary drinking water regulations	1975, 1976
Total Trihalomethanes Rule	1979
Fluoride Rule	1986
Phase I (VOCs)	1987
Total Coliform Rule	1989
Surface Water Treatment Rule	1989
Phase II	1991
Lead and Copper	1991
Phase V	1992
Stage 1 Disinfectant and Disinfection Byproduct Rule	1998
Interim Enhanced Surface Water Treatment Rule	1998
Radionuclides	2000
Revision to the Lead and Copper Rule	2000
Arsenic	2001
Filter Backwash Recycling Rule	2001
Long Term 1 Enhanced Surface Water Treatment Rule	2002
Long Term 2 Enhanced Surface Water Treatment Rule	2006
Stage 2 Disinfectant and Disinfection Byproduct Rule	2006
Ground Water Rule	2006
Lead and Copper Rule	2007
Airline Drinking Water Rule	2009
Revised Total Coliform Rule	2013

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Regulated drinking water contaminants include microorganisms, disinfectants, disinfectant byproducts, inorganic chemicals, organic chemicals, and radionuclides. The list of regulated contaminants can be found on the USEPA website at https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants. The list includes maximum contaminant level goals (MCLG), maximum contaminant level or treatment technique (MCL or TT), exposure health effects, and potential sources of contamination.

USEPA completed the third "6-year review" of contaminant levels in 2016. Based on the Agency's detailed review of 76 national primary drinking water regulations (NPDWRs), EPA concluded that eight NPDWRs are candidates for regulatory revision. The eight candidates are Chlorite, Cryptosporidium (under the SWTR, IESWTR, and LT1), Haloacetic acids, Heterotrophic Bacteria, Giardia lamblia, Legionella, Total Trihalomethanes, and Viruses (under the SWTR). In addition to the 76 NPDWRs, this review included 12 other NPDWRs that did not need a detailed review because of recent, ongoing, or pending regulatory actions. Those contaminants having recent or ongoing regulatory actions are: lead, copper, total coliforms (under ADWR and RTCR), E. coli, and eight carcinogenic volatile organic compounds (cVOCs). (USEPA, 2017)

Source Water

Guam drinking water is supplied by both groundwater and surface water sources.

GWA obtains groundwater from wells and the Santa Rita Spring. All groundwater is chlorinated prior to introduction to the distribution system. Two wells are equipped with granular activated carbon (GAC) systems to provide additional treatment. The treatment of GWA groundwater complies with SDWA requirements.

Surface sources used by GWA include an intake from the Ugum River and water purchased from the Navy supplied by the Fena Reservoir. The Ugum SWTP draws raw water from the Ugum River near its confluence with the Talofofo River. Allowable withdrawal volume is contingent upon maintaining stream flows to support aquatic life. Additional detail regarding minimum stream flows are presented in Section 5.3.1. Drinking water from the Ugum SWTP complies with SDWA requirements.

Water produced at the Fena WTP contains dissolved organic carbon molecules that react with chlorine to form regulated disinfection by-products (DBPs), most notably in the form of total trihalomethanes (TTHMs) and five specific haloacetic acids (HAA5). The Navy completed a DBP reduction study in 2014 that included implementation of a 1.0 mgd GAC pilot treatment unit to remove DBP precursor chemicals from Fena WTP water. During the DBP reduction study, the Navy was able to achieve compliance with the Stage 2 DBP rule by eliminating the prechlorination process at the Fena Water Treatment Plant (WTP), and implementing aggressive distribution system flushing.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Primary Drinking Water Standards Compliance

Contaminants detected in GWA water and regulated under primary drinking water standards from 2007 to 2015 are presented in Table 6-16.

Table 6-16. Water Quality Data 2007–2015 (Primary Standards)

Contaminant		Monitoring Year								
		2007	2008	2009	2010	2011	2012	2013	2014	2015
Regulated VOCs	Carbon tetrachloride	Detected	Detected		Detected	Detected				
	Tetrachloroethylene (PCE)	Detected	Detected	Detected	Detected	Detected	Detected	Detected		
	Trichloroethylene (TCE)	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
Regulated SOCs	Chlordane	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Endrin (ppb)		Detected			Detected	Detected		Detected	Detected
	Heptachlor epoxide	Detected			Detected	Detected				
	Hexachlorocyclopentadiene			Detected						
	Lindane (ppt) [a]						Detected			
	Picloram		Detected							
Regulated IOCs	Arsenic			Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Antimony		Detected						Detected	Detected
	Barium	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Chromium	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Fluoride	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Nitrate-N	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Selenium			Detected	Detected	Detected			Detected	Detected
Radionuclides	Radium 226						Detected	Detected	Detected	Detected
	Radium 228		MCL exceeded	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Gross alpha activity	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Gross beta activity	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
Microbial Contaminants	Total coliform (TC)	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Fecal coliform (FC) or E. coli			MCL exceeded						
DBPs	HAA5 (five haloacetic acids)	Detected	MCL exceeded	MCL exceeded	Detected	MCL exceeded	Detected	Detected	Detected	Detected
	Total trihalomethanes	Detected	MCL exceeded	MCL exceeded	MCL exceeded	MCL exceeded	MCL exceeded	MCL exceeded	Detected	Detected
Lead and Copper	Copper								Detected	Detected
	Lead								Detected	Detected

Contaminant detected

MCL exceeded

Source: GWA Annual Reports 2007–2015.

a. Ppt = nanogram per liter (ng/L)

SOCs = synthetic organic contaminants

IOCs = inorganic contaminants

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Monitoring of DBPs in the Central Distribution System showed a violation for the years 2008 through 2013. This distribution system is served by water from the Fena Reservoir purchased from the Navy and supplemented by water from Santa Rita Springs. The Navy completed upgrades to their surface water treatment process in 2014, reducing DBP levels to acceptable levels. DBPs detected in the Southern Distribution System in 2012 were attributed to construction at the Ugum SWTP, and returned to acceptable levels once the upgrades were complete.

A fecal coliform violation occurred in 2009, localized in the Agana Heights district of the Northern Distribution System. The problem was attributed to a cracked vacuum hose at Well A-31. A boil water notice was issued for residents on November 13 and rescinded on November 15, when bacterial contamination was no longer indicated in the system.

Samples from both Fena and groundwater sources water showed elevated levels of Radium 228 in 2008. The systems have not exceeded MCLs for radionuclides since that time.

Secondary Drinking Water Standards Compliance

Secondary MCLs monitored by GWA include chloride, conductivity, and pH. This monitoring assists GWA to determine supply areas in need of adjustment, additional maintenance, or rehabilitation to both provide high quality water and protect water resources. Surface water from both Ugum and Fena sources are well within the MCL; however, groundwater supplies regularly exceed the MCL for both chloride and conductivity.

Unregulated Contaminant Monitoring

Unregulated contaminant monitoring data assists USEPA to determine where certain contaminants occur and whether there is a need to regulate those contaminants. The unregulated contaminants detected in GWA water are:

- Unregulated Volatile Organic Compounds (VOC) – bromodichloromethane, bromoform, chlorodibromomethane, and chloroform
- Unregulated Synthetic Organic Compounds (SOC) – dieldrin
- Unregulated Inorganic Compounds (IOC) – sulfate

6.2.3 Future Regulatory Considerations - Water

In the interest of protecting public health, research is constantly ongoing on the subject of drinking water contaminants. As new information becomes available, regulatory changes are considered where necessary. The following regulations are under development or review by USEPA and may have an effect on future GWA monitoring or treatment requirements.

Contaminant Candidate List

The SDWA directs the USEPA to publish a drinking water Contaminant Candidate List (CCL) every five years. Contaminants listed on the CCL may require future regulation. CCL 4 is currently in draft form and includes 100 chemicals or chemical groups and 12 microbial contaminants that are known or anticipated to occur in public water systems. The list includes, among others, chemicals used in commerce, pesticides, biological toxins, DBPs, pharmaceuticals, and waterborne pathogens (USEPA, 2015).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Lead and Copper Rule

USEPA is considering Long-Term Revisions to the Lead and Copper Rule (LCR) to improve public health protection by making substantive changes and to streamline the rule requirements. USEPA's primary goals in considering LCR Long-Term Revisions are to improve the effectiveness of the corrosion control treatment in reducing exposure to lead and copper, and trigger additional actions that equitably reduce the public's exposure to lead and copper when corrosion control treatment alone is not effective.

USEPA is also currently conducting a rulemaking to clarify issues related to the prohibition on use of lead pipes, solder, and flux as outlined in Section 1417 of the SDWA.

Perchlorate

In January 2009, USEPA issued an Interim Health Advisory for perchlorate to assist state and local officials in addressing local contamination of perchlorate in drinking water while the Agency conducted its evaluation of the opportunity to reduce risks through a national primary drinking water regulation.

On February 11, 2011, USEPA determined that perchlorate meets SDWA criteria for regulation as a contaminant. It was found that perchlorate may have an adverse effect on the health of persons and is known to occur in public drinking water systems with a frequency and at levels that present a public health concern. Since that time, USEPA has been reviewing the best available scientific data on a range of issues related to perchlorate in drinking water including its occurrence, treatment technologies, analytical methods, and the costs and benefits of potential standards.

Sampling at current and formerly used defense sites detected perchlorate, primarily in association with sites historically involved in the manufacture, maintenance, use and disposal of ammunition and rocket fuel (USEPA, 2014).

Perfluorooctanoic Acid and Perfluorooctanesulfonic Acid

On May 20, 2016, USEPA issued a health advisory for PFOA and PFOS. The health advisory is based on a developmental toxicity study in mice; consequently, the sensitive sub-populations of concern are fetuses and lactating women. PFOA and PFOS were monitored in the third round of Unregulated Contaminant Monitoring Rule.

GWA has detected the presence of PFOS in three wells with levels that are above the 70 ng/L lifetime exposure health advisory established by the USEPA.

GWA is in the process of modifying existing or adding new treatment systems and other system modifications at the affected wells. The wells with PFOS have been removed from the distribution system, and will remain isolated until treatment measures are in place.

6.2.4 Wastewater

The principal regulations affecting GWA wastewater utility are included in the federal CWA. The CWA regulates the discharge of pollutants into a water of the United States through NPDES permits. In Guam, NPDES permits are issued by the USEPA.

Although Guam EPA does not have permitting authority, certification of the USEPA-issued NPDES permits is required by Guam EPA under Section 401 of the CWA to ensure that the permit will meet all applicable water quality standards. The 2001 Guam Water Quality Standards are currently undergoing revision.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

TMDL limits are a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. Generally, TMDLs are made up of wasteload allocations for point sources, load allocations for nonpoint sources, a margin of safety, and possibly a reserve allocation. The wasteload allocations are then used to develop NPDES permit limits. On July 22, 2013, USEPA approved Guam's Section 303(d) list for impaired waters. GWA facilities discharging into impaired receiving waters will be now subject to TMDL-related waste load allocation limits in NPDES permits.

As part of the NPDES permitting process, other federal laws are considered including:

- 1973 Endangered Species Act (considers impacts to threatened and endangered species)
- Coastal Zone Management Act (requires that the discharge complies with the Guam Coastal Management Program and that the territory or its designated agency concurs)
- 1996 amendments to the Magnuson-Stevens Fishery management and Conservation Act (if discharge occurs into areas of essential fish habitat, determine whether it may adversely impact the habitat)
- National Historic Preservation Act (considers whether there is potential to affect any historic or culturally significant areas).

GWA Compliance History

The six NPDES permits issued to GWA are listed in Table 6-17.

Table 6-17. NPDES Permit Information

NPDES Permits	Permit Number	Permit Issued	Permit Expiry	Receiving Water
Baza Gardens	GU00200095	August 19, 2015	August 31, 2020	Togcha River
Umatac-Merizo	GU0020273	August 19, 2015	August 31, 2020	Toguan River
Ugum	GU0020371	July 8, 2016	August 31, 2021	Ugum River
Agat-Santa Rita [a]	GU0020222	January 1, 2018	December 31, 2022	Philippine Sea
Northern District	GU0020141	April 10, 2013	May 31, 2018	Philippine Sea
Hagåtña	GU0020087	April 10, 2013	May 31, 2018	Philippine Sea

a. Current permit expired, new permit will be issued upon completion of new Agat-Santa Rita WWTP.

General wastewater regulatory compliance history for each GWA wastewater facility is outlined below. Specific NPDES effluent limits and monitoring requirements, influent characteristics, and biosolids management for each facility is detailed in Volume 3, Section 7.

Northern District WWTP

The Northern District WWTP historically operated under a secondary treatment variance (waiver) issued by USEPA under Section 301(h) of the CWA that allowed discharge of primary effluent to the Philippine Sea via an ocean outfall. In 2009, USEPA issued a final decision to deny renewal of the 301(h) variance, as it did with most other agencies in the U.S. that had been operating under similar variances. GWA appealed the decision, but the appeal was denied review by the Environmental Appeals Board in 2011.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA completed a CEPT upgrade project at the Northern District WWTP that brought it into compliance with the 2011 Court Order. USEPA subsequently issued a new NPDES permit for the facility that became effective on June 1, 2013. The new NPDES permit includes secondary treatment levels with which the existing Northern District WWTP is unable to comply until a secondary treatment process is implemented.

Therefore, the Northern District WWTP is not currently in compliance with the 2013 NPDES permit. The permit does not include an enforceable compliance schedule. GWA believes that the costs and timing of upgrading the Northern District WWTP warrants an extended compliance schedule. Until 2015, USEPA and GWA were negotiating a schedule that would delay secondary treatment implementation until after the provisions and capital requirements of the 2011 Court Order were satisfied. Implementing a secondary treatment process at the facility will be a complex and costly endeavor that will take approximately five years to design and construct. A facility planning process has recently been completed to better define how secondary treatment would best be implemented at the facility.

In 2015, DoD acknowledged in the ROD that increased wastewater flows of 1.2 mgd generated from the relocation of Marines to Guam would result in a significant indirect impact to the Northern District wastewater system. Further, increasing the wastewater discharge from the Northern District WWTP outfall and corresponding increases in pollutants (e.g., orthophosphates, nitrate-nitrogen, and ammonia) from a noncompliant treatment plant would be a significant indirect impact to nearshore waters until upgrades are complete.

Recognizing the inability of Guam to mitigate these impacts on the schedule required to support the relocation, the EAC recommended financial support from the federal government up to $139 million to upgrade the Northern District WWTP and provide secondary treatment. The upgraded plant is scheduled to be in operation by 2021.

Hagåtña WWTP

The Hagåtña WWTP has historically operated under a secondary treatment variance issued by USEPA under Section 301(h) of the CWA that allowed discharge of primary effluent to the Philippine Sea via an ocean outfall. In 2009, USEPA issued a final decision to deny renewal of the 301(h) variance, as it did with most other agencies that had been operating under similar variances. GWA appealed the decision, but the appeal was denied review by the Environmental Appeals Board in 2011.

GWA constructed a CEPT upgrade project at the Hagåtña WWTP that brought the facility into compliance with the 2011 Court Order. The plant has generally been operating within the limits of the secondary treatment variance since the upgrade was completed.

The Hagåtña WWTP, like the Northern District WWTP, has a current NPDES permit that includes secondary treatment. USEPA issued a new NPDES permit for the facility that became effective on June 1, 2013. The 2013 NPDES permit includes secondary treatment standards with which the existing WWTP is unable to comply until a secondary treatment process is implemented. Therefore, the WWTP is not in compliance with the June 2013 NPDES permit. The permit does not include an enforceable compliance schedule. USEPA and GWA have been meeting regularly to negotiate a compliance schedule. Other agencies facing a similar secondary treatment implementation requirement (e.g., City and County of Honolulu) have successfully negotiated extended (20+ years) compliance schedules for implementing secondary treatment. GWA intends to obtain a schedule that will delay secondary treatment implementation until after the provisions and capital requirements of the 2011 Court Order are satisfied. Implementing a secondary treatment process at the facility will be a complex and costly endeavor that will take approximately five years to design and construct.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Conceptual-level cost estimates to provide secondary treatment at Hagåtña WWTP indicate that the cost could be as high as $200 million. Upgrade to the Hagåtña Main lift station will also be required. GWA believes that the cost and timing of this compliance warrants an extended compliance schedule. A facility planning process will be completed in early 2018 and will better define how secondary treatment would best be implemented at the facility. The facility planning effort will yield a preliminary design and cost estimate, which will be used to negotiate an agreement with USEPA on a schedule for secondary treatment improvements. Additionally, because of the small site available for expansion at the Hagåtña WWTP, and public support to reclaim the property upon which the plant currently resides, evaluation of alternatives for WWTP relocation will be included in the facility planning process.

Agat-Santa Rita WWTP

The original Agat-Santa Rita WWTP was not able to reliably achieve the effluent discharge requirements established in the facility's current NPDES permit. The collection system also experiences high infiltration and inflow (I/I), resulting in flow rates that exceeded the capacity of the WWTP during wet weather conditions and subsequent discharge of untreated or poorly treated wastewater. GWA conducted I/I analyses and sanitary sewer evaluation studies (SSESs) to assess the problem. Near-term repair and rehabilitation measures are in progress to address deficiencies. The near-term measures plan, I/I analysis, and SSES are 2011 Court Order projects.

As a result of engineering recommendations in the April 2014 *Agat-Santa Rita Wastewater Systems Evaluation Report*, construction of a new WWTP is underway to replace the existing facility. The new WWTP is being constructed at the Tipalao Pump Station site, a 44.37-acre site deeded to GWA by the Navy in March 1998 exclusively for wastewater treatment purposes. The new WWTP will retain the Agat-Santa Rita name. Construction is partially complete and the plant is currently treating the Agat-Santa Rita wastewater. The existing WWTP facilities will be retained as a pump station to the new facility. The new WWTP provides secondary treatment using an oxidation ditch, and effluent is discharged to the Apra Harbor ocean outfall shared with the Navy.

The capacity of the new facility is 1.6 mgd daily dry weather flow and 9.3 mgd peak daily wet weather flow. By April 2018 this plant will also treat flow re-routed across the island from Baza Gardens. The facility design also provides for possible future expansion to accommodate flows from the Apra Harbor WWTP.

USEPA recently issued a new NPDES permit for the Agat-Santa Rita WWTP. The new Agat-Santa Rita WWTP will meet NPDES permit requirements and disinfect all effluent. The USEPA had allowed the existing plant to operate under the expired permit, while the new plant was under construction and a new permit was being developed. To assist in the development of the new permit, GWA completed a field-level mixing zone evaluation of the Tipalao Bay in 2017 to determine the dilution factors for contaminants and chronic toxicity limits. The study refined the dilution factor calculated in a 2015 desktop evaluation submitted by the Navy for the Apra Harbor joint outfall.

Baza Gardens WWTP

The Baza Gardens WWTP is not able to consistently achieve the effluent discharge requirements established in the facility's NPDES permit. The existing treatment process is unable to achieve the nutrient reduction and disinfection requirements required for discharge to the Togcha River.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

In April 2014, GWA completed a 2011 Court Order project to prepare the Baza Gardens Wastewater System Evaluation Report. The Wastewater System Evaluation recommended converting Baza Gardens to a flow stabilization facility, and conveying flow by pumping across the island to the new Agat-Santa Rita WWTP for treatment. GWA has initiated a project to convert the existing Baza Gardens WWTP and construct the pump stations, pipelines, and odor control systems needed to achieve 2011 Court Order compliance and regulatory compliance. Engineering designs have been completed with construction planned for completion in 2018.

GWA has conducted I/I analyses and SSESs to address excessive I/I in the Baza Gardens and Talofofo collection systems. The studies have shown several reported instances of excessive I/I entering into the sewer collection system. GWA has completed engineering design for resolving the I/I issue, and construction of the repair and rehabilitation of the deficiencies found during the studies is in progress with completion expected in 2017. The Wastewater System Evaluation, I/I analysis, and SSES are 2011 Court Order projects.

A new NPDES permit was issued in August 2015. The Togcha River is not listed as impaired, but due to downstream water and beach impairment USEPA has added Enterococci effluent limits to the 2015 permit. Other significant changes from the previous permit are included in the Permit Fact Sheet. Although GWA plans to remove the Baza Gardens WWTP from service by the end of 2018, the permit will be retained so that GWA can keep their options open for future use of the site.

Inarajan WWTP

The Inarajan WWTP is not subject to a NPDES permit because the facility does not discharge to surface waters and treated effluent is disposed via surface percolation basins. Guam EPA does not issue land discharge permits, so there is no discharge permit for the facility. The facility is currently in compliance with applicable discharge requirements.

The percolation basins are located near the shoreline and are not located over a drinking water aquifer, so there are no impacts to the GWA water supply system. Guam EPA initially expressed concern that percolated water from the facility may emerge in the near-shore reef downgradient of the facility. GWA conducted a flow validated dye trace study at the facility in July 2011, and found no evidence that percolated water from the facility emerges into the near-shore reef under normal operating conditions.

Umatac-Merizo WWTP

The Umatac-Merizo WWTP has not been able to reliably achieve the effluent discharge requirements established in the facility's NPDES permit. During dry weather conditions, effluent is disposed of via evapotranspiration and percolation on the facility's overland flow terraces. During wet weather the assimilative capacity of the overland flow terraces is exceeded, and effluent is discharged to the Toguan River. The existing treatment process is unable to achieve the nutrient reduction and disinfection requirements prior to discharge to the Toguan River. In addition, because of an identified pumping system deficiency, the facility's aerated lagoon has overflowed directly to the Toguan River during extreme wet weather events, resulting in unauthorized bypassing of the overland flow treatment process.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

In December 2013, GWA prepared the Wastewater System Evaluation (WSE) Report for the Umatac-Merizo collection and treatment system in accordance with the 2011 Court Order. A supplement to the WSE Report was submitted in June of 2014. The WSE Report identified improvements necessary to address system deficiencies in the collection and pumping systems and at the WWTP. After evaluating various effluent disposal methods to meet current NPDES permit requirements, the WSE Supplement recommends that GWA initiate discussions with the regulatory agencies regarding relaxing the nutrient standards, in addition to WWTP improvements, for a continued discharge to the Toguan River.

GWA is conducting water quality and river flow monitoring to establish data to justify modifications to the Guam Water Quality Standards applicable to the Toguan River. The monitoring data should provide sufficient evidence to request that Guam EPA grant a Guam Water Quality Standards variance for the discharge or provide site-specific water quality requirements for the Umatac-Merizo WWTP discharge. The data collected will also be used to justify a mixing zone at the discharge enabling GWA to meet the existing NPDES permit conditions year round. If GWA is successful, regulatory compliance will be achieved through 2035 for significantly lower cost than the other options evaluated in the wastewater system evaluation. The mixing zone study and expanded receiving water monitoring are requirements of the August 2015 NPDES permit.

In accordance with the 2011 Court Order, the Umatac-Merizo WWTP is currently under construction to improve treatment performance, including addition of an effluent disinfection system. The facility upgrade, including improvements to the pump station, headworks, aerated lagoons, overland flow terraces, yard piping, and electrical system, will be complete in 2018. Collection system improvements, with a targeted I/I reduction of 50 percent, have also recently been completed.

Pago Socio WWTP

The Pago Socio WWTP is not subject to an NPDES permit because the facility does not discharge to surface waters. Influent is treated in a centralized septic tank, and effluent is disposed via leach fields. Additional treatment is realized as the water percolates downward through the permeable geology to groundwater. Guam EPA does not issue land discharge permits, so there is no discharge permit for the facility. The facility is currently in compliance with applicable discharge requirements. The facility is not believed to have any significant impacts on the underlying aquifer because of the small size of the discharge. Long-term plans for this facility are discussed in more detail in Volume 3 of the WRMPU.

Ugum Surface Water Treatment Plant

The Ugum SWTP is the major source of water supply for the Southern Public Water System. GWA upgraded the facility in 2011 from conventional sand filtration to a microfiltration system as part of the 2011 Court Order. The microfiltration system requires regular clean-in-place and maintenance backwash cycles utilizing water containing sodium hypochlorite, citric acid and sulfuric acid. The used backwash water is transferred to a recycle tank and clarifier prior to discharging into the Ugum River.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The previous Ugum NPDES permit expired in 2015. The facility was unable to meet requirements of the expired permit for pH, turbidity, total suspended solids (TSS), and aluminum. The previous permit did not take into account that the plant is a net remover of sediment and turbidity from the Ugum River. In addition, the TSS concentration limit incorporated into the permit (30 mg/L) is well below the average receiving water body TSS concentration (approximated at 77 mg/L). GWA worked with USEPA to ensure that the new permit limits could be met with 100 percent compliance. The current permit became effective September 1, 2016 and has numeric effluent limits for pH, turbidity, TSS, TDS, residual chlorine and aluminum. TSS limits were adjusted to 30 mg/L (average monthly) and 45 mg/L (max daily). Monitoring requirements are also in place for flow rate, BOD_5, and ammonia.

6.2.5 Future Regulatory Considerations - Wastewater

Future regulatory requirements that may have a significant influence on wastewater systems include proposed rules on SSOs and related capacity, management, operation and maintenance (CMOM) guidance; potential enforcement of nutrient regulations; and new guidelines surrounding emerging contaminants.

Sanitary Sewer Overflow Regulations

SSO regulations are intended to provide communities with a framework for eliminating overflows from sewers, thereby reducing the health and environmental risks associated with such overflows. CMOM programs will be required under the SSO regulations to help ensure that communities have adequate wastewater collection and treatment capacities and that they incorporate standard O&M practices to assure good system performance. Many wastewater agencies have already embarked upon CMOM planning and implementation efforts to meet the new federal guidelines. GWA has taken steps to reduce SSOs in all wastewater collection systems.

Contaminants of Emerging Concern

Research indicates that many chemical and microbial constituents that have not historically been considered as contaminants are present in the environment on a global scale. These contaminants of emerging concern (CECs) are commonly derived from municipal, agricultural, and industrial wastewater sources and pathways and include materials such as pharmaceuticals and personal care products that act as endocrine disruptors. CECs are increasingly being detected in surface water, and there is concern that these compounds may have an impact on water quality and aquatic life.

CECs have no published health standards or guidelines associated with them, and removal from municipal wastewater if required could be complex and costly. The USEPA developed a white paper detailing the technical issues and recommendations to serve as a basis for modifying the 1985 Guidelines for Deriving National Water Quality Criteria for the Protection of Aquatic Life and Their Uses. USEPA CEC guidance documents generally focus on drinking water treatment as opposed to removal from municipal wastewater discharges. Should changes to water quality criteria be implemented in the future, affected GWA wastewater facilities could be subject to revised discharge requirements.

Nutrient Regulation

Nationally, higher water quality is being required in wastewater discharge permits to reduce impacts on impaired waters. Consequently, lower nutrient limits in receiving waters and wastewater plant discharges are also being established.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

USEPA is taking steps to combat nitrogen and phosphorus pollution in the United States, including:

- Providing states with technical guidance and resources to help them develop water quality criteria for nitrogen and phosphorus as part of their water quality standards regulations for surface waters.
- Working with states to identify waters with nitrogen and phosphorus pollution and to develop TMDLs to restore the waters by limiting allowable nutrient inputs.
- Administering a permit program that restricts the amount of nitrogen and phosphorus released to the environment from point sources.
- Providing funding for the construction and upgrade of municipal wastewater facilities and the implementation of nonpoint source pollution control and estuary protection projects.
- Conducting and/or supporting research on nitrogen and phosphorus pollution-related topics.

Enforcement of nutrient limits on Guam will continue to necessitate upgrades at affected facilities.

6.3 Security

Threats to water and wastewater systems traditionally included natural disasters, recurring extreme weather events such as flooding and lightning, and accidental (human caused) events such as chemical spills and vehicle collisions. The events of September 11, 2001 heightened the way that utilities must think about malevolent events such as vandalism, criminal activity and terrorism. Publicly owned utilities are now clearly potential targets for purposeful disturbance and destruction. In addition, infrastructure that has long been subject to risks associated with physical threats and natural disasters is now increasingly exposed to cyber risks, which stems from growing integration of information and communications technologies with critical infrastructure operations and an adversary focus on exploiting potential cyber vulnerabilities (USDHS, 2013).

Disruption of a wastewater treatment utility or service can threaten life, affect the economy, and result in public health and environmental impacts. If wastewater infrastructure is damaged, lack of redundancy may cause service interruption. A drinking water contamination incident or denial of drinking water services can have far-reaching public health, economic, environmental, and psychological impacts. Critical services such as fire protection, healthcare and industrial processes can also be disrupted by the interruption of drinking water service, resulting in significant economic consequences (USDHS, 2015).

Various tools have been developed to assist utilities in addressing complex issues of security. The 2013 National Infrastructure Protection Plan (NIPP) was created to guide the national effort to address risks to critical infrastructure, including water and wastewater utilities. Managing the risks from significant threat and hazards to physical and cyber infrastructure requires an integrated approach to:

- Identify, deter, detect, disrupt, and prepare for threats and hazards to the critical infrastructure.
- Reduce vulnerabilities of assets, systems, and networks.
- Mitigate the potential consequences to infrastructure of incidents or adverse events that do occur.

The 2013 NIPP emphasizes the complementary goals of security and resilience for critical infrastructure. To achieve these goals, cyber and physical security and the resilience of infrastructure assets, systems, and networks are integrated into an enterprise approach to risk management (DHS, 2013). Enterprise-wide security components include management policies, administrative procedures, operational practices and network security.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The AWWA J100-10 (R13) Risk and Resilience Management of Water and Wastewater Systems (RAMCAP) standard documents a process for identifying natural and human-caused security vulnerabilities, consequences, and incident likelihood in water and wastewater utilities, and it provides methods to evaluate options for improving these weaknesses. The standardized RAMCAP method allows for repeatability and comparison of data across sectors and over time. Updates to the GWA Vulnerability Assessment, the first step in creation of an overall GWA security program, should follow this guidance. After the vulnerabilities have been identified, the relative risk associated with each vulnerability can be rated and overall security plan created.

6.3.1 Physical Security

Concern regarding the physical security of the nation's water utilities led to the Bioterrorism Act of 2002. The Bioterrorism Act required vulnerability assessments (VA) to be completed and an Emergency Response Plan (ERP) developed incorporating the VA. GWA completed a VA in 2003 and the ERP in 2004. These plans should be updated every 5 years, and form the basis of creation of an overall Physical Security Plan.

Current Conditions

In 2017, GWA conducted an audit of water and wastewater facilities which included an inspection of visibility, security, lighting, fencing, vegetation, site and building access conditions and signage. Completion of the audit was limited by personnel availability. Costs for repair and upgrades are being gathered as time and opportunity permits.

Available Resources

The Guidelines for the Physical Security of Water Utilities and The Guidelines for the Physical Security of Wastewater/Stormwater Utilities (ANSI/ASCE/EWRI 56-10 and 57-10) provide detailed direction for the protection of infrastructure from physical threat.

Published in 2011, the document begins with a description of the elements of a physical protection system (deterrence, detection, delay and response) and identification of different types of threats (vandal, criminal, saboteur and insider). The document goes on to detail step-by-step instructions to apply the guidelines, and considerations for planners to take into account when establishing a physical security program. The bulk of the document outlines, by facility type, benchmark security measures to deter a threat or detect and delay the threat until the appropriate response force arrives. Design of the physical security elements is detailed in the appendices of the 56-10 and 57-10 Guidelines (ASCE 2011).

Recommendations

Recommendations for the physical security of GWA assets include:

- Update the 2003 Vulnerability Assessment and 2004 Emergency Response Plan now and every 5 years as supported by the ANSI/AWWA J100-10 RAMCAP standard.
- Utilize the ANSI/ASCE/EWRI 56-10 and 57-10 Guidelines to update the system audit and create a Physical Security Plan. Work with GPA to identify system overlap and opportunities to utilize shared resources.
- Create SOPs to ensure security measures implemented are inspected, maintained, and replaced as needed.
- Prioritize, procure and install physical security elements identified in the Physical Security Plan.
- Incorporate security into the design of new facilities and facility upgrades.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

6.3.2 Cyber Security

Cyber security is the protection of enterprise information systems from outside or inside attack. Cyber systems include SCADA, process systems and operational controls, and enterprise-wide systems such as financial software, email, asset management and GIS.

Current Conditions

GWA is facing the challenge of maintaining compliance with up-to-date cyber security requirements while keeping pace with ever-changing technology. GWA is working with GPA to complete a cyber security assessment and network penetration test in 2018, using shared system resources to address some of the technical requirements. This assessment and testing will direct the next steps in security.

An interim Cyber Security Policy is in place. Adopted from GPA, the policy is based on the Framework for Improving Critical Infrastructure prepared by the National Institute of Standards & Technology (NIST 2014). A GWA Cyber Security Awareness Training program has been developed.

Available Resources

In 2008, AWWA partnered with the US Department of Homeland Security (DHS) to develop a Roadmap for Securing Process Controls Systems in the Water Sector. In an effort to provide utilities with more actionable information, AWWA also developed the Process Control System Security Guidance for the Water Sector and a supporting Use-Case Tool in 2017. This resource includes a series of best practices that are designed to support a utilities capability to mitigate, detect and recover from potential attacks targeting process control systems. This AWWA guidance provides a sector-based approach that aligns with the principles of Executive Order 13636—Improving Critical Infrastructure Cybersecurity (Federal Register 2013), and the voluntary NIST Cybersecurity Framework (NIST, 2014).

Recommendations

The DHS USEPA Water and Wastewater Systems Sector-Specific Plan provides a roadmap to achieve secure systems with goals and objectives. The plan involves implementing the NIPP risk management framework. It is recommended that GWA continue to develop and update an action plan for cyber security in conjunction with GPA as applicable for the purposes of resource sharing. SCADA-specific recommendations are discussed further in Section 9.2.

6.3.3 Security of Service and System Resilience

Utilities that have incorporated security for malevolent events are also finding that they have enhanced response capabilities for natural disasters and unanticipated system failures, effectively increasing system resilience. Like all public utilities, GWA is faced with funding requirements ranging from regulatory compliance to annual O&M. Security enhancements can both address a system vulnerability and provide O&M benefits. Similarly, capital improvement projects can address security related issues although the main project justification may be unrelated to physical or cyber security.

As critical infrastructure is built and refreshed, personnel involved in making design decisions, including those related to control systems, should consider the most effective and efficient ways to identify, deter, detect, disrupt, and prepare for threats and hazards; mitigate vulnerabilities; and minimize consequences. This includes considering infrastructure resilience principles.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

6.4 Summary

The purpose of this section was to identify EEFs with the potential to impact GWA operations and analyze three of the most important of those factors.

The relocation of U.S. Marine Corps forces to Guam from Okinawa will be ongoing until 2028, and impact the population, environment, and labor availability on Guam. In addition, GWA operations will be affected by both increased wastewater flows generated and withdrawals from the NGLA. Upgrades to the Northern District WWTP and interceptor sewer have been identified as necessary for the relocation, and planning is underway to fund and construct those projects in time for the arrival of the Marines in 2022.

Water and wastewater regulations affect every aspect of GWA planning and operations. From design to operations, the need to comply with regulations drives both annual budgets and capital improvement plans. Regulatory requirements change over time, and GWA must continue to be aware not only of current requirements, but also upcoming revisions and emerging issues with the potential to impact GWA customers and resources.

Physical and cyber security issues will continue to require consideration in the unpredictable natural and geopolitical environment to develop resilience to natural disasters, accidents and malevolent threats.

Many of the EEFs presented in Table 6-1 will be addressed in context within the relevant sections of the WRMPU. These include SCADA, water supply, labor market conditions, culture, land use, and climate change. Although useful from an organizational standpoint, other factors such as Guam's economy and political climate and GWA organizational structure are beyond the specific scope of this planning document.

All of these EEFs can impact GWA and each has the potential to change over time. Some factors are within the control or influence of GWA but many are not, underscoring the necessity to review the WRMP on a regular basis to account and plan for the changing environment in which GWA operates.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 7

Asset Management

Asset Management (AM) uses inventory, criticality, and work requirements data to support risk-based resource decision-making in alignment with an organization's mission, vision, goals and objectives. AM is used to make the most efficient and effective use of an organization's resources and assets to achieve desired outcomes and objectives.

USEPA Region 9, under USEPA Contract Number: GS-10F-0227J Order Number: EP-G119-00034, initiated a contract in 2011 to provide technical assistance to GWA for establishing a proactive program and become a fully compliant, sustainable water and wastewater utility.

7.1 Current Adequacy of the Asset Management Program

The following section describes GWA's existing AM program.

7.1.1 Asset Management Program Evaluation

The 2006 WRMP contained an AM program evaluation (AMPE) that includes 112 individual elements within 16 topic areas structured into eight key groupings shown in Figure 7-1.

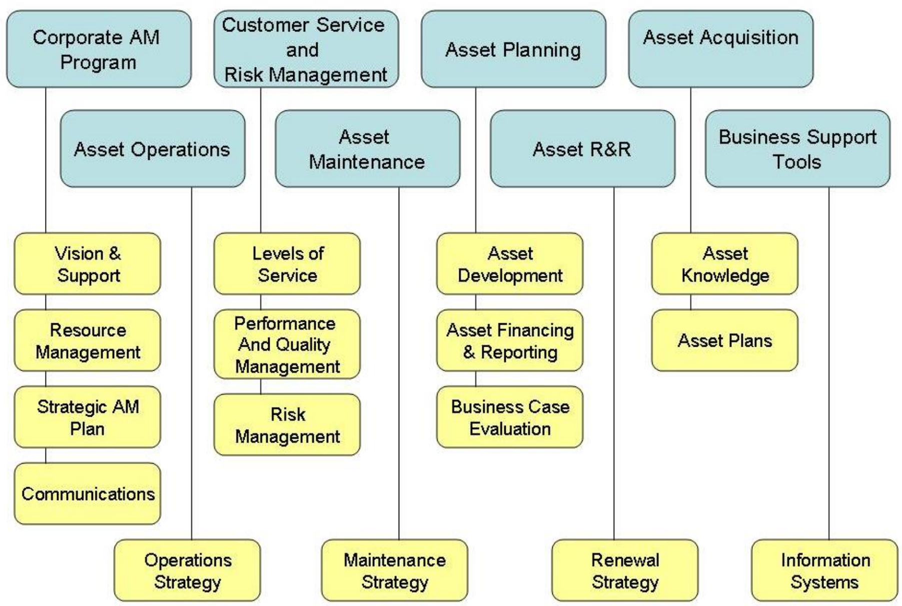


Figure 7-1. AM Program Evaluation

A list of the AMPE best practices is presented in Appendix 1I of the 2006 WRMP and the resulting scores of the evaluation are presented in Volume 1, Table 8-2 of the 2006 WRMP.

Most the scores based on staff interviews in 2006 were within the "unaware" or "initiating" phase of implementation, with 5 of the 16 topics areas scoring into the beginning defined approach area.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA did not establish target goals for the 16 topic areas, so a numeric gap between the current (2006) practice score and the target practice score was not developed. After the 2006 WRMP was released, GWA did not complete the AMPE visioning process or update the AMPE gap chart as was recommended.

The scores for the AMPE elements have been updated to reflect GWA's status regarding AM. Table 7-1 includes the previous 2006 scores and updated 2016 scores based on review of the AM program and the Operations Division. The full scoring table is presented in Appendix A-1.

Table 7-1. AMPE Updated Scores

Element	2006 Score	2016 Score	Rationale for Change
1.1 Vision and Support	28 Initial	32 Defined Approach	CCU Board has communicated the importance of asset management. The current GM is structuring staff within Operations Division to move forward.
1.2 Resources Management	17 Unaware	28 Initial	Establishment of AM Steering Committee, designation of asset management leader, and ongoing asset management program development.
1.3 Strategic Asset Management Plan	18 Unaware	22 Initial	Asset life cycle process diagram, and standard operating procedure management.
1.4 Communications	21 Initial	21 Initial	
2.1 Levels of Service	35 Defined Approach	35 Defined Approach	
2.2 Performance and Quality Management	19 Initial	19 Initial	
2.3 Risk Management	24 Initial	27 Initial	Asset criticality defined and partially implemented.
3.1 Asset Development	32 Defined Approach	33 Defined Approach	New asset tracking in CMMS defined.
3.2 Asset Financing and Reporting	34 Defined Approach	35 Defined Approach	Process to verify financial Fixed Asset Registry versus O&M Asset Registry planned.
3.3 Business Case Evaluation	27 Initial	27 Initial	
4.1 Asset Knowledge	33 Defined Approach	44 Defined Approach	Asset criticality process defined and partially implemented. Asset classes defined though inventory process with associated expected life. Asset organization based on asset type and facility type incorporated into CMMS.
4.2 Asset Plans	25 Initial	29 Initial	PM plans and schedules developed for critical assets at each facility and implemented in CMMS.
5.1 Operations Strategy	28 Initial	35 Defined Approach	Operational procedures documented. Condition monitoring methodology and cost tracking developed and being implemented through the new CMMS work order management process. Predictive analysis tools introduced.
6.1 Maintenance Strategy	30 Defined Approach	39 Defined Approach	Planning and tracking maintenance integral to newly implemented CMMS.
7.1 Renewal Strategy	26 Initial	26 Initial	
8.1 Information Systems	28 Initial	34 Defined Approach	Implementation of CMMS with tight GIS integration and mobile app for field data collection is underway. CMMS linked with JD Edwards warehouse. Reporting tools based on agency tool (WebFocus8) as a single point of data access and reporting is underway.

CMMS = computerized maintenance management system

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA has made progress in each of the categories, especially in Vision and Support, Resource Management, Asset Knowledge, Operations Strategy, and Maintenance Strategy, as described in Table 7-1. Currently 8 of the 16 elements are in the defined approach area.

7.1.2 Asset Management Roadmap and Maturity Model

As part of the technical services for asset management development in 2011, GWA developed an AM roadmap describing the 12 steps suggested in a process to implement an AM program, as shown below in Figure 7-2. A maturity matrix model was also developed based on the road map elements with evaluation scoring like the AMPE: 0 – absent, 1 - initiation/awareness, 2 - developing, 3 – implementing, 4 – maturing, and 5 - optimizing.

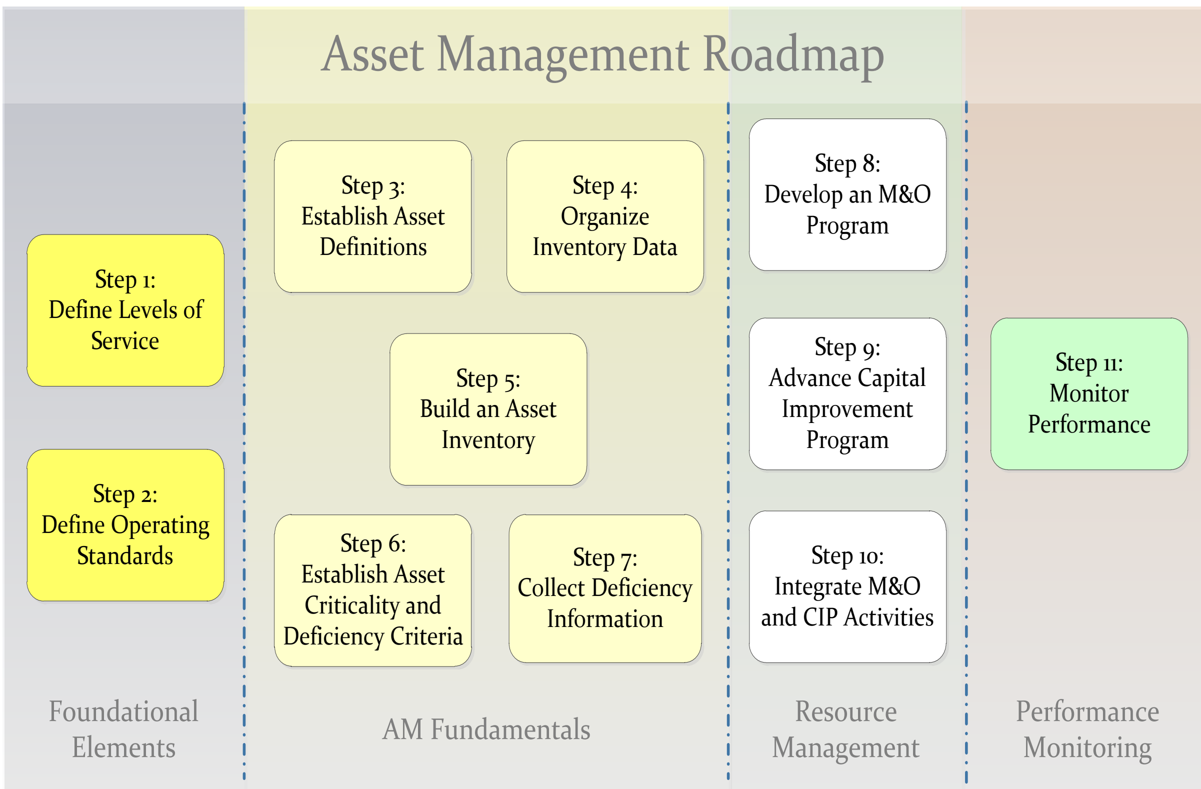


Figure 7-2. AM Roadmap

7.1.3 Asset Management System Maturity

The GWA AM system was assessed for maturity in October 2011 (based on the initial EPA support contract Gap Analysis), January 2013, and February 2016. The maturity scores for each of the elements of the road map, as well as the objectives for each of the 12 elements based on the scope of the technical support contract, are shown in Figure 7-3 and tabulated in Table 7-2. The rubric used to assign scores to the elements is included in Appendix A-2.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

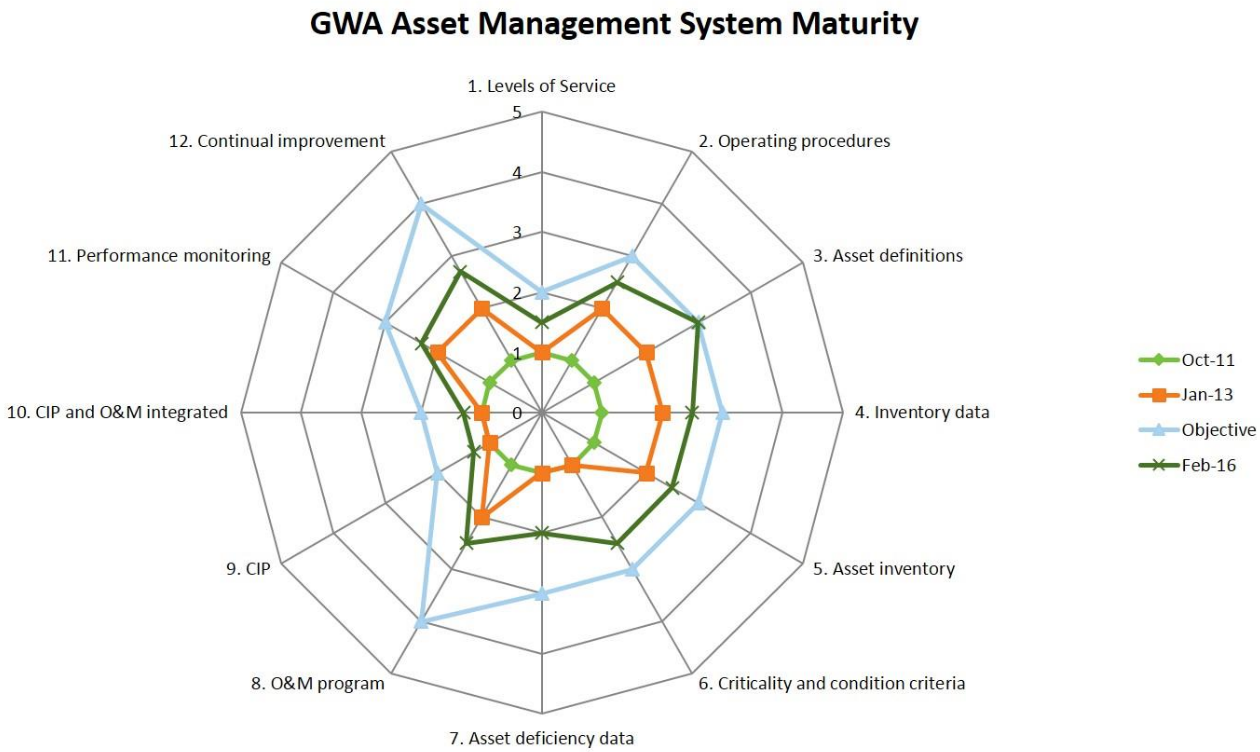


Figure 7-3. GWA AM System Maturity

Table 7-2. Maturity Matrix Model Categories and Scores

Scores	Program Initiation	Phase II Start	Phase II Conclusion	Phase II
AM Element	October 2011	January 2013	February 2016	Objective
1. LOS	1	1	1.5	2
2. Operating procedures	1	2	2.5	3
3. Asset definitions	1	2	3	3
4. Inventory data	1	2	2.5	3
5. Asset inventory	1	2	2.5	3
6. Criticality and condition criteria	1	1	2.5	3
7. Asset deficiency data	1	1	2	3
8. O&M program	1	2	2.5	4
9. CIP	1	1	1.3	2
10. CIP and O&M integrated	1	1	1.3	2
11. Performance monitoring	1	2	2.3	3
12. Continual improvement	1	2	2.7	4

Use of contents on this sheet is subject to the limitations specified at the end of this document.

As can be seen by the maturity model, GWA has made significant progress in gathering the data that will enable more proactive management, namely an inventory of assets, condition scoring, criticality determination protocol, beginning the development of a maintenance program and defining operating procedures. This is a good beginning and comes close to meeting the objectives of the implementation program (2013–2015). GWA should establish new objectives for the coming three to five years. The overall objective is continual improvement and not necessarily reaching optimized status in all areas. GWA should strive to be at implemented status (or managed status in the parlance of the AMPE) for each element and then select those elements that would provide the greatest benefits to GWA and plan and execute improvements in those areas.

As work continues in all areas of AM, the aggregation of maintenance management performance data through the CMMS will enable integration of O&M data with CIP planning to improve the efficiency and effectiveness of the CIP process. This will take two to three years before the data is sufficient for decision-making.

GWA should revisit the AMPE elements and incorporate additional elements into their AM program development moving forward. Elements of the Corporate Asset Management Program and Asset Planning are two areas for strengthening the program, in addition to the existing elements of the matrix.

Training workshops were conducted in April 2016 with GWA on the development of updated LOS and KPIs for the utility. GWA should formally select and adopt the LOS and KPIs it feels are appropriate and perform the required measurements. As performance indicator data is collected and analyzed and by the continuing establishment of structure, policies and procedures, GWA will continue to make progress in the AM arena.

7.1.4 Cross-walk

A cross-walk between the AMPE topic areas and the maturity matrix model is presented in Table 7-3. The cross-walk attempts to correlate the AMPE elements (columns 2 and 3) with an appropriate element from the maturity matrix (column 1). Each of the eight key groupings of the AMPE (shown in column 2) are related to the maturity matrix model, except for the first grouping from the 2006 WRMP, named Corporate AM Program. As can be observed in Table 7-3, the Corporate AM Program is not shown in Column 2.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 7-3. Cross-walk Between AMPE and Maturity Matrix		
AM Maturity Matrix Model	AMPE Gap Chart Tier 1	AMPE Gap Chart Tier 2
1. LOS	2.0 Customer Service and Risk Management	2.1 Levels of Service
2. Operating Procedures	3.0 Asset Planning 5.0 Asset Operations	5.1 Operations Strategy
3. Asset Definitions	3.0 Asset Planning	3.1 Asset Development
4. Inventory Data	3.0 Asset Planning	3.1 Asset Development
5. Asset Inventory	4.0 Asset Acquisition	4.1 Asset Knowledge
6. Criticality and Condition Criteria	2.0 Customer Service and Risk Management 4.0 Asset Acquisition	2.3 Risk Management 4.1 Asset Knowledge
7. Asset Deficiency Data	5.0 Asset Operations	5.1 Operations Strategy
8. O&M Program	4.0 Asset Acquisition 6.0 Asset Maintenance 7.0 Asset Replacement and Renewal Strategy	4.2 Asset Plans 6.1 Maintenance Strategy 7.1 Asset Renewal Strategy
9. CIP	3.0 Asset Planning	3.2 Asset Financing and Reporting 3.3 Business Case evaluation
10. CIP and O&M Integrated	7.0 Asset Replacement and Rehabilitation	7.1 Asset Renewal Strategy
11. Performance Monitoring	2.0 Customer Service and Risk Management 8.0 Business Support Tools	2.2 Performance and Quality Management 8.1 Information Systems
12. Continual Improvement	2.0 Customer Service and Risk Management	2.2 Performance and Quality Management

7.1.5 Status of 2006 Recommendations

The following section summarizes the status of AM-related recommendations included in the 2006 WRMP.

Computerized Maintenance Management System

Technical Memorandum 5.3 – Software Systems Review, dated October 18, 2011, identified the absence of an asset-based maintenance tracking program as a critical gap to establishing an AM Program. GWA chose to implement the JD Edwards (JDE) Plant and Equipment Module (PEM) to fill this gap.

After attempting to use JDE PEM, it became clear that the PEM module was inadequate for O&M needs due to:

- The challenges of a steep learning curve on the system
- A challenging user interface, precluding O&M staff from effectively using the system
- The complexity of managing assets from an O&M and financial (fixed asset registry) perspective within a single system
- Limitations in reporting capabilities

GWA therefore decided to implement a modern CMMS. Lucity was selected as the CMMS vendor and the system was placed into production in October 2016.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Corporate Asset Management Strategy

In assisting GWA with the design and implementation of an AM program, an Asset Management Steering Committee (AMSC) was assembled, which included an AM Project Manager, representatives of the four O&M groups (water production, water distribution, wastewater collection/central maintenance, and wastewater treatment), and one or more representatives from Engineering, IT, Finance/Accounting, Procurement/Warehouse and Planning. The AMSC would meet to discuss AM implementation requirements, status, and plans.

In 2016, with the installation of a new permanent GM and support of the CCU Board, GWA began to evaluate and restructure the organization and structure of the Operations Division for Maintenance and AM. GWA has created a Systems Control Center (SCC), which is charged with coordinating efforts to maintain LOS to GWA's customers, and includes customer call-in and a dispatch office, as well as AM. GWA has named the group leader from the SCC to lead the AM effort. The group leader has brought together a reconstituted AMSC focused on the O&M groups and is leading CMMS implementation and defining the processes to manage new and updated asset data.

Additional Asset Management Training

GWA has participated in a series of training workshops related to best practices in strategic AM program implementation and specific maintenance management practices. Most of these sessions were conducted during AMSC meetings. A list of these training sessions is presented in Table 7-4.

Table 7-4. AM Training Workshops

Date	Subject
August 2011	Asset Definition
August 2011	Building an Asset Registry
August 2011	Developing a Maintenance Plan
August 2011	Asset Condition and Criticality
March 2013	Asset Inventory Data Needs
June 2013	Asset Condition Assessment
June 2013	Asset Criticality
March 2014	Economic Decision Making (Repair/Replace and Portfolio Risk Analysis)
June 2014	Maintenance Management Planning and Structure
August 2014	Maintenance Management and CMMS Functions

In addition to the AM program-focused training, GWA received training in the computer-based tools introduced as part of the implementation process, namely two weeks of training on the JDE PEM in 2012 and two weeks of training on the Lucity CMMS, one each in June and September 2016.

Multi-day training workshops in predictive analytical techniques for maintenance planning, including field training, were also conducted with field exercises (September/October 2014) on analytical tools to measure asset condition, using infrared cameras for heat signatures in electrical rotating equipment, and vibration analysis for rotating equipment.

GWA has hired a new Employee Development Specialist III, who has been working with the O&M groups to:

Use of contents on this sheet is subject to the limitations specified at the end of this document.

- Create a competency matrix that spells out the experience and capabilities that O&M staff must develop to advance within the organization.
- Develop a list of training courses available in Guam, with input from Guam EPA, that can help O&M staff develop according to the competency matrix.
- Arrange for and host a multi-week training program for water and wastewater operators, and proctor a certification exam for GWA staff (May 2016). The event was well attended and well received.
- Revamp GWA's new O&M employee orientation sessions, which were delivered to a group of 25 new trades helpers in July 2016.

The Employee Development Specialist has also worked with BC on the preparation of a comprehensive GWA Training Master Plan.

Complete the Asset Management Program Evaluation Visioning Process

As discussed in Section 7.1.1, GWA did not carry on with the AMPE visioning process after release of the 2006 WRMP. The level of complexity, combined with the fact that it was another six years or so before GWA began to put the structures in place to manage an AM program, may have been factors in not completing the process.

Whether GWA chooses to continue use of the maturity matrix tool or revisit the baseline targets for the AMPE tool, it is recommended that GWA continue to monitor the status of their AM program progress on a regular basis, at least every six months.

7.2 Asset Management Continuing Training

Continuing training is an important part of maintaining GWA's progress in AM implementation.

This training should consist of orienting new O&M employees to the AM program, training staff moving into new roles (supervisory or management), and educating staff on new procedures.

As part of the USEPA Region 9 contract to provide technical support to GWA, a series of training workshops were held on the aspects of AM planning and implementation as described in Section 7.5.3. These training materials are available to GWA and can be used for new employee training as well as refresher training in aspects of AM as GWA matures in the AM program.

The CMMS training was presented in a train-the-trainer style such that senior staff maintenance leads, supervisors, and managers were trained so that they could in-turn train their staff to use the system. GWA-specific user guides have been developed by Lucity and provided to GWA electronically. All CMMS users should be encouraged to consult the user guides to develop further competency in use of the CMMS.

The O&M Division should continue to work with the Employee Development Specialist to identify training needs for staff competency and develop programs in-house or use outside resources to deliver the training needed to strengthen GWA's O&M workforce.

As the O&M team enters into more advanced elements of their AM program, specific elements such as risk identification and quality management may require outside assistance to better equip GWA for success.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

7.3 Corporate Strategy

The following section describes the corporate strategy of GWA's AM program.

7.3.1 Vision and Support

GWA has recognized the potential strategic value in AM as a tool to improve service delivery within economic constraints.

The USEPA-supported AM program addressed strategic elements and tactical approaches. Some features have been put in place, while others are in progress (see Table 7-5). For example, the AMSC was created under Corporate Support. The AMSC provides a venue for regular input to the AM development process by all divisions. The AMSC has continued to track their progress using the maturity matrix, and they created an asset life cycle diagram that describes the roles and procedures for action in each part of the life cycle from asset creation and acquisition, through operation and maintenance, to asset replacement and disposal. A copy of the GWA asset life cycle diagram is included in the Appendix A-3.

Strategic leadership from GWA's top level managers is important to establish asset management as a sustained integral component of utility operations. The current GWA Mission statement (May 2016) states that:

"We (GWA) *will provide outstanding customer service by delivering excellent water and wastewater services in a safe, reliable, responsible and cost effective manner."*

It is recommended that GWA senior management document the framework of their AM program, establishing goals and objectives for the program that are consistent with organizational objectives. This should be shared with staff internally and be available to external stakeholders as appropriate.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 7-5. AM Program Elements		
Strategic Element	**Tactical Approach**	**Outcomes**
Corporate Support	AMSC	Ongoing support across all GWA divisions.
LOS	Performance measures developed and LOS defined	KPIs and LOS updated 2016.
Defined operating procedures	SOP creation and deployment by division “champions”. SOP committee formed to maintain and update SOPs.	SOP binders available as hardcopy and via a network drive. AM-related SOP are being updated as the program matures.
Asset definition and registry	AMSC works across all water and wastewater groups to define and identify assets. Field mobilization for inventory and condition assessment.	Asset registry created in the Lucity CMMS.
Assess asset condition and criticality	Develop protocols for condition assessment and criticality. Condition scores are gathered as part of inventory.	Asset conditions in CMMS will be updated as part of maintenance. Criticality scores partially developed.
O&M program	Define program activities, organizational structure, roles and responsibilities, and schedule.	Maintenance management guide is under review by GWA. Project management plans established for critical assets.
Asset repair/replacement plan	Develop a program plan and risk assessment tool.	Risk assessment tool is available. Maintenance data to be collected in CMMS before 2017.
Performance measurement	Identify performance indicators and KPIs. Define measures. Collect data and generate reports.	KPIs established 2016. Measurement process under development.
Continual improvement	Establish a QA program.	

7.3.2 Resource Management

Over the past six years, staffing levels at GWA have been reduced, primarily within the water and wastewater groups of the Operations Division. This has largely affected their ability to perform preventive maintenance on a regular basis. In April 2016, as part of a request by the new GM to the CCU for restructuring the GWA organization, a report on past and current staffing levels, as shown in Table 7-6, was presented. The CCU approved the GM’s request to move forward with restructuring the organization and that process is currently underway.

Table 7-6. GWA Staffing Levels FY 2011–2016							
Division	**FY2011**	**FY2012**	**FY2013**	**FY2014**	**FY2015**	**FY2016**	**Change 2011–2016**
Administration	129	134	129	129	140	154	19%
Water	119	110	117	110	106	95	-20%
Wastewater	76	74	68	62	63	57	-25%
Total	**324**	**318**	**314**	**301**	**309**	**306**	**-6%**

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The water groups (production and distribution) have traditionally maintained staff that worked across both O&M. While some specialty trades (electrical and instrumentation) had focus areas, there were no staff dedicated specifically to maintenance activities versus operations. Other than some light maintenance performed by the rovers and at Ugum SWTP, most maintenance performed was corrective maintenance (CM) rather than preventive maintenance (PM). GWA's run-to-failure operations culture was predominantly caused by low revenues and high operating costs. Lately, the Board has approved recurring rate increases and evidence shows that funding is becoming more available for O&M and preventative maintenance.

From 2007 to 2013, a contract operator managed the wastewater system at GWA and instituted a specific maintenance function with staff dedicated to preventive maintenance. They also introduced use of a CMMS, which was the contractor's proprietary system named GAMA. It was used for scheduling and tracking maintenance and operations activities. GWA staff have reported that while using GAMA, the PM/CM ratio improved to an estimated 60:40 or higher, though no data records are available to substantiate that ratio. Upon conclusion of the Contract Operator's term of service, GAMA was withdrawn from use. In recent years, as wastewater staffing levels dropped, work order tracking was transferred to the JDE system and previously dedicated maintenance staff have been reallocated to operations and corrective maintenance. The wastewater maintenance staff now estimate that the current ratio is well below 50:50. O&M managers and supervisors estimate the division-wide PM/CM ratio as approximately 20:80, but hard data is not readily available to support either estimate.

O&M managers and supervisors have a general sense of the level of PM and CM activities being conducted in their functional areas, but tracking within the new CMMS will enable GWA to have hard data to evaluate trends in the maintenance functions and allocate resources appropriately.

In July 2016, GWA hired 25 new trades helpers for the water and wastewater groups. With the implementation of a new CMMS in the last quarter of 2016, GWA will be able to track labor and overall costs for PM and CM within each section and group, which will allow them to create a baseline and begin to take steps to improve the ratio. Part of that adjustment will be to designate trained and competent staff to perform preventive maintenance routinely. Additional staffing, implementation of a new CMMS, and ongoing restructuring of O&M roles and responsibilities should enable GWA to improve maintaining and operating their water and wastewater systems and collect the data necessary to measure that improvement over time. This increase in asset data collection, including asset condition assessments as part of all work orders, will facilitate GWA's ability to evaluate groups of assets across the entire asset portfolio to improve repair and replacement decision-making as part of the AM program.

7.3.3 Communications

For the most part, communications within GWA have been informal, not well-documented, and infrequently shared below managerial levels. While some discussions are by necessity not widely shared, the result is the staff level employees do not have a clear idea of GWA's goals, objectives, and initiatives towards AM beyond the short term.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The annual report is probably the most important communication vehicle that GWA currently uses to let the public know what GWA is doing. Over recent years, the amount of information about customer service and capital improvement projects has increased and the 2015 report contained a map of all capital projects across the island. But there is only so much information that can be conveyed in limited space. With electronic media becoming so prevalent, GWA may consider ways to highlight certain improvement projects on the web site or their Facebook site to let people know about the positive changes that are taking place within the water/wastewater systems. Communicating about service outages and customer service center wait times is important, as is letting your customers know about the good things being accomplished by GWA.

In February 2015, a workshop was held on overall utility performance, which included participation of the management levels across the utility as well as CCU board members and USEPA staff. One result of the workshop was to identify critical success factors in order of importance from the viewpoint of participants. The group identified communications as the number one critical success factor for GWA. The full list included:

- Communication: transparent, proactive, and timely
- Alignment: roles, responsibilities, and organizational structure reflect key organizational objectives
- Processes: clearly defined protocols for budgeting, requisitions, and procurement
- GIS/AM: current data available to all staff

Further discussion of communications indicated that top-down, peer-to-peer, and intergroup communications work best when:

- Program needs and requirements are openly discussed
- Changes to needs and requirements or agreed actions are communicated proactively
- Information is communicated in a timely manner

GWA should prepare an updated communication plan to support asset management and other master plan initiatives. It should clearly state the types of information to be communicated internally and externally, by whom, and the desired frequency and communication channels (in-person meetings, email, newsletters, the GWA website, etc.).

7.4 Customer Service and Risk Management

The following section describes GWA's customer service and risk management approach.

7.4.1 Performance Measures

GWA has tracked performance measures and reports these to senior managers and the CCU Board. These measures are primarily inwardly focused operational performance measures which are compiled into an annual report for internal distribution. Tracked measures include:

- Customer complaints – counts and response
- Fleet availability
- Active fire hydrants
- Water production, purchases, and well operability
- Chlorine usage
- Water outages
- Cost efficiency – purchased water and lost water

Use of contents on this sheet is subject to the limitations specified at the end of this document.

In the April 2016, BC conducted a series of workshops to guide GWA through the process for developing LOS and KPIs. The process and results are described in Section 3 (Levels of Service).

7.4.2 Performance and Quality Management

Annual performance reports are generated and shared within GWA and the CCU. The performance measures include:

1. Number of complaints
2. Complaint work order completion rate
3. Complaints response time – within 24 hours, 1–3 days, 4–7 days, 8 days or longer
4. Number of available fleet vehicles
5. Number of active hydrants

GWA has worked to develop an updated (2016) list of performance indicators. GWA is working on finalizing the list to implement and identify the data measurement requirements.

As part of the implementation of a structured maintenance management program (Section 7.6) and the Lucity CMMS (Section 7.7.4), the Operations Division should describe the processes it will use to verify the asset and maintenance data collected. This should include new and revised data for:

- Updating asset inventory
- Condition assessments
- Capturing frequency, types, and costs for maintenance across the asset portfolio

7.4.3 Risk Management

The concept of managing risk as it relates to utility infrastructure was introduced through the 2006 WRMP and again during AM program development and implementation.

GWA has asset condition data for all vertical assets and some of horizontal assets, but the data is old (one year or more) and needs to be validated or updated. Criticality determinations have been piloted but not all assets have been addressed.

Risk associated with infrastructure assets is developed as a product of probability of failure and the consequence of failure as shown in Figure 7-4.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

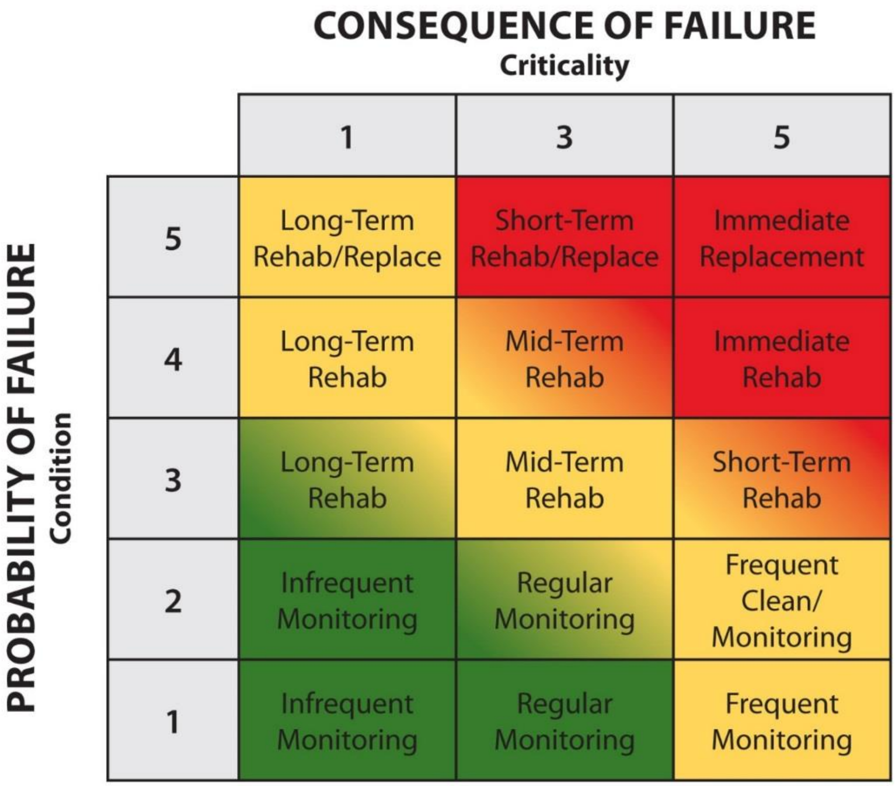


Figure 7-4. Consequence and Probability of Failure

From an AM standpoint, the potential risk of an asset failure is balanced against the cost of rehabilitating or replacing the asset.

GWA now has an application called the Computerized Asset Management Program (CAMP) tool to assess risk over GWA's entire asset portfolio or a subset of that portfolio and provide estimated renewal costs.

CAMP analyzes information about infrastructure assets and models how infrastructure is likely to degrade in performance and decrease in remaining useful life over time. It analyzes asset attribute data and projects, including the condition degradation of assets and the impact renewal and replacement of those assets will have on the overall risk profile. This provides a mechanism for prioritizing asset maintenance and renewal activities so that an acceptable balance of investment and risk mitigation can be achieved. This tool should be placed into use after sufficient maintenance cost data (more than two years' worth) has been collected in the CMMS.

CAMP is best used for long-term planning, identifying and prioritizing asset renewal actions, and identifying the optimal time frame for major expenditures associated with such renewals. The CAMP analysis should be performed on an annual basis as part of the capital improvement planning process.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

7.5 Asset Planning

The following section describes the asset planning process.

7.5.1 Asset Development

An asset inventory and condition assessment was performed of all vertical assets in the water system and an inventory of all vertical assets in the wastewater system. That data was used as the starting asset registry in the new Lucity CMMS. The capture and update to horizontal data (pipe networks) was performed by updating the GWA GIS database.

GWA has made changes to the process for managing CIP projects, which includes requiring contractors to provide a list of components by facility or process as part of the contract deliverables. This is addressed in an updated SOP on CIP project management, and the GWA Engineering Division is incorporating that requirement into the standard technical specifications issued for every construction contract. That data can be used to update the CMMS database and fixed asset registry in the financial system.

In July and August 2016, the AM leader met with the Engineering and Finance divisions to develop a work flow to define the steps within and between the departments for information transfer. These new and updated asset records result from maintenance replacements, CIP project completion, and non-CIP capital projects. This transactional process will include the Engineering, Finance, and O&M Divisions and needs to account for testing and acceptance of assets, schedule of payments and depreciation of the delivered assets, warrantee information, and capture of original equipment manufacturer (OEM) specifications, manuals, and maintenance requirements.

7.5.2 Current Practices in CIP Project Analysis

The CIP project analysis process stems from GWA's implementation of their SOPs. GWA developed "checklists" for staff to complete as part of daily tasks within the Engineering Division, which also include when the various SOPs should be used. The next logical step that GWA has undertaken is an analysis of the "checklists" to determine where and how the various processes within the CIP can be streamlined to increase efficiency and reduce costs. The intent is for the process developed by the Engineering Division to be used as a model for the remaining divisions within GWA.

As part of the AM program implementation, input from the Finance Division was obtained to investigate the CIP project life cycle. A diagram of the process steps, and the GWA divisions that have a role in each step, is provided in Appendix A-4.

Many of the process steps are not well defined or documented and GWA is working to develop some additional SOPs in this area. Those SOPs were under review for acceptance at the time of writing this report.

7.5.3 Business Case Evaluation

As part of the 2006 WRMP development, workshop sessions were conducted on analysis of alternatives and business case evaluation for capital programs. As part of the AM program implementation, training workshops were also provided on business case development and economic decision-making for asset portfolio management, which is under review at GWA.

GWA should select an approach to be used for evaluation of alternatives in asset planning, document it, and implement it as soon as practical. It is worth noting that for this process and all of the processes connected with AM, procedures should be updated and revised as needed to suit GWA's circumstance and organization.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

7.6 Operations and Maintenance

The following section describes the O&M strategy, procedures, and plans developed as part of the AM program.

7.6.1 Operational Strategy and Procedures

As part of the AM program implementation, several SOPs were developed for use in conjunction with GWA staff and with GWA's GM approval. A list of these SOPs is presented in Appendix A, Section A-5. The highlighted SOPs are under review or are currently being updated. Additionally, SP0310-19, "Substantial Change in Water Systems", dated August 9, 2011, is also being considered for revision placing the SCC in a role to coordinate changes and updates to the O&M asset inventory. The approved SOPs have been distributed through the O&M Division and have been implemented. GWA is currently using an SOP committee to verify implementation of these SOPs and revision of SOPs when needed.

To proactively address standardized work practices across GWA, the GWA General Manager has assigned a Management Analyst IV associated with his office to lead an SOP Committee that meets regularly to address questions or requests related to SOPs. The SOP Committee is comprised of a series of "champions" representing GWA's functional areas who are designated to coordinate distribution, use, and updating of these documents. The areas covered by SOP champions includes AM, Engineering, Procurement, Finance, and GIS.

7.6.2 Maintenance Strategy and Plans

A maintenance management program plan was prepared for GWA in 2015/2016 that presents various options and guiding principles for maintenance strategies and practices. The program plan includes the use of various types of maintenance (preventive, corrective, predictive, and reliability centered) to improve the operability of equipment at the lowest possible life cycle cost. As GWA's AM program matures, the maintenance strategies may change over time.

The concepts included basic to more complex features so that GWA could grow their maintenance management program as their AM program matures.

GWA's next steps would be to take the program plan and define a tactical approach appropriate for GWA's position for now and in the next few years.

7.7 Business Support Tools

The following section describes business support tools used to support the AM program.

7.7.1 J.D. Edwards

GWA uses the JDE enterprise resource planning software for financial tracking of fixed assets. The CDM Smith Phase 1 *Technical Memorandum 5.3–Software Systems Review* dated October 18, 2011, identified the absence of an asset-based maintenance tracking program as a critical gap to establishing an AM program.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

As GWA began inputting asset data collected in the field into the JDE PEM module in 2015 and creating work orders, it became evident that the entry of assets, even without cost data, was interrupting the Financial Division's use of the fixed asset module and the ability to retrieve data regarding schedules and costs associated with corrective and preventive work orders. The GWA O&M team strongly advocated for a system that focused on the O&M features of tracking work orders and associated costs at the asset level, enabled integration to the GIS system, and had a user interface that would allow O&M staff to interact with the system directly. In 2015, the AMSC agreed to seek a CMMS to be implemented as an O&M centric data-based management tool to facilitate the AM program. Through a competitive process, the Lucity CMMS was selected for implementation at GWA.

The JDE platform is still used by GWA for engineering job costing for CIP projects, financial depreciation of fixed assets, time-keeping, payroll, and human resources activities. Some functions of the Finance Division are being managed outside of JDE using spreadsheets with only final data entered into the JDE system. This process should be explored further to try to bring into the system as much of the data as possible and address and fix functional challenges.

7.7.2 Customer Information System

In 2014, GWA began implementing a customer information system (CIS), the Oracle Utilities Customer Care and Billing System Release 2.4.0, which went live in March 2015. The system runs on Red Hat Linux 6 and provides GWA with data reports on monthly billing statements, revenue summary and details, accounts receivable, and collections. GWA is receiving additional training on the system in 2016 to make better use of its functionality.

The system does not include data directly regarding critical customers, which might be used to facilitate recovery from significant service disruptions including storms, typhoons, earthquakes, or other significant events by prioritizing customer response. The water use data and customer location data was used along with geographic proximity to sensitive areas to determine critical customers as part of the water and wastewater system evaluations. GWA should consider the possibility of incorporating that data into the CIS to consolidate another key piece of data for development planning and emergency response actions.

Data from the CIS is exported for the generation of collection notices. Service connection data for water and sewer customers in the CIS has been brought into the GIS. The CIS is also integrated to the JDE General Ledger module and the OC-IVR/Online payment system/WSS (web self-service portal) called "My Water" and a customized point-of-sale system developed by WIPRO (the implementation contractor).

Future targets for integration include the Outage Management System, CMMS to track work orders at or near customers, mobile workforce management solution, AMR to AMI, and enhancement of web self-service capabilities by enabling customers to register/de-register online or at payment kiosks.

7.7.3 Geographic Information System

The GWA GIS was developed during the mid-2000s as part of water and wastewater master planning efforts to support the development of hydraulic models to test the overall adequacy of the systems. A reasonably complete representation of the pipe networks (both water and wastewater) was required for the master planning effort, and it is normal to develop these pipe networks using GIS technology as the base and then export the networks for use in the respective hydraulic models. Developing the water and wastewater pipe networks in the GIS involved significant research and effort, and after the Master Plan was completed, the GIS files were kept as the permanent GIS databases.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

From 2014 to the end of 2015, the GWA GIS was updated with information from record drawings and field data collection activities including:

- Acquisition of new, high-resolution aerial base mapping to increase GWA field staff's confidence in the tools at their disposal and enhanced confidence in GWA from the customer base.
- Integration of the leak, valve, and water line locations collected during the leak detection activities by outside contractors and GWA staff.
- Collection of information and locations of 3,800 hydrants in the system including make, model, ports, etc., and visual condition scores to aid in preparing GWA's hydrant maintenance program and coordination with fire department readiness programs.
- Inspection of approximately 400 manhole features to collect condition and elevation information and collection of over 1,100 manhole locations using global positioning system (GPS) technology in support of the development of the Northern District sewer model.

Additionally, the locational accuracy of 6,500 manhole features was updated based on the location as shown on the aerial photography. An internal GIS web site was implemented so that all GWA staff can now view water and wastewater system information on their desktops. The site includes an easy-to-use interface providing access to scanned as-built documents and valve isolation tracing, customer notification list generation, buffer analysis, and map printing

A feature of the new CMMS is tight integration with the GIS. Staff have been trained in accessing the GIS through the Lucity interface to identify maintenance areas or create work requests and work orders from the GIS. This will increase the use of the GIS and streamline the process to update GIS features. As new or incorrectly positioned features are identified in the field, crews can pinpoint the feature and change and send an electronic request to the GIS team for update.

7.7.4 Computerized Maintenance Management System

The Lucity CMMS was installed on the GWA network in April 2016 as a test environment. In June 2016, Lucity provided live training sessions for a pilot group of GWA O&M staff who served to test configuration and functional test scenarios. After a second round of training sessions using a train-the-trainer approach, GWA moved to production use of the system in October 2016.

7.8 Recommendations

GWA has made significant progress in implementing many features of an AM program. Building upon the good work to date, it is recommended that GWA pursue the tasks listed below. These tasks involve defining the program so that GWA's efforts are known and understood by staff and all involved stakeholders, drive the maintenance management plan to improve PM/CM ratios in each work group from year to year, and are rigorous in collecting up-to-date data on assets and maintenance costs to enable improved CIP decision making.

1. Define and document the structure for the O&M organization and AM under the SCC.
2. Devote resources as necessary for continued implementation of the Lucity CMMS. This system will serve as the data center for maintenance and AM.
3. Establish specific objectives for progress in each of the AM elements over the next three to five years.
4. Revisit AMPE elements and incorporate additional elements into the AM program development moving forward. Elements of the Corporate Asset Management Program and Asset Planning are recommended as two areas for strengthening the program, in addition to the existing elements of the matrix.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

5. Complete criticality determination for all operational assets and put the data into the Lucity CMMS.
6. Using the maintenance management program guidance, begin to outline GWA's maintenance management program. It is recommended to start with a simple structure and then grow as PM practices and work order management within the new CMMS are fully deployed. Establish and implement a phased approach to improve GWA's PM/CM ratio as part of a comprehensive maintenance management program.
7. Establish a quality management program for AM to monitor and guide ongoing implementation of the AM system. This quality management program should include:
    a. Verifying asset inventory data at various locations (water production, water distribution, wastewater collection, and wastewater treatment) on a rotating basis. The reason for discrepancies between what is in the CMMS and what is in the physical systems should be investigated so that processes and procedures can be tightened-up.
    b. O&M supervisors or their designee should review all work orders before closing them out. The type of maintenance performed should be clear, and the work crew(s) involved and the capture of labor, materials, and if appropriate, equipment costs should all be included before the work order is closed.
    c. Section managers should perform a desktop review of a representative sample of work orders monthly to verify that the information required in item 2 (listed above) is being captured.
    d. O&M supervisors or their designee should provide field verification or review of a percentage of completed work orders (PM and CM) on a weekly basis.

    The O&M quality management program plan should detail the information required for these checks, the required frequency, and the roles and responsibility for completing and recording the checks.
8. Evaluate the effectiveness of new procedures for acceptance of assets into operations, asset cost and installation date, depreciation of the delivered assets, warrantee information, and capture of OEM specifications, manuals, and maintenance requirements.
9. Compile procedures and policies developed for AM into a comprehensive program plan that guides ongoing operational improvements and provides system-wide training and awareness in AM. Procedures should be reviewed and field checked on a regular basis and at least annually. Identify and fill any gaps in defined policies and procedures.
10. Develop and implement a communications plan for AM that includes:
    a. Internal communications to staff regarding expectations and rationale for new and changing processes.
    b. External communications to stakeholders regarding how the GWA asset management will improve GWA delivery of service and maximizing economic stewardship of system components.
11. Establish a risk management protocol for periodic analysis of the asset portfolio. Utilize CMMS data to populate the CAMP for risk analysis. Update GWA's CAMP installation and provide training for asset managers to run varying scenarios as inputs to the CIP budgeting process. Evaluate and update process and procedures for the GWA asset life cycle from CIP planning, funding decisions, engineering/design, contract management, and O&M of assets.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 8
GIS Program

This section documents the current state of the GWA GIS and its supporting computer software and hardware components. This section includes descriptions of the status of the GIS in regards to the following:

- Recommendations made in the 2006 WRMP.
- Information within the current system that fulfills the 2006 WRMP recommendations.
- 2006 WRMP recommendations that remain to be addressed.
- Recommendations regarding additional future improvements to the GIS including organizational structure, resources, and equipment based on changes in the GIS standards of practice and technology since 2006.

8.1 GIS Program Accomplishments 2006-2016

GWA developed a GIS of its water and wastewater system pipeline networks in the 1990s. In 2006, a review of the GIS data sets, computer hardware, and software identified several limitations and deficiencies within the system. In 2006, GWA's then relatively new GIS program was still in its first stage of development. Section 9.9 of Volume 1 of the 2006 WRMP recommended changes to GWA's GIS system in the following areas:

1. Staffing
2. Software
3. Hardware
4. Workflow
5. CIP projects

Over the 10 years since 2006, progress was made by GWA in all five of these areas. During 2015 and 2016, GWA implemented several improvements to the GIS as part of the "GWA In-Kind Technical Support" contract (Support Contract). The Support Contract was completed in early 2016 and the items addressed by GWA are described in the following subsections.

8.1.1 Staffing

The 2006 WRMP GIS recommendations included the following: "GWA should hire new staff members committed to developing and improving its GIS program. Two key positions needed are a GIS Administrator and a GIS Analyst. GIS Technicians should be hired as needed to support the Analyst and Administrator."

A GIS Administrator was hired and continues today in that role. However, full-time permanent supporting staff have not been hired so the GIS Administrator must do all GIS-related tasks. Only temporary GIS help has been available for specific projects. The need for additional permanent personnel remains. Due to staffing limitations, important GIS activities have often been deferred because the current GIS staff feel that their first priority is to address map and data requests from GWA operations and management staff. This section addresses the deferred GIS activities.

Updated staffing recommendations are included in Section 8.3.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

8.1.2 Software

The 2006 WRMP GIS recommendations included the following: “GWA’s GIS program will require additional software to support the growth of the program. It is recommended that GWA add the following software to complement the two ArcInfo licenses it currently owns: two ArcView licenses, two ArcEditor licenses, ArcSDE, and SQL Server.”

In 2010, the island’s GIS public agency users, in a coordinated effort led by the Governor and administered through the Bureau of Statistics and Plans (BSP), organized a multi-agency consortium and negotiated an agreement between GovGuam and the Esri regional office to acquire the needed Esri software. An Esri Enterprise License Agreement (ELA) was initiated in 2012 that covered all of the GIS software needs for the island’s government agencies with sufficient additional licenses for growth in staff. Each GovGuam agency was assigned a pro-rata cost based on their estimated use of the licenses. The ELA provided GWA with the software recommended within the 2006 WRMP and included ArcGIS for Server software, which supports GWA’s new GIS Web Portal. In addition to the Esri software licenses, a Microsoft SQL Server database license was obtained to run ArcSDE in GWA’s new enterprise GIS.

At the time of this report, GWA did not need to acquire additional GIS software licenses because the ELA agreement provides GWA with sufficient licenses for its needs as well as free upgrades of the software as Esri releases new versions. However, there is an issue that the GovGuam consortium and its primary contributor, BSP, may not be able to sustain the payments for the ELA and the group funding agreement may cease to be viable. The Office of Technology (which performs information technology, or IT) is currently negotiating with Esri and Consortium stakeholders to craft a new ELA that may resolve this issue. The new ELA agreement will be administered by IT. It is anticipated that under a new agreement, each agency will be assigned an appropriate share of the overall cost. GWA should settle the ELA license issues so the newest versions needed for the ongoing GIS work can be acquired on a yearly basis or as new versions are available.

8.1.3 Hardware

The 2006 WRMP GIS recommendations included the following: “GWA’s GIS staff will need computers designed to perform with ESRI’s ArcGIS family of products.” A dedicated GIS server was not specifically included in the 2006 recommendations, but the recommended SQL Server and ArcSDE software packages are normally installed on server computers. Therefore, the need for a server computer was implicit in the 2006 WRMP recommendations.

GWA currently has the following hardware to support their GIS:

- **GIS server:** GWA purchased the required GIS server in 2013, which has the needed capabilities including support for a high-availability VMware virtual machine cluster.
- **GIS workstations:** GWA upgrades its computers on the IT Division’s equipment replacement schedule and have the required computers to run GIS software.
- **Other computer peripherals:** GWA has a large format color inkjet plotter and an old black and white scanner/plotter. GIS staff have had trouble getting ink cartridges and other ink supplies, so they have not been able to plot in color. The scanner/plotter is old and needs to be replaced.
- **GPS equipment:** GIS staff have acquired excellent GPS survey equipment, which has been well maintained. The GPS survey equipment is capable of centimeter accurate horizontal positioning. GWA also has handheld Trimble Geo-XH-3000s, which can collect sub-meter horizontal positions and Trimble’s Pathfinder Office.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

All of the desktop and server hardware issues discussed in the 2006 WRMP have been addressed and the equipment is currently working and is satisfactory for the proper functioning needs for the GIS. Updated hardware recommendations are included in Section 8.3.

8.1.4 Workflow

The 2006 WRMP GIS recommendations included using custom ArcGIS functions developed by the GIS consultant, IIS-GIS, who designed the GIS database. The IIS-GIS recommendation to use enhanced data entry tools was in response to the massive digitizing effort required to jump-start the GIS system. These workflows and tools were developed for the GIS development circa 2006 and technology has advanced since then making more robust GIS editing tools available directly within the Esri software.

During the GIS update recently completed under the 2013 Support Contract, several SOPs detailing editing workflows were developed. The GIS updating work has shifted from the bulk digitizing done in 2006 to maintaining and improving the utility databases. GIS updating work now focuses on:

- Incorporation of aerial imagery capable of supporting the GIS layers.
- Correction of feature locations to within one-meter accuracy.
- Corrections to topological and connectivity errors that hamper upstream and downstream tracing.
- Correction of incorrect and/or missing attributes.
- Completion of missing portions of the system as data become available for inclusion in the GIS.

The Support Contract developed the following set of SOPs as part of the GIS and the leak detection and line location tasks:

- Water leak detection data capture.
- Water line location data capture.
- Water repair data capture.
- Water feature data incorporation and the correction of feature positions in the water GIS using data from the three activities listed above.
- Water and sewer field data collection.
- Water and sewer GPS data collection and feature positional corrections.
- Water and sewer maintenance using ArcSDE versioned databases.
- Water and sewer automated checks using Data Reviewer software. The Data Reviewer software is a new Esri extension used for quality control checking of data, as opposed to completely custom software (as recommended in the 2006 WRMP) that needs to be maintained in-house.

The developed SOPs provide guidance for a wide range of GIS data workflows. The following are recommendations for the future:

- The incomplete networks for both water and sewer with an estimated 15 percent of the features missing present a challenge. Collecting water information from scratch in the field is covered by the line location procedures. However, a similar set of SOPs for the sewer system should be developed that build on the field data collection work performed by Veolia, who at the time was an engineering consultant tasked with managing portions of the system. Veolia developed approaches to identify unknown assets within the system and collect CCTV pipeline inspection data.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The SOPs cover most of the data collection and GIS updating activities, but if their guidance is not followed the work effort will suffer. At present, the work performed in the field is documented on paper forms. Approximately 80 percent of the forms are missing an accurate description of the location of the assets that can be used to identify the area in the system and assets worked on. Recommendations for addressing this issue are presented in Section 8.3.

GWA is currently implementing a new work order management software package (Lucity) that will further enable the electronic capture and storage of information regarding work performed on the system assets and the recommendations presented in this section should be integrated with that on-going implementation project.

8.1.5 Capital Projects

The 2006 WRMP GIS recommendations include the following regarding capital planning: "GWA's geodatabase will need field investigation for areas of the water and wastewater system that do not have record drawings. The initial GIS CIP uses five years of projects to update and improve the data. A budget of $160,000 per year for five years will help GWA continue to improve the geodatabases and recruit personnel for the GIS program."

The aggressive 5-year program to update the GIS recommended by the 2006 WRMP was not fully implemented. For the sewer system, GWA estimated that approximately 1,500 manholes were missing from the GIS and that they needed to be field-located as no paper records existed for them. Additional infrastructure has also been constructed since 2006 with no record drawings provided to GWA. The following efforts have been done since 2006 to improve the water and sewer GIS:

- Some manholes have been located and updated in the GIS during various projects since 2006, including 425 manholes located by Veolia staff and numerous manholes located in 2013 during SSESs in the southern villages.
- Under the Support Contract, a substantial number of assets and GIS corrections were incorporated into the water and sewer GIS networks. The initial digitizing of features during the creation of the new GIS in 2006 was done without high quality aerial imagery and features were often digitized directly from drawings that were not registered correctly to the 1993 Guam coordinate system. This resulted in many features being incorrectly placed by up to 100 feet from their true locations. The acquisition of a higher quality aerial image, with an approximate 1-foot accuracy, allowed for features, such as manholes that were visible on the aerial imagery, to be shifted to within the desired 1-meter accuracy level in the office rather than requiring costly field data collection.
- Approximately 16,000 sub meter accurate GPS points were collected over several years by the leak detection and line location programs. In addition, hydrant locations were collected using GPS technology in the field in 2013 and 2014. Valve locations were also updated using aerial imagery. Overall, locations of over 20,000 water system assets were updated or new features were added to the existing GIS data layers. Edits correcting other connectivity issues within the GIS dataset resulted in another 10,000 features being modified.
- Using the aerial imagery, GPS equipment, and available sewer infrastructure record drawings, approximately 7,000 manhole assets were relocated to within 1-meter accuracy during 2013 and 2014. The connected pipes that were in the wrong locations were also corrected as the manholes were moved. Edits to correct approximately 10,000 other connectivity issues within the GIS dataset were also made as part of the Support Contract. Field location and condition assessments of approximately 500 manholes were performed and an additional 30,000 features were visually checked and corrected when automated checks indicated there were connectivity errors and when the information required to fix the visible problems was available.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

It is recommended that GWA hire an entry-level GIS field technician to continue collecting data to improve the GIS. The technician could be trained by GWA and then could perform surveying, field data collection, and data entry into the GIS. Data should be collected at features that have not been surveyed, such as manholes and water valves (especially in areas without record drawings). A technician could also survey new pipelines as they are constructed to collect accurate pipe locations, depths, diameters, materials, etc.

8.2 Needs Addressed by Recent EPA Region 9 Contract Request

On August 18, 2016, the USEPA Region 9 issued a Request for Quotation (RFQ-CA-16-00034) for services to address several of the recommended follow-on actions that were made as part of the Support Contract. The resulting services contract is anticipated to address the recommendations which included:

- Continue to collect additional information for water and sewer assets currently missing from the GIS.
- Integrate the CCTV pipeline inspection data into the GIS so that it is accessible through the GIS web portal.
- Enhance the scanned record drawing library through the development of a more complete and efficiently searchable index and directory storage structure.

Recommendations regarding the approach to each of these activities is provided in the following subsections.

8.2.1 Continued GIS Data Collection

The following section describes recommendations regarding GIS data collection.

Water System

Although the water GIS has been updated considerably since 2006, there are still geographic areas where the pipe network is missing. Many of the rural areas are served with 2-inch pipes and the original 2006 GIS data conversion and digitization process prioritized larger diameter water pipes in areas with a higher density of customers so many of the rural pipes are missing from the GIS. Other areas that were not addressed include those areas where paper drawings and plans were not available and are still not available. Missing and incorrect features can be updated in the GIS using the following methods:

- The line location and leak detection programs have been in use by GWA since 2010 and have helped to locate previously undocumented pipes, valves, fittings, and hydrants as described in Section 7 of Volume 2. These programs have contributed thousands of updates to the water system GIS. This approach remains an effective way to discover and record the underground water infrastructure. Volume 2, Section 9 gives recommendations for these programs.
- The missing features can be determined by plotting the known location of water meter and hydrant features and then using spatial analysis in the GIS to identify areas where customer meters or hydrants exist but no water pipe network is present. Efforts to locate missing infrastructure can be focused on these areas.
- The organization and indexing of the scanned drawings should be completed to better determine if there are source drawings that can be used to update the GIS (as described below).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Sewer System

Similar to the water system, there is a substantial amount of the sewer infrastructure missing in the GIS. The geographic areas where the sewer pipe network is missing can be identified by plotting the location of water meter locations that are flagged as providing sewer service. Locations with sewer service but no GIS piping indicate areas where sewer data is likely missing from the GIS.

The process of collecting manhole and pipe data is relatively straightforward at manholes that can be easily accessed. Data collection includes recording the required manhole and pipe attributes and sketching a map of connecting pipes at each manhole. Because many of the manholes that will need to be opened are in busy streets, it will be difficult, time consuming, and expensive to inspect all of the manholes. GWA should coordinate with engineering, operations, and hydraulic modeling staff to determine which manholes and pipes should be visited. By collecting data at intervals along pipelines instead of collecting data at each manhole, the amount of time and cost to map the system can be reduced while still providing the necessary data to support hydraulic analyses. During the Support Contract, a large representative neighborhood was mapped and the level of effort from that experience can be used to estimate the level of effort for the other areas within the system.

The CCTV data collection effort has filmed many miles of pipes and has collected manhole and pipe data with attributes. The CCTV data is stored in GWA's Granite XP CCTV data collection software database. Often the manhole locations found during the CCTV have not been transferred to the GIS but are stored in shapefile format or on paper sketches. Using the aerial imagery, the corresponding manholes can often be identified and digitized within the GWA GIS and the attributes collected during the CCTV work can be used to create pipes between the manholes within the GIS. There are a substantial number of CCTV videos and data that are available for use as part of this process. However, many of the CCTV inspection records collected in the past do not reference the same unique pipeline identification codes used in the newly updated GWA GIS database. The following process should be used to match the historic CCTV inspection records to pipelines in the GIS:

- Identify the inspection records that have matching identification codes between CCTV and GIS.
- Develop links between the Granite XP records and GIS pipes records that do not have matching identification codes based on historic copies of the GIS database in use when the inspections were undertaken. This process will require spatial analysis to link the older pipeline identifications codes to the new codes based on coincident locations between the old and new GIS databases (i.e. old pipes in same locations as the new GIS pipelines).
- Update the Granite XP inspection database containing links between Granite XP and GIS features with the correct new identification code to facilitate retrieval of all inspection data for the historic inspections.

8.2.2 GIS Web Portal

The GIS web portal site should be modified so that CCTV data can be retrieved when searching for a pipe in the GIS system. This feature should include the following:

- The web portal should allow users to identify the pipeline assets that have been previously inspected and the date of the inspection.
- The GWA computer network should be checked to see if it has sufficient bandwidth to allow users to view video files over the network. If there is sufficient bandwidth, the videos should be set up so users can find and view them over the network.
- The CCTV database and media files should be installed on the GWA GIS server.
- Training sessions should be held for GWA staff to learn how to:

Use of contents on this sheet is subject to the limitations specified at the end of this document.

- Find and view CCTV database information and related video files on the web portal and within desktop GIS and video viewing software packages.
- Combine new video and database records into the master CCTV database and video library.
- Maintain the links between the Granite XP inspection database and GIS features with the new identification codes in the future as additional CCTV work is performed.

8.2.3 Scanned Image Document Library

GWA currently has a scanned record drawing library. The scanned documents are not well organized or consistently named. The library has an index but the index is missing key information. The library and index need to be updated. It is recommended that a comprehensive effort be undertaken to address the issues in the current library using the following process:

- Identify and collect all new relevant scanned drawings from GWA staff and different office/computer locations for inclusion in the existing document library on the GWA GIS server.
- Develop and apply naming conventions to the existing drawings and develop SOPs for GWA staff to apply to future digital drawing sets. This process will involve the development of electronic scripts to rename the individual digital files within the library as well as within the drawing index to ensure that they are consistent throughout the library.
- Identify and delete all duplicate files to avoid future confusion and increase available storage space.
- Convert all image files (TIF/TIFF and JPEG/JPG) into PDF format to be consistent and make the files more accessible to all users.
- Combine drawings from sets that have multiple pages currently in single files into multi-page PDF files and compress the files to reduce file size.
- Rotate pages that are incorrectly rotated so the files can be more easily read.
- Add or modify index information regarding project name, area, asset type, date of project, etc. if the data is missing or incorrect in the drawing index database.
- Finalize the drawing index database and quality control check all records to verify linkages between the index records and digital drawing files in the library.

With a reorganized image library and a new electronic document indexing system, new documents of any type can be added. Documents can include scanned drawings, O&M manuals, etc. The documents can then be more easily accessible thru the GIS web portal.

8.3 Recommendations

This subsection contains recommendations for the GWA GIS, including recommendations remaining from the 2006 WRMP and new recommendations. Some of these recommendations were included in the recently released RFP-CA-16-00034, GWA In-Kind Services Technical Support (Module 3), which includes a request for engineering services to address items that remain unresolved by recently completed support contracts.

8.3.1 Staffing

Staff recommendations include:

- One full-time analyst should be hired as soon as practical and a second technician should be hired in 2018. These positions require a budget and a multi-year work plan. An additional technician may be necessary to collect the field data and perform surveying as discussed in Section 8.2.5.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

8.3.2 Software and Hardware

Software and hardware recommendations include:

- Ink cartridges and other ink equipment should be purchased as needed so that GIS staff can plot in color. The scanner/plotter should be replaced. In addition, the plotters should be replaced as they approach the end of their life expectancy.
- There should be redundancy or backup put in place, so if any equipment critical to the use of the GIS (plotter, database server, etc.) fails, there is another machine to continue the work. Cost sharing options should be explored with GPA GIS staff as the proximity of their offices to GWA's could eliminate the need for duplicate equipment in each office whereby each agency would share its equipment when the other's is offline for maintenance.
- The desktop and computer hardware should be replaced or significantly upgraded on a 5-year cycle at a minimum. The IT Division should take this timing into account with their equipment replacement schedule.

8.3.3 Field Equipment and Processes

The following equipment should be acquired and the following processes should be implemented to support field data collection:

- Metal detectors should be acquired to locate manhole and valve covers under pavement in the streets and in areas of highly overgrown vegetation.
- Use of GPS and electronic compass-enabled cameras should be implemented to take digital photographs, including while trenches are open and with sufficient background in the photographs, to assist in finding a location in the GIS.
- Tablet computers should be loaded with the GIS database or with cellular access to future versions of the GWA GIS in a web-based format to facilitate collection of updated GIS features and feature attributes in the field for inclusion into the GIS.
- GWA should consider upgrading the handheld GPS units to achieve greater accuracy without the need for post-processing as new technology becomes available and as GWA begins to use the GIS in the field on a regular basis.
- All field operations team leaders should be trained in the use of GPS technology to collect asset information and accurate locations of the work performed.
- Standard maps from GIA should continue to be used for field operations activities that could benefit from mapping. In future years, GWA should invest in mobile computerized tablet technology to transition the collection of data and work records to a digital format that can be integrated with the GIS and new work order management software systems.
- If staff levels permit, a GIS technician should be sent into the field to record location data. This can be done when GWA staff perform activities where the location data could be gathered to improve the GIS.
- SOPs should be developed for collecting field data for the sewer collection system. These can build from the procedures developed during field work performed by Veolia.
- As new technologies are implemented, the existing GWA SOPs should be updated as changes to the processes are made so that future staff can be correctly trained in the new procedures.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

8.3.4 Reference Layers

Reference GIS layers should be maintained as follows:

- Maintain working relationships with agencies responsible for the GIS building outline layer, GIS parcel layer, and other reference layers to obtain updated data when available.
- New satellite imagery should be obtained on bi-annually or as needed pending the amount of infrastructure change on the island. Data and cost sharing arrangements should be explored with other public and private agencies on island.
- Street centerline files are routinely used to locate street addresses and to act as a spatial index so GIS map display programs like GWA's GIS Web Portal, Google Maps, and others can zoom to an address. The centerline file can be used by itself or in conjunction with other data files to locate nearby customers, utility features, and to perform routing. While GWA does not have a mandate to update or maintain the street centerline file, GWA should coordinate with GPA and other island agencies to provide labor or budget to maintain the street centerline file to more effectively support their operations.

8.3.5 Customer Meter Layer

Customer meter locations are important for operations staff, hydraulic modeling, mapping, and other uses. GWA recently acquired a new customer system and all of the pre-2014 customer meters were replaced with new radio-read meters. Of the approximately 42,000 customer meters, all but about 1,500 of the meters have been located as of February 2016. The located meters have been uploaded to GIS.

The following items are recommended for the customer meter layer:

- The database query system currently in place should continue to be used to read the customer system database and provided feedback to update the GIS layer of customer locations when required.
- The quality of the already collected meter data is unknown. The positional quality of the existing meter data should be reviewed to determine if the existing data can be used and built from or if further work is needed to modify the points that do exist.
- The Meter Group should continue locating missing customer meters which should be added to the GIS layer as necessary.

8.3.6 Field Updates

New trends in GIS processing allow updates to be made real-time in the field, both connected wirelessly or off-line. In the latter case, updates are merged periodically back into the database when a wireless connection is available. The Enterprise GIS design implemented at GWA contains the infrastructure to be able to use this technology. At present, GIS data are updated in the office using ArcMap. This process requires more time and effort for updates than using real-time processing. But the current process also provides a more traditional workflow and allows GIS staff to review and perform quality assurance and quality control (QA/QC) as updates are made in the office. However, with the versioning capabilities of the Enterprise GIS, QA/QC checks can be done whichever way the data are collected pending GWA's desired method of performing the updates.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The consultant implementing the Lucity CMMS software recommended the use of field data collection using new GIS tools to support the use of the CMMS software in the field. GWA, in conjunction with Lucity, should determine how the existing GIS and work order integration can be augmented using handheld field computing technology to provide electronic mapping to GWA staff in the field in support of work order-driven activities. Additional recommendations could not be made at the time of this report because the CMMS implementation was still underway.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 9

SCADA Program

This assessment update focuses on the existing and recommended SCADA technology and controls to assist GWA in accomplishing its goal "...to plan, design, build, operate, maintain and manage GWA's systems and facilities in a manner that provides long-term value while meeting Guam's vision for growth and development in a sustainable manner and complies with all Federal and local environmental and safety regulations." This assessment aligns with GWA's SCADA Master Plan and follows an organized scope.

GWA and GPA have issued a MOU to share the GPA ABB/Tropos wireless system to avoid building a separate system for GWA. A separate DB project will design and install a new central infrastructure for GWA and GPA.

This section discusses the four phases described in GWA's SCADA Master Plan and its subsequent revisions and addendums.

As a point of reference, the phases described in the 2006 Master Plan were replaced in the GWA 2014 SCADA Master Plan. Three phases (later expanded to four phases) were defined to implement SCADA at 341 out of the 420 remote sites:

- **Phase A-I:** initial project of 19 sites, SCADA system with central infrastructure connecting through GPA network
- **Phase A-II:** additional 188 sites
- **Phase B:** additional 134 sites
- **Phase C:** additional instrumentation for sites above

The focus of this section includes:

- Telemetry and control system definitions
- Existing control and communication system infrastructure description
- System site observations
- Implementation activities
- Conclusions
- Recommendations

GWA requires several telemetry and control systems:

- SCADA
- Distributed process controls (DPC) (internal to GWA water or wastewater facilities)
- Local area-wide (LAW) telemetry and control functions involving several facilities
- Field telemetry and control (FTAC)

SCADA systems provide limited remote operation at some sites and unattended status and alarm monitoring of the GWA water and wastewater facilities. The system can also offer a valuable management tool in providing historical operational and trending data and, when integrated into a preventive maintenance program, improves resource allocation.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

DPC systems are internal to GWA water or wastewater facilities. They control the processes within GWA facilities. Control processes include but may not be limited to:

- **Wastewater treatment controls** for primary and secondary treatment, clarifiers, flocculation, dewatering, sludge pumping, and advanced treatment such as ultraviolet disinfection.
- **Water treatment controls** for raw water pumping, coagulation, flocculation, sedimentation, dewatering, recycling, filtration, disinfection, and chemical treatment (chlorination).
- **Water distribution controls** for reservoir levels, BPSs, and pressure zone controls.

Equipment condition monitoring could also be provided, which would include online and portable vibration monitoring, motor diagnostics, pump diagnostics, infrared thermography, laser alignment, and back-up generation fuel and lube oil analysis.

LAW telemetry and control functions provide automatic telemetry and control functions exercised over several GWA facilities near each other. An example would be automating a reservoir tank with several nearby water wells. The reservoir would monitor its tank levels and exercise controls over nearby water wells based on its tank levels. It would also monitor the condition of these wells to ascertain which wells are operational and their constraints, and optimize the operating costs.

FTAC functions include but may not be limited to:

- Water zone flow metering
- PRV telemetry and control
- Lift station facility telemetry

9.1 Existing SCADA and Control System Description

This section describes the existing SCADA, local DPC, LAW telemetry and control, FTAC, Government of Guam Trunked Radio System (800 MHz), and GWA and GPA communications infrastructure.

A SCADA system was installed in the mid-1990s but became nonfunctional after a few years, primarily as a result of storm damage and vandalism of the central base unit. This system operated on the Government of Guam's Trunked Radio System (800 MHz). The SCADA system no longer uses the trunked radio system.

Motorola installed the initial SCADA system in the early to mid-1990s at WTPs and WWTPs, pump stations, reservoirs, and related facilities. The radio frequencies used were within the Government of Guam's trunked system (800 MHz band) through four repeater sites that provide coverage throughout the island. This is the same system that is used by the Guam Police and Fire and Emergency Services. This radio system has since been abandoned for SCADA use and most of the radio equipment has been removed from GWA sites.

Programmable logic controllers (PLCs) were installed at some locations as part of the Well Chlorination Program and at Ugum SWTP and Hagåtña WWTP. These PLCs will be upgraded to be ready to connect to the SCADA system during the Phase A-I and Phase A-II of the SCADA implementation.

The SCADA system relies on input information from process instrumentation in the field, including such basic items as power failure, high water pressure, pump and generator operation, flow rate, wet well level, and alarms. The SCADA output at the water pump stations is planned to ultimately provide pump starting and stopping capability in response to high-level condition at a tank or reservoir.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA and GPA have issued a MOU to share the fiber and wireless infrastructure installed under GPA's Smart Grid Grant Program. This communication and network infrastructure has been renamed the GPA and GWA (GPWA) Consolidated Communication Network (GPWA CCN). The GPWA CCN consists of the following communication and network systems:

- Island-wide fiber optic communications network (Tier 1)
- ABB/Tropos wireless system (Tier 2)
- Landis+Gyr grid stream wireless system (Tier 3)
- Fixed microwave (Tier 4)

Joint use of the GPWA CCN avoids building a separate communication system for GWA. GWA SCADA sites will connect into the closest, least-cost interconnection GPWA CCN tier network available. Additionally, a separate joint design-build project will design and install a new central infrastructure for GWA and GPA.

9.2 SCADA and Control Implementation Activities

The process control system is a critical component in achieving GWA's goals for operational efficiency. Therefore, the recommendations in this report include technologies that comply with the following criteria:

- Adoption of standards for hardware installations
- Open standards for software programming languages and protocols
- Leveraging existing communication infrastructures (including protocols in use)
- Integration of current IT systems

The adoption of equipment installation standards and procedures will help GWA employees to become more familiar and proficient with specific types of hardware. In turn, this will reduce maintenance costs associated with decreased inventory and maintenance labor (e.g., lower repair and troubleshooting time).

Also, the adoption of "open" standards for PLC programming languages defined in IEC 61131-3 as ladder diagram, function block diagram, sequential function chart, instruction list, and structured text, will enable maintenance and IT staff to become proficient in standardized programming languages in lieu of learning multiple proprietary languages. Maintenance and IT staff will then be able to skillfully respond to software maintenance and troubleshooting issues, which will decrease system downtime.

As mentioned in the 2006 Master Plan, leveraging Guam's existing communication infrastructure and equipment will relieve GWA's burden of operation and maintenance of the communication infrastructure, thus reducing downtime.

Finally, integration of the current IT architectures will enhance the ease of distributing the process control system information to a broad variety of staff. This information includes real-time process control information, alarm information distribution, historical reporting and analysis, and maintenance management system interface, plus automated report generation for federal and local agencies.

These four components will significantly assist in meeting GWA's vision for growth and development in a sustainable manner and enhance its ability to comply with all federal and local environmental and safety regulations.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Because the Motorola radio system will not be used in the future, the phases described in the 2006 WRMP that were focused around upgrading the existing Motorola equipment were modified. The GWA 2014 SCADA Master Plan defined three phases (later expanded to four phases) to implement SCADA at 341 out of the 420 remote sites and then more fully instrument those sites.

Phase A-I–initial project of 19 sites: this phase consists of the must have and very high priority sites integrated with a central infrastructure. Must have and very high priority instruments and functions at these sites are also included. SCADA servers or virtual servers will be located at the GWPA administration building and the Hagåtña WWTP. Each site will connect to the system through the GPA mesh wireless network using the nearest pole-mounted router. However, GPA will need to install some additional routers at certain sites. Operator access to the graphical SCADA screens will be at the server locations and in the field using portable notebook or tablet computers. The initial 19 proposed sites include the following:

- Deep Wells: A-01, A-03, A-05, A-06, A-12, A-23, A-25, A-29, A-30, A-31, A-32, M-17B, and M-20A
- Reservoirs: Agana Heights and Chaot
- BPS: Agana Heights
- WWTP: Hagåtña WWTP
- Lift stations: Fujita and Route 16

Phase A-II–additional 188 sites: this phase consists of the must have and very high priority sites integrated with a central infrastructure. Must have and very high priority instruments and functions at these sites are also included. Each site will connect to the system through the GPA mesh wireless network using the nearest pole-mounted router. GPA may need to install additional routers at certain sites.

Phase B–additional 134 sites: this phase consists of desirable sites that GWA may want at some point to integrate with a central infrastructure. Must have and very high priority instruments and functions at these sites are also included. Each site will connect to the system through the GPA mesh wireless network using the nearest pole-mounted router. GPA will need to install some additional routers at certain sites.

Phase C–additional instrumentation for sites above: this phase will add “desirable” and “may-want-at-some-point” instruments at the SCADA sites.

A separate design-build project will design and install a new central infrastructure for GWA and GPA.

9.2.1 Local Process Control Improvement Recommendations

This section describes general process control equipment recommendations including design standards.

Standardization of Automation Devices and Design

A wide variety of equipment and equipment manufacturers, performing nearly identical functions, currently exists throughout the various types of GWA installations. This has developed naturally over several years of operation and maintenance and construction of facilities under different contracts. Unfortunately, because of such an extensive variety of designs and manufacturers, it is costly for GWA to maintain and troubleshoot, and to maintain an adequate reserve supply of replacement parts. Therefore, it is recommended that GWA select a standard device or family of devices for each process control component, as well as standardize the design schematic and wiring diagrams.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Simple design. Although complex systems are available in the market today, they may not be the best solution for GWA. It was observed that many of the electronic devices and wiring methods had failed and these systems were bypassed or replaced with more simple systems. An electronic level sensor is the most common example that is replaced with a simple bubbler or float system. Some devices will include electronics; however, they should be industrial-rated and suitable for use in a harsh environment.

Manufacturer selection criteria. The manufacturer of the automation device should be a commonly used vendor for this industry with local representation of products and a large installed base with parts readily available in stock. The manufacturer should demonstrate a track record of support and supply of replacement stock over a long period. Unfortunately, these criteria may eliminate some of the newer companies with new products. GWA will have to weigh the advantages of their products against the risk of potentially losing long-term support.

9.2.2 Local Process Control Recommendations

Many of the sites have magnetic relays, timers, pump alternators, and other hard-wired components that composed the local process control functions. While these systems operate effectively, they usually only control the "core" function of the site. However, the complexity of the hard-wired systems increases dramatically when additional functions are added to the control systems. Consequently, a critical threshold is reached whereby it is no longer feasible to operate a site using traditional hard-wired components. As the number of inputs and outputs at a site increase, the complexity of the wiring increases dramatically. Troubleshooting the wiring becomes a difficult and complex task.

PLCs are designed to replace complex hard-wired control systems. However, even in a highly-automated system, providing hard-wired circuits to run individual equipment in manual is generally evaluated/included during design. In addition, most PLCs are capable of a direct connection to a telemetry system or have a telemetry system built into their architecture. PLCs perform process logic electronically. PLCs usually do not have built-in communication systems and generally require an external radio or modem.

The PLC offers a high input/output (I/O) density so that the unit does not have a large footprint. The typical I/O density per I/O module is:

- Digital inputs: 16 (non-isolated)
- Digital input: 8 inputs (isolated)
- Analog input: 8 inputs
- Relay output: 8 outputs (isolated and non-isolated)
- Analog output: 4 outputs

The PLC should have the capability to add additional inputs and outputs without having to replace the entire unit. The hardware should have the ability to be expanded to accept up to 16 I/O modules. The PLC should support remote access for remote configuration, programming, and troubleshooting. This support should include full function capabilities using various communication methods.

As stated in the 2006 WRMP, the PLC should support open logic programming languages defined in international IEC-61131-3 standard. This will enable GWA to train its staff on the use of one programming package that has the ability to program the processors located in remote pump stations as well as those located in the treatment plants.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

9.2.3 Operations and Maintenance Implementation

A detailed training program should be initiated. The content will vary, depending on the job responsibility of each staff member. In general, there are four training classifications:

- Operations
- Maintenance
- IT/automation
- Management

Operations. Operator training includes the basic operation of the device, hardware, or software if the operator's normal job functions require direct interaction with the product. For example, an operator should understand the process functions whenever a PLC logic program is activated. However, the operator is not required to know how to program the PLC. The training should include hands-on work with the process and equipment. Testing is also a necessary portion of the training program to determine the level of operator competence. Regular refresher training courses and testing ensures that the operators maintain their understanding of the systems and are able to continue operating the systems properly.

Maintenance. Maintenance staff training includes all the topics presented to the operators, plus a more in-depth training on the actual installation including wiring, terminations, processors, modules, power supplies, calibration, and testing. It also includes detailed training on PLC programming, troubleshooting, and monitoring. All training should be hands-on in the classroom and at actual field installations. In general, GWA maintenance staff should be thoroughly trained so that they can troubleshoot, replace hardware, and load PLC logic without requiring outside assistance. Testing is also necessary to determine the level of individual competence. Regular refresher training courses and testing ensures that GWA maintenance staff retain a high level of competence in keeping the systems operating properly.

IT/automation. IT/automation staff training includes all of the topics for operators and some of the general topics provided to the maintenance staff. In addition, IT/automation staff should be thoroughly trained in the network infrastructure, hardware (servers and workstations), and all software programs running as part of the process control system. IT staff should be trained in performing backup and restoration of the programs and in communications troubleshooting. IT/automation staff should also be trained on report generation. The GWA SCADA Master Plan (2014) recommends adding new FTE PLC programmers to augment the Instrumentation Technicians with a SCADA Developer (hired either as GWA FTE or under contract) to maintain the SCADA system.

Detailed PLC programming is not necessarily a job responsibility required by the IT staff because it involves detailed process and equipment operation knowledge and uses languages and controllers not normally familiar to traditional IT staff. There is a current need for a PLC programmer, but whether the PLC Programmer(s) should fall under GWA's O&M Division or IT Division in the organizational chart needs be determined by GWA.

Management. GWA's management staff should be trained on the overall concept of the SCADA and control systems, as well as thoroughly educated on the function and capabilities of each hardware and software component. Detailed management training should be provided in all aspects of historical trending, analysis, report generation, monitored alarm sequencing, and performance monitoring, together with all other types of administrative capabilities of the SCADA system.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The GPA Strategic Planning and Operations Research Division (SPORD) is setting up DNP.ORG memberships for GWA and GPA. SPORD is arranging for the following joint GPA/GWA training:

- DNP3-SA protocol training
- Modbus protocol training
- ASE AS2000 protocol test set training
- OSIRIS remote terminal unit (RTU) training

SPORD has two AS2000 test sets and two OSIRIS RTUs. SPORD will work with GPA/GWA IT, Guam Power System Control Center staff, and GWA Engineering to set up a lab to simulate master station and RTU operations using the test sets.

9.2.4 GWA Maintenance Equipment Requirements

GWA maintenance staff should be equipped with the proper tools for calibrating the instrumentation. In addition, the staff should have a minimum of two ruggedized notebooks loaded with the PLC programming software as well as a copy of all PLC programs.

GWA should maintain an adequate supply of replacement parts in stock.

9.2.5 Site Security and Intrusion Detection Security Monitoring System

GWA's remote stations have been affected by considerable vandalism and unauthorized intrusion. Intrusion detection devices, such as motion detectors, magnetic door detectors, and infrared light beams, among others, should be installed at each remote location for monitoring purposes. Any intrusion will be displayed as an alarm with a date and time stamp. Video monitoring was addressed in the 2014 GWA SCADA Master Plan and was not deemed to be a system-wide requirement. GWA and GPA are working on allowing video surveillance over the CCN. It will be assessed on a site by site basis after the sites are integrated into the SCADA system. Additional discussion on system-wide physical and cyber security recommendations can be found in Section 6.3.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

9.2.6 SCADA System Communication Improvement Implementation

SCADA systems require communications between the SCADA system and the remote PLCs. Two main categories of communication are currently in use today: hard-wired and wireless.

Hard-Wired Technologies

Hard-wired technologies include the following types of installations.

Private Communication Systems

A private communication system would require GWA to install wiring or fiber optic cable between each of the sites and connect them to the main administration building.

Because this approach is extremely expensive, it will not be considered as a system-wide option but may be used in the Tier 1 network when it presents a good investment. For example, GPA is expanding its fiber facilities to each of its substations and the GWA Tumon Office. GWA and GPA should coordinate fiber drops to GWA facilities along GPA planned fiber runs. For example, GPA will install underground fiber runs to the new generation plant adjacent to the Northern District WWTP. This run could accommodate the Northern District WWTP. GPA will explore three fiber run options to the new generation plant:

1. GPA Bulk Fuel Storage Farm (Piti) to new generation plant with the new ultra-low-sulfur diesel pipeline
2. Harmon Substation to the new generation plant with the new 115 KV transmission line project
3. Tie-in with the existing Harmon substation to Tanguisson underground fiber line.

Additionally, GWA and GPA should coordinate underground projects and share costs for construction of fiber conduits. For example, as part of the Baza Gardens Conveyance Project, GWA will be installing fiber conduit from the Baza Gardens WWTP north on Route 17 to the intersection with Route 5, then west to the intersection with Route 2A. GPA will install the fiber optic cable.

Public Communication Systems

GTA provides a hard-wired public communication system that serves the island. Traditionally, the copper telephone systems were somewhat unreliable and provided a low data connection speed. However, GTA has installed fiber optic rings on Guam which provides high-speed access for data transmission.

Current Wireless Technologies

Four main wireless technologies commonly used with current SCADA systems are:

- Licensed radio (800 MHz, UHF, and VHF)
- Unlicensed radio (Spread Spectrum)
- Cellular communications
- Satellite communications (not practical for Guam)

Although other wireless communication systems are available, such as microwave, they are too expensive, too specialized, or not widely used in today's SCADA applications.

All four technologies are currently used with SCADA systems. However, under a 2009 MOU, GPA has agreed to allow GWA to use the GPA island-wide ABB/Tropos wireless mesh network to connect remote sites to the GWA SCADA system. This is a form of unlicensed radio as described above.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The CCN was first deployed in 2013. It currently has 400 routers, which will be expanded once the GWA routers are installed. GPA is also expanding the ABB/Tropos network to support the Mobile Workforce Management (MWM) application currently under development. Mobile routers are installed in GWA and GPA vehicles to allow mobile access into the system.

The GPWA network as shown in Figure 9-1 consists of 3 tiers:

- Tier 1 is fiber optic.
- Tier 2 is the ABB/Tropos system providing up to 18 megabits per second (Mbps) of throughput with 4.5 Mbps being the average. A 1-GbE (transmitting Ethernet frames at a rate of a gigabit per second) fiber will be used to connect the gateways back to the main network.
- Tier 3 is the Landis and Gear system with collections using 900 megahertz (MHz).

The Tier 2 router batteries provide 6–8 hours of backup power. GWA will add a RTU to the designated sites to convert DNP3-SA protocol to Modbus for the site PLCs. It will also have a wireless access point to connect to the power pole mounted routers. The network traffic will be separated using virtual local area networks and will use AES-256 encryption. Bandwidth controls are implemented on an application level, although quality of service is currently not implemented because traffic is currently light. Some tuning of the system has been done to prevent certain routers from switching modulation schemes to make the system more stable. Typically, there are 20 routers to a gateway which follows ABB's recommendations. There is one licensed microwave link in the system, capable of 250 Mbps, which is in a backup mode to the fiber optic link serving the same locations.

The reasons for this include the following:

- Makes use of existing GPA infrastructure (does not require GWA to build infrastructure)
- Low initial cost of installation
- Low cost of ownership because GPA owns and operates the infrastructure
- High reliability
- Acceptable signal strengths
- Voice communication using network-based voice over IP (VoIP) technology

Use of contents on this sheet is subject to the limitations specified at the end of this document.

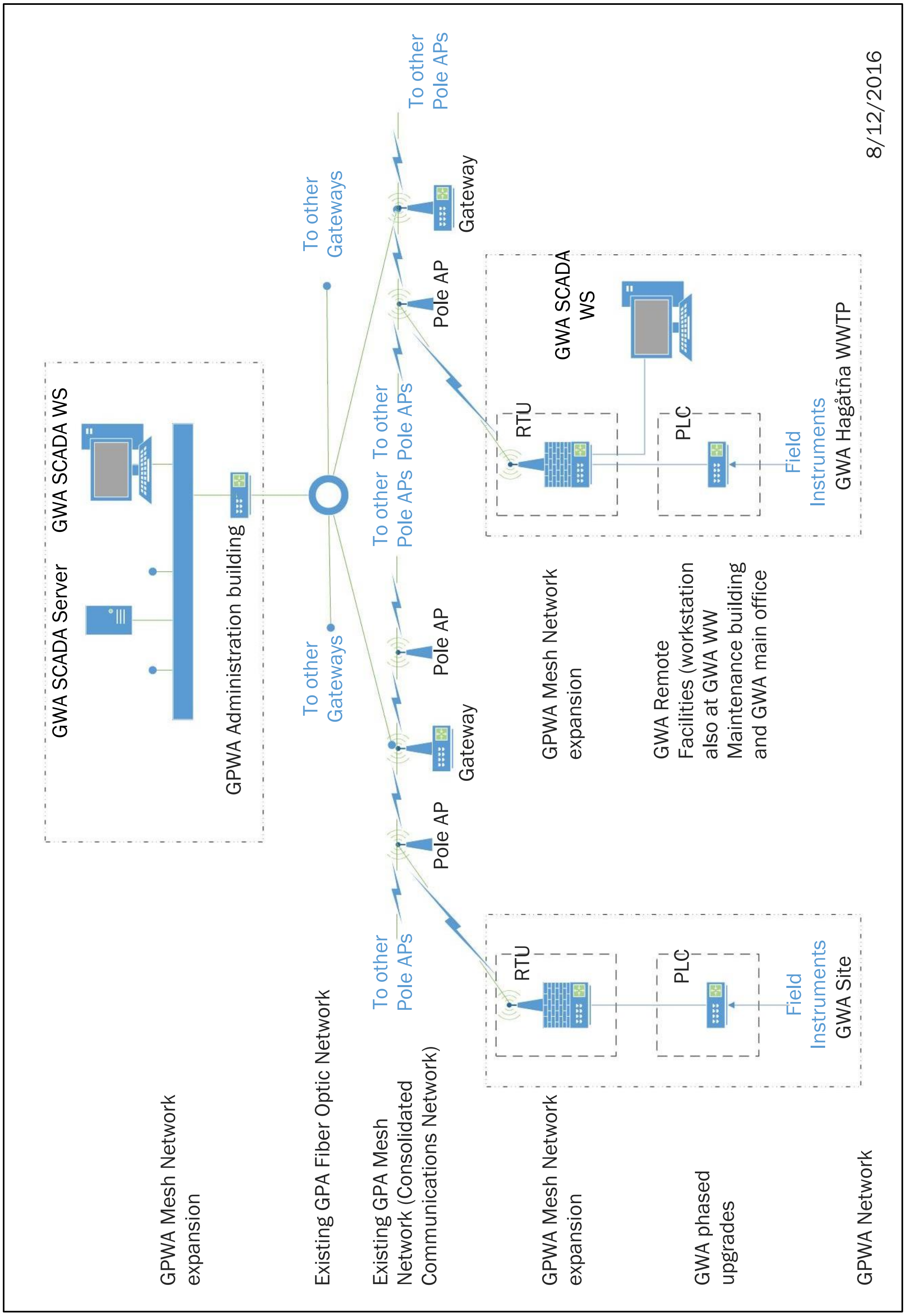


Figure 9-1. GPWA Network Diagram

Use of contents on this sheet is subject to the limitations specified at the end of this document.

9.2.7 SCADA System Improvement Implementation

One of the key functions of a SCADA system is alarm annunciation. If alarm conditions are detected early, maintenance or operation staff can be dispatched to make repairs and avoid more serious damage to equipment. A SCADA alarm system could also assist in avoiding wastewater spills and loss of potable water supply to consumers. There are many other benefits that result from the alarm function of a SCADA system.

SCADA Supervisory Function

A SCADA system supervisory function is designed to operate only in a supervisory capacity. That is, it is not designed for continuous process logic, which is a function of the PLC. The SCADA remote terminal unit (RTU) communicates continually as a submaster with the PLC processors and the process logic in the PLC should continue to operate normally in the event that the SCADA system computer ceases communication with the PLC. For example, the SCADA system would not contain logic that would continually coordinate booster pumps. This task would be the responsibility of the PLC (and possibly the SCADA RTU) independent of the SCADA function.

GWA and GPA are considering standardizing on the OSI Inc. OSIRIS RTU. This RTU supports open logic programming languages defined in the international IEC-61131-3 standard and support multiple masters. This consolidates the function of a master PLC at each site with separate communications.

Key Features of OSIRIS include:

- Full TCP/IP Stack with dual-standard Ethernet interfaces
- Linux® operating system
- Multiple concurrent sessions over one Ethernet port
- Integrated firewall
- Client/server protocol compliance
- DNP3 (slave/master) with secure authentication
- Modbus (slave/master)
- IEC 60870-05-104 (slave)
- IEC 60870-05-101 (slave/master)
- SES92
- Telegyr
- Cooper 2179
- SNMP protocols
- IED Integration/data Concentration
- IEC 61131-3 PLC programming capabilities
- Resident web-enabled configuration utility
- Integrated configuration validation tool
- Terminal-based diagnostics
- Time Synchronization via NTP, IRIG-B, or Protocol
- 1 millisecond sequence of event (SOE) data
- Compact size: 10 x 8.69 x 1.63 inches (25.5 x 22 x 4.2 cm)
- Utility grade, industrial temperature range of -40–80°C
- 16 digital inputs, 8 Form C digital outputs and 8 analog inputs
- Base unit I/O expandable up to 10x using OSIRIS XM Expansion Module

Use of contents on this sheet is subject to the limitations specified at the end of this document.

SCADA Data Acquisition Function

A SCADA system data acquisition function is designed to acquire data from the remote PLCs. The data is then electronically transferred into a real-time database, which is used to provide data to the following software applications:

- Graphical objects on the display screen
- Real-time trending
- Historical collection applications
- Real-time reporting applications
- Voice, e-mail, and telephone alarm annunciation (for example WIN-911 software)
- Other databases via ODBC (Open Data Base Connectivity) connections
- OPC (an open protocol used in process control) connections to other applications

SCADA Clients

A SCADA client is defined as a remote display terminal that allows the viewing and operation of the SCADA system screens. The location of and access to the SCADA clients will be based on the job responsibilities of the GWA employee. A SCADA client can be located on the existing GWA network, as part of a plant network, or as a wireless connection. The following is a list of future SCADA client locations:

- GPA/GWA Administration Building
- Hagåtña WWTP control room
- Ugum SWTP control room
- Northern District WWTP
- Agat-Santa Rita WWTP

There will be other SCADA terminals located remotely at Wastewater Central Maintenance Building (Hagåtña) and GWA Administration Building (Upper Tumon) for the four water and wastewater O&M managers.

Central Command Location

The SCC is located in the Gloria B. Nelson Public Service building with the GWA and GPA IT departments. The SCC will operate as a dispatch center, staffed with System and Trouble Dispatch personnel, and will normally monitor, track, alert, communicate, coordinate, verify, and document incidents, actions and other activities. In addition, the SCC will provide centralized command and coordination of resources to respond to and recover from a major crisis.

When the GPA/GWA SCADA EMS system design-build project is completed, the SCC will be equipped with four dispatcher terminals, one dispatcher training simulator terminal, and one auxiliary terminal (for a guest, operations personnel, engineering personnel, or other) and two 65-inch wall-mounted HDTVs in lieu of a costly multiscreen video wall.

The SCADA servers and network equipment will be located in the secured GPWA server room within the IT Division. The GWA IT Division is intended to be the SCADA System Administrator, managing the maintenance and operations of the SCADA system (central master system that will be running in a single platform with GPA), IT network, and island-wide communications infrastructure, and ensuring that the system is always available, working as designed, and protected against cyber and physical attacks.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

When the GPWA SCADA EMS system project is completed, the GWA IT Division will be equipped with three SCADA terminals (GWA IT Manager, GWA IT Supervisor, GWA IT Lab). The SCADA Servers in the GPWA Server room will include a rack mount monitor and keyboard drawer.

SCADA Maintenance and Development Location

The SCC will also serve a dual purpose as the SCADA maintenance location by the GWA staff. It will also be used by the SCADA installation contractors for software installation, testing, training, and final acceptance.

SCADA Security

The SCADA system serves as the monitoring and communication backbone for a utility and it must be secured from unauthorized access at all times. Joint cyber security policies will need to be developed between GWA and GPA. GPA uses the National Institute of Standards and Technology (NIST) guidelines as the foundation for its cybersecurity plan, and is considering adopting some NERC security requirements. GPA's cybersecurity plan was created with GWA IT. GWA shares some responsibilities under this plan. GWA and GPA may consider benefits from AWWA/Water Environment Federation and International Society of Automation/ International Electrotechnical Commission guidelines. Some NIST 800-82 guidelines include:

- Physically separating the water/wastewater control system from the electric utility control system.
- Designing the wireless system to be secure because it is exposed to outside threats.
- Creating a secure network architecture with demilitarized zones (DMZs) between enterprise and control system zones.
- Restricting direct data connections from outside the control network to protect it from thick client connections that bypass the DMZ.
- Physically locking or disabling USB ports on workstations to avoid malicious or unauthorized software installation.
- Installing a cyber network and physical intrusion detection system.

Security can be improved by implementing one or more of the following security features as deemed necessary to protect GWA operations:

- Hardware firewall with virus signature analysis
- Anti-virus protection
- Windows security
- Network encryption
- Virtual private network (VPN) wireless connections
- Dynamic internet protocol (IP) addressing
- Dynamic Welch codes (a data compression coding algorithm)
- Secure site connections (using AES encryption)
- Lock and key

Additional discussion on system-wide physical and cyber security can be found in Section 6.3.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

9.2.8 Information Management System Improvements

This section describes recommended improvements to GWA's information management system.

GWA Information Technology Division Requirements

It is recommended that the core hardware and software components of GWA's SCADA system reside in the IT Division at the GPA/GWA administration building. The term "core hardware and software" refers to a central location that serves as a central repository of SCADA information and has the ability to monitor all installations, generate alarms, provide trending information, collect historical data, generate administrative reports, and provide facility operational metrics. The core components communicate with other SCADA servers, such as those in the WTPs and WWTPs and monitor their operations. Finally, the core hardware and software will perform general system duties such as adjusting and monitoring the reservoir level set points and associated alarm points.

Data Highway

As detailed in the architecture provided in Volume 3 of the SCADA bid and subsequent amendments to it, the main wireless connection will tie into the SCADA system from the IT Division's switches. The data will arrive on the GPA wireless network as specified by GWA and GPA. All data should pass through a hardware firewall that supports virus signature scanning and provides front-line security protection to all computers behind the firewall. The data should then pass through a router to isolate SCADA traffic from GPA traffic and GWA administration traffic.

Hardware Location

SCADA servers will be blade servers in a separate chassis reserved for operations networks and virtualized. The chassis should be located in a temperature- and humidity-controlled room and be provided with uninterruptible power and a backup generator. The room should be physically secure, lockable and monitored with an access control system.

Thin SCADA Clients

The SCADA clients will be located on the existing GWA local area network and operate as single board thin client (limited processing computers that depend on a central server) computers that have terminal server sessions on the terminal server computer. The SCADA thin clients do not require any added software or maintenance because all software applications and licenses are loaded and maintained on the terminal server. This significantly reduces any maintenance requirements of client personal computers. Thin client single board computers do not have any moving parts and therefore have a significantly longer hardware life span. In addition, thin clients require very little IT personnel maintenance because all maintenance is performed in the server rack located in the IT Division.

Printers

SCADA printers will be on the SCADA network separated from the corporate network. Reports will be printed from the SCADA reporting software. Refer to the architecture provided in Volume 3 of the SCADA bid and subsequent amendments to it.

Information Technology Staff Responsibilities

GWA staff will be responsible for maintaining all the equipment located in the Operations Applications Blade Server Chassis. In addition, IT staff is responsible for backup of data and applications on a regular basis. This equipment will be separated from the corporate network.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

In addition, IT staff should be highly trained on all applications loaded on the SCADA servers, with the possible exception of PLC programming, as discussed in Section 9.2.3 (Operations and Maintenance Implementation). At least two people in the IT Division should be trained on the SCADA software and communication drivers.

9.3 Summary

GWA's existing SCADA system can be summarized as follows:

- A SCADA monitoring system, which was installed in the 1990s, was never functional.
- Water BPS automatic controls are currently operating only in a manual mode.
- Site visits revealed that many complex electrical instrumentation and controls systems were not operational.
- During field visits to facilities, it was evident that skills of O&M personnel must be improved or new staff added to operate and maintain control system.
- Effective information transfer would be enhanced by providing two-way communication between operations, maintenance, and administrative personnel.

9.4 Recommendations

Recommended improvements to GWA's SCADA system include the following:

- Install and activate an operational SCADA system as per the current plan under Phases A-1, A-II, B and C of GWA's 2014 SCADA Master Plan.
- Repair or replace control instrumentation as required at all sites and plants.
- Continuously train personnel, using both internal skilled personnel to provide IT, as well as external assistance from on-island educational resources and off-island experts.
- Standardize equipment and device manufacturers to the extent possible.
- Use standards-based (IEC 61131-3) PLC programming languages.
- Use simple designs.
- Standardize control panel wiring as much as possible.
- Implement the use of the GPA wireless network.
- Develop a highly-trained maintenance, IT, and automation workforce that will be able to skillfully respond to software maintenance and troubleshoot issues.
- Perform a complete site field assessment of all sites to reduce design risks.
- Repair/replace the air conditioning unit(s) at the Hagåtña WWTP with corrosion-resistant versions.
- Install intrusion detection at sites to respond to unauthorized intrusion and vandalism.
- Locate at least two SCADA clients at a secure site that would serve as a central command post during storms or other emergencies.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 10

Recommended Projects

This section describes recommendations as outlined in this Volume 1. These projects typically cover non-specific requirements for the overall organization that are necessary for the operations of GWA, but are not specific capital improvements to the water or wastewater systems.

10.1 General Projects Development

Potential improvement projects were developed for the overall system and costs were assigned to each project. Table 10-1 lists all proposed improvement projects with estimated planning costs. The planning costs are the total costs for each project over the 20-year planning period. For a breakdown of annual costs refer to Section 11. Each project was assigned a unique project number, grouped by the system component. Detailed descriptions of each proposed project are included on the following pages.

The proposed projects are subject to change and are based on information available at the time of this report. Projects will generally include an engineering study, field verification, detailed design, and construction services to refine exact project scope. Engineering staff will lead the design for new or rehabilitated facilities with assistance from operations staff. Other projects are necessary to maintain the operational condition of GWA's systems. Items such as software purchases, maintenance vehicle replacement, etc., will be enacted as software licenses expire or new improved systems become available and as specific vehicles need to be replaced.

Table 10-1. General System Improvements Projects with Estimated Costs

Report Project Number	Report Project Name	Total Cost [a]
MP-Gen-Misc-01	GWA Systems Planning	$14,000,000
MP-Gen-Misc-02A	WRMP Update (Comprehensive Update)	$5,200,000
MP-Gen-Misc-02B	WRMP Update (Interim Update)	$800,000
MP-Gen-Misc-03	Surveying and Property Delineation	$2,500,000
MP-Gen-Misc-04	Information Technology Improvements	$4,000,000
MP-Gen-Misc-05	GWA Infrastructure Improvements	$12,500,000
MP-Gen-Misc-06	GPWA Fleet Maintenance Facility	$500,000
MP-Gen-Misc-07	Mobile Equipment Replacement Program	$7,600,000
MP-Gen-Misc-08	General Plant Improvements	$10,000,000
MP-Gen-Misc-09	Security and Resilience Program	$2,700,000
MP-Gen-EE-01	SCADA Implementation Phase A2 – Initial Project Completion	$12,814,000
MP-Gen-EE-02	SCADA Implementation Phase B – Additional Sites	$11,416,000
MP-Gen-EE-03	SCADA Implementation Phase C – Additional Instruments	$8,326,000
MP-Gen-EE-04	SCADA System Improvement Program	$4,620,000

a. Costs are the total projected for the 20-year planning period in 2017 dollars

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Two general projects that were developed in the 2006 WRMP are currently ongoing, including the SCADA Implementation Phase A – Initial Project and General Plant Improvements Projects. When the SCADA Phase A project is complete, it will be followed by the planned Phase A2 project MP-Gen-EE-01. The General Plant Improvements project is continued in a new project as identified in project MP-Gen-Misc-08.

10.2 Project Rankings

The projects proposed for general system improvement projects were ranked based on the criteria developed the water and wastewater system workshops. The ranking system provides a non-financial method to prioritize implementation. The project rankings also provide a general sequence for which projects should generally be scheduled in the future financial program. Each project was ranked with a score from 1 (lowest importance) to 3 (highest importance) for each of nine categories used in the rankings. Section 2 describes the rankings in more detail. Based on the project ranking system and overall financial analysis, selected projects to pursue in the 20-year Master Plan time frame are included in Sections 11 and 12.

The rankings for the general system improvements are listed in Table 10-2. As illustrated in the first column of Table 10-2, raw ranking scores were converted into a score out of 100 with 100 representing the highest ranked project.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 10-2. General System Improvements Projects Ranking

Report Project Number	Report Project Name	Score out of 100	Health and Safety	Regulatory or Mandated	Reliability and Redundancy	Capacity	Operation, Maintenance, and Rehabilitation	Environmental Impact and Resource Use	Revenue and Expenditures	Customer Service and Stakeholder Confidence	Economic Development
MP-Gen-Misc-01	GWA Systems Planning	76	1	1	2	1.7	2	2	1	2	2.3
MP-Gen-Misc-02A	WRMP Update (Comprehensive Update)	84	1	1	2	2	2	2.3	2.7	2	1.3
MP-Gen-Misc-02B	WRMP Update (Interim Update)	91	1	1.7	2	2	2	2.3	2.7	2	1.3
MP-Gen-Misc-03	Surveying and Property Delineation	64	1	1	1.3	1	2.3	1.3	1.3	1.7	1
MP-Gen-Misc-04	Information Technology Improvements	73	1.3	1	1.7	1	2	1	1.7	2.7	1
MP-Gen-Misc-05	GWA Infrastructure Improvements	78	2.3	1	1.3	1	2	1	1.7	2	1
MP-Gen-Misc-06	GPWA Fleet Maintenance Facility	90	2.3	1	2.7	1	3	1.3	1.3	1.3	1
MP-Gen-Misc-07	Mobile Equipment Replacement Program	90	2	1	3	1	3	1.3	1.3	1.7	1
MP-Gen-Misc-08	General Plant Improvements	94	2	1	2.7	1.7	2.7	2	1	2.3	1
MP-Gen-Misc-09	Security and Resilience Program	100	3	2	2	1	2	1	1.3	2.3	1
MP-Gen-EE-01	SCADA Implementation Phase A2 – Initial Project Completion	72	1	1	2.3	1.3	2	1.7	1	1.7	1
MP-Gen-EE-02	SCADA Implementation Phase B – Additional Sites	72	1	1	2.3	1.3	2	1.7	1	1.7	1
MP-Gen-EE-03	SCADA Implementation Phase C – Additional Instruments	59	1	1	1.7	1	1.7	1	1	1	1
MP-Gen-EE-04	SCADA System Improvement Program	63	1	1	2	1	2	1	1	1	1

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

10.3 Recommended Project Sheets

This section contains a project sheet for the proposed improvement projects listed in Table 10-1.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA Systems Planning	
Project Number	MP-Gen-Misc-01
Description	This project includes miscellaneous long-term planning, system planning, and environmental planning to maintain GWA systems. System planning includes but is not limited to GIS mapping, asset inventory, asset management, asset management software, GIS software, GIS training, asset management training, and asset condition assessment. Hydraulic modeling includes the potable water bubble map, software, hardware, travel, and training. This project will also include a project for a water affordability study to review the impacts on Lifeline rate customers and a cost of service study to review the customer rate classes and evaluate the impacts of increasing rates on each class in the future.
Justification	Long-term planning, system planning, and environmental planning is essential for developing capital improvement programs. Potable water and wastewater system planning ensures that a systematic approach is used in project development, which outlines how specific projects fit into GWA's overall planning goals. This is a continuation of projects CIP PW 05-10 and WW 05-04.
Proposed Schedule	Annually
Cost Estimate	$1,000,000
Reference Documents	

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

WRMP Update	
Project Number	MP-Gen-Misc-02A, WRMP Update (Comprehensive Update) MP-Gen-Misc-02B, WRMP Update (Interim Update)
Description	This project updates the Water Resources Master Plan. The Master Plan will be periodically updated to reflect actual conditions at the time of the update. The Master Plan should undergo a high-level review of projects and schedules approximately every two years and a complete update every five years.
Justification	Due to changes in growth, water use, condition of facilities, etc., a master plan needs to be updated on a regular cycle. Many utilities use a five-year cycle for updating their master plans. The Guam Consolidated Commission on Utilities Resolution No. 11-FY 2007 Relative to Approving the Guam Waterworks Authority Master Plan also requires the Master Plan to be updated every two years.
Proposed Schedule	Every two and five years
Cost Estimate	$200,000: Two-year update $1,300,000: Five-year update
Reference Documents	Consolidated Commission on Utilities Resolution No. 11-FY 2007 Relative to Approving the Guam Waterworks Authority Master Plan

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Surveying and Property Delineation	
Project Number	MP-Gen-Misc-03
Description	This project provides surveying for land and easements for existing and new facilities, including property to be deeded to GWA to include the properties in GWA's assets. This project may also address property encroachments, utility locations, and easements assessment of the requirements to realign or reconfigure pipelines, property access, etc.
Justification	Property issues exist throughout GWA's system and property is required for the new pipelines and facilities needed to extend GWA's water and sewer systems. This project is also a continuation of previous CIP MC 05-02.
Proposed Schedule	Begin 2020 (every two years)
Cost Estimate	$200,000
Reference Documents	

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Information Technology Improvements	
Project Number	MP-Gen-Misc-04
Description	The technology improvement projects will improve GWA's ability to obtain real time information for customer requests, maintain important customer data history more effectively, and improve employee productivity through implementation of emerging technology. Typical efforts identified under this project include mobile workforce management solutions, imaging and document management solutions, desktop computer replacement program, voice over Internet Protocol (VOIP) solutions, network communication and security system improvements, enterprise information, etc.
Justification	Information technology integration improvement projects are required to help maintain GWA's level of service to customers and improve operations functionality. Current technology systems within GWA are becoming obsolete due to the ever-changing/improving computer system and programming platforms in the industry. Updates and improvements are necessary for GWA to meet and maintain expectations of the GWA mission. This project is a continuation of previous CIP MC 15-01.
Proposed Schedule	Annually
Cost Estimate	$200,000
Reference Documents	

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA Infrastructure Improvements	
Project Number	MP-Gen-Misc-05
Description	This project will provide new facilities or renovation of existing facilities within GWA's systems. The project is expected to initially fund the following projects, but may be used for any necessary infrastructure upgrades and other projects identified in the future. • Existing warehouse expansion and renovation • Facilities Maintenance and Environmental Services (FMES) building renovation • Harden Upper Tumon Facility for GPWA IT Network Disaster Recovery Center • Upper Tumon Facility Renovation The project provides funding on a recurring basis to fund future facilities or renovations as they are required.
Justification	Modern and renovated facilities will provide GWA employees suitable, safe, and efficient working environments to complete required activities for office, maintenance, and operations.
Proposed Schedule	Recurring project with initial effort planned for 2018
Cost Estimate	$500,000 for renovations, $2.5M for major facility
Reference Documents	

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GPWA Fleet Maintenance Facility	
Project Number	MP-Gen-Misc-06
Description	This project will provide new maintenance facilities for GWA vehicles and is GWA's portion of a proposed joint GPA/GWA Fleet Maintenance Building. GWA currently has three maintenance bays, with one outdoors, that are old and need to be replaced. The new facility will provide a minimum of three new maintenance bays for GWA's use to replace the old bays.
Justification	GWA vehicles need regular maintenance to maintain their operational status and prevent major breakdowns. The Fleet Maintenance Building will provide a suitable environment to properly and efficiently complete required maintenance. This project can also fund the purchase of maintenance equipment required for the facility.
Proposed Schedule	Estimate 2019
Cost Estimate	$500,000
Reference Documents	

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Mobile Equipment Replacement Program	
Project Number	MP-Gen-Misc-07
Description	Regularly replace specialty water and wastewater system mobile equipment as needed. Equipment is expected to include items such as: • Well maintenance vehicles • Vactor trucks • Cranes and lowboy trailers • CCTV trucks • Small-scale road repair equipment • Bypass pumps • Heavy equipment service truck • Sludge hauling vehicles This project covers mobile equipment not typically available on island or difficult to schedule by leasing when needed. Initially, it is expected that three jetting/Vactor trucks will be required within the first three years, then replacement of one major item every two years thereafter, and smaller items in the alternate years. The equipment to be replaced will be selected based on the current condition and demand for the equipment.
Justification	Specialty mobile equipment is required for GWA to properly complete certain maintenance and operations activities such as well and well pump maintenance, sewer jetting, and CCTV work and other similar activities. This equipment is not currently available for long-term rent or lease on the island and must be available for GWA's use.
Proposed Schedule	One major replacement every two years, minor replacements in alternate years
Cost Estimate	$400,000 per year
Reference Documents	WRMPU

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

General Plant Improvements	
Project Number	MP-Gen-Misc-08
Description	This project covers capital improvements that will provide GWA with general plant improvements to enhance O&M capabilities throughout the utility. The criteria for a project and/or general plant improvement to be considered a capital and eligible for bond funding is that the value is greater than $5,000 and has a life span greater than 1 year. This project is general in nature to support O&M programs that meet the funding criteria noted above. Work items to support O&M include replacing failing pipelines and pumps and refurbishing PRVs to improve water system pressure zones. Work related to failing pipes includes but is not limited to repairing and replacing valves, vaults, and pipeline segments, and locating and fixing pipes that pass under buildings. Work related to pumps includes but is not limited to purchasing equipment such as pump rigs to remove, repair, and replace pumps. Some pumping and other equipment will also need to be replaced outside of the scheduled rehabilitation projects.
Justification	Capital improvement projects are required to help maintain GWA's level of service to its customers, and the work described above will enhance O&M capabilities. For example, the water and wastewater system consists of hundreds of miles of infrastructure, including facilities that are failing due to improper construction, earthquake damage, and/or material failures. This project is a continuation of Project CIP MC 09-01.
Proposed Schedule	Annual
Cost Estimate	$500,000
Reference Documents	

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

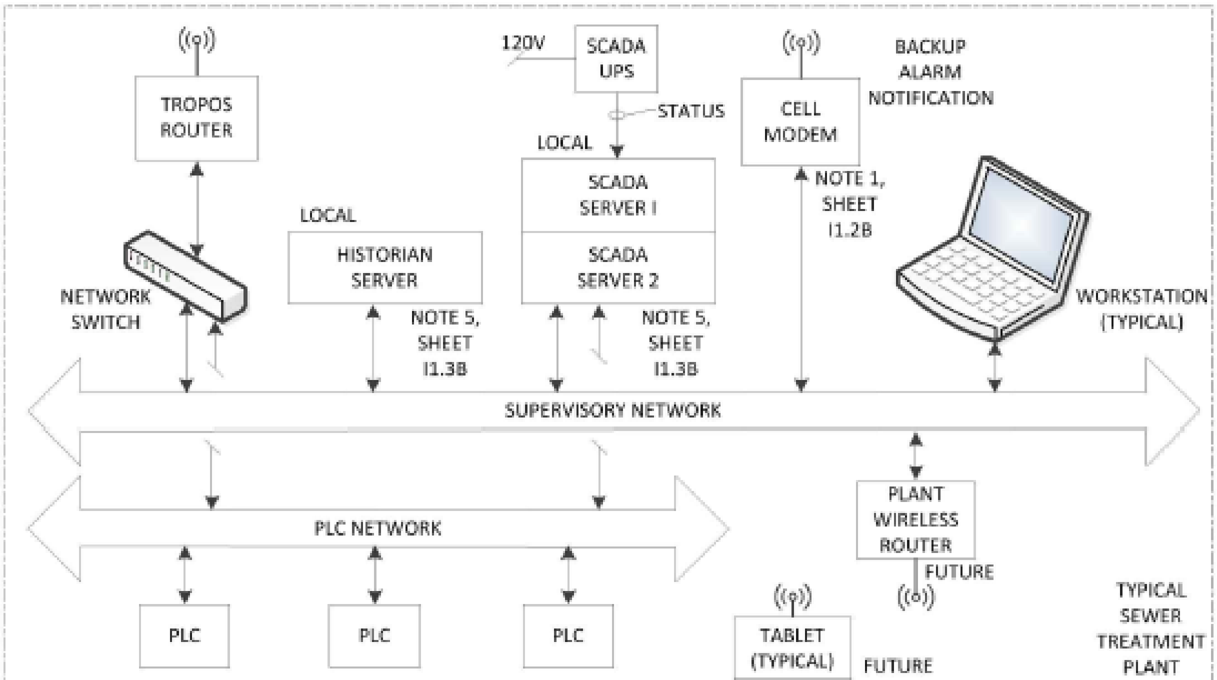
Use of contents on this sheet is subject to the limitations specified at the end of this document.

Security and Resilience Program		
Project Number	MP-Gen-Misc-09	
Description	This project will develop a GWA Physical and Cyber Security Plan; develop SOPs to ensure security measures implemented are inspected, maintained, and replaced as needed; update the Vulnerability Assessment and ERP every five years as regulated; and complete physical cyber security assessments and upgrades.	
Justification	Threats to water and wastewater systems have traditionally included natural disasters, recurring extreme weather events such as flooding and lighting, accidental (human-caused) events and purposeful disturbance and destruction (sabotage, vandalism, and terrorism). In addition, infrastructure that has long been subject to risks associated with physical threats and natural disasters is now increasingly exposed to cyber risks, which stems from growing integration of information and communications technologies with critical infrastructure operations and an adversary focus on exploiting potential cyber vulnerabilities. Planning for and implementing security measures to identify and address threats is necessary to ensure ongoing water and wastewater service in the face of natural and man-made risks.	
Proposed Schedule	2018–2037	
Cost Estimate	$2,400,000	$200,000 Physical and Cyber Security Strategy Plan $1,200,000 Vulnerability Assessment and ERP Update ($300,000 every 5 years: 2018, 2023, 2028, 2035) $500,000 physical security upgrades ($50,000/year for 10 years) $500,000 cyber security upgrades ($50,000/year for 10 years)
Reference Documents	WRMPU Volume 1, Section 6.3	

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

SCADA Implementation Phase A2 – Initial Project Completion	
Project Number	MP-Gen-EE-01
Description	This project will complete the initial SCADA implementation plan including approximately 30 additional sites.
Justification	This project will continue to improve and enhance the coverage and reliability of electrical and SCADA systems within GWA. This project is the completion of Phase A of the SCADA Master Plan.
Proposed Schedule	2018–2020
Cost Estimate	$12,400,000
Reference Documents	SCADA Master Plan



This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

SCADA Implementation Phase B – Additional Sites	
Project Number	MP-Gen-EE-02
Description	This project covers Phase B of the SCADA implementation from the SCADA Master Plan. Phase B will add approximately 134 additional sites into the SCADA system.
Justification	This project will continue to improve and enhance the coverage and reliability of electrical and SCADA systems within GWA. This project is Phase B of the SCADA System Master Plan.
Proposed Schedule	2020–2022
Cost Estimate	$11,414,000
Reference Documents	SCADA Master Plan

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

SCADA Implementation Phase C – Additional Instruments	
Project Number	MP-Gen-EE-03
Description	This project covers Phase C of SCADA implementation from the SCADA Master Plan. Phase C will add additional instruments at the existing sites for enhanced coverage of the system operations.
Justification	This project will continue to improve and enhance the coverage and reliability of electrical and SCADA systems within GWA. This project is Phase C of the SCADA System Master Plan.
Proposed Schedule	2021–2023
Cost Estimate	$8,324,000
Reference Documents	SCADA Master Plan

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

SCADA System Improvement Program	
Project Number	MP-Gen-EE-04
Description	SCADA/electrical systems require routine upgrades to maintain technology, security, programming licenses, etc. Typically, electrical and SCADA upgrades will be completed with other routine upgrades and renovation projects for the respective facility. This project is intended to pick up any electrical or SCADA specific upgrades, modifications, or replacements that must be completed independently of other facility work.
Justification	This project will continue to improve and enhance the coverage and reliability of electrical and SCADA systems within GWA. This project is a follow-up to the SCADA Master Plan.
Proposed Schedule	Estimated to begin in 2024
Cost Estimate	$300,000
Reference Documents	

This proposed project is subject to change. Projects will generally include an engineering study, detailed design, and field verification to refine the exact project scope and budget. Costs are presented in 2017 dollars and do not account for increases due to inflation and escalation. See Volume 1, Appendix D for cost estimate assumptions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 11

Overall Capital Improvements Summary

Capital improvement projects are necessary for any utility to maintain systems in operational condition as the infrastructure ages and as expansion is required to service developing areas. Improvements can also be driven by a utility's desire and customer expectations for improved or additional services and to comply with current and prospective regulatory requirements.

Potential capital improvement projects were developed for GWA's general organizational requirements in WRMPU Volume 1, for the water system in Volume 2, and for the wastewater system in Volume 3. General projects include planned upgrades and expansions to GWA facilities such as:

- new fleet maintenance facility
- warehouse improvements
- purchase of unique vehicles required for GWA operations
- upgrades to computer systems and related software for systems such as hydraulic modeling software and asset management systems

Water system projects include:

- new pipelines
- replacement of small diameter and asbestos cement pipelines
- new water storage tanks
- refurbishments to the Ugum SWTP
- construction of new and refurbishment of existing wells

Wastewater projects include:

- new collection system pipelines
- refurbishment of existing sewer and force main pipelines
- lift station improvements
- WWTP refurbishments and upgrades

Each of the proposed projects was evaluated and ranked to assist GWA with prioritization over the 20-year planning period. The ranking is a non-economic evaluation that considers several operational parameters as described in Section 1. Cost estimates were developed for each potential project so that the economic requirements of the projects can also be considered for future CIP planning. A baseline 20-year CIP program was then developed considering the following factors:

- Project non-economic prioritization
- Estimated project costs and funding requirements
- Projected timing of the project with respect to capacity and development requirements

Each of these factors must be considered in developing the final implementation program to achieve the correct balance between project needs, available funding and system requirements. It is not practical to plan for projects if the necessary funding cannot be obtained or if it places an undue

Use of contents on this sheet is subject to the limitations specified at the end of this document.

burden on GWA's financial or staffing resources, particularly within the engineering department where many of these projects will originate. There are other recommendations described in this WRMP update that are not specific to CIP. These recommendations are described within each volume of the WRMPU.

11.1 Non-Economic Project Prioritization

This section presents a summary of the prioritization of recommended projects in this WRMPU. It is important to note that the scores provided for each project serve only to prioritize projects with respect to others in the same category (General System, Water System and Wastewater System). This method of scoring does not allow for a relative comparison between projects proposed in each volume of the WRMPU.

Table 11-1 presents a summary of the recommended projects and the non-economic project prioritization for the General System Improvements arranged from highest priority to lowest. Project Sheets for each of these recommended projects are included in Section 10.

Table 11-1. General System Improvements Project Prioritization (Non-Economic)

Report Project Number	Report Project Name	Score out of 100
MP-Gen-Misc-09	Security and Resilience Program	100
MP-Gen-Misc-08	General Plant Improvements	94
MP-Gen-Misc-06	GPWA Fleet Maintenance Facility	90
MP-Gen-Misc-07	Mobile Equipment Replacement Program	90
MP-Gen-Misc-02B	WRMP Update (Interim Update)	87
MP-Gen-EE-01	SCADA Implementation Phase A2 – Initial Project Completion	80
MP-Gen-Misc-02A	WRMP Update (Comprehensive Update)	79
MP-Gen-Misc-05	GWA Infrastructure Improvements	78
MP-Gen-Misc-01	GWA Systems Planning	76
MP-Gen-Misc-03	Surveying and Property Delineation	73
MP-Gen-Misc-04	Information Technology Improvements	73
MP-Gen-EE-02	SCADA Implementation Phase B – Additional Sites	72
MP-Gen-EE-04	SCADA System Improvement Program	63
MP-Gen-EE-03	SCADA Implementation Phase C – Additional Instruments	59

The Security and Resilience Program, which is a continuation of work currently in progress by GWA, was identified as the top priority, followed by General Plant Improvements and projects associated with GWA maintenance vehicles and equipment. The majority of the remaining General System Improvements projects are recurring projects that require sustained funding to maintain the operational effectiveness of GWA.

Table 11-2 presents a summary of the recommended projects and the non-economic project ranking for the Water System Improvements from highest priority to lowest.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-2. Water System Improvement Project Prioritization (Non-Economic)		
Report Project Number	Report Project Name	Score out of 100
MP-PW-Pipe-12	Rehabilitation and Replacement Program	100
MP-PW-Pipe-13	2-Inch Pipe Replacement Program	100
MP-PW-Tank-22	Existing Tank Assessment Inspections	100
MP-PW-Tank-23	Recurring Tank Inspections	100
MP-PW-Pipe-15	PRV Rehab and Replacement	99
MP-PW-Well-01	Well Rehabilitation Program	94
MP-PW-SWTP-02	Ugum SWTP Intake Modifications	93
MP-PW-SWTP-01	Ugum SWTP River Intake Cleaning Project	92
MP-PW-SWTP-03	Ugum SWTP Reliability Improvements	91
MP-PW-SWTP-04	Ugum SWTP 7-Year Improvement Project	90
MP-PW-Pipe-14	Asbestos Cement Pipe Replacement Program	88
MP-PW-Well-02	Well Equipment Overhaul Program	87
MP-PW-Pipe-16	Valve Exercise, Repair, and Replacement Program	85
MP-PW-Well-06	Well Repair Program	85
MP-PW-BPS-01	Rehabilitate and Replace BPSs	84
MP-PW-Well-03	Capacity Enhancement – Well Exploration Program	84
MP-PW-Well-04	Capacity Enhancement – Well Development and Construction Program	84
MP-PW-Tank-02A	Airport Tanks A	83
MP-PW-Tank-01	Agat-Umatac Tank	81
MP-PW-Tank-09B	Manenggon Hills Tanks B	79
MP-PW-Tank-10A	Nimitz Hill Tanks A	79
MP-PW-Tank-10B	Nimitz Hill Tanks B	79
MP-PW-Tank-17	Sinifa Tank	79
MP-PW-Tank-19	Umatac Subdivision Tank	79
MP-PW-Tank-18B	Ugum Tanks B	78
MP-PW-Misc-01	South Guam Water Supply Study	78
MP-PW-Tank-13	Piti Tank	77
MP-PW-Tank-21	Yigo Tanks	77
MP-PW-Misc-03	Hydrant Condition Assessment and Maintenance	77
MP-PW-Tank-03A	Astumbo Tanks A	76
MP-PW-Tank-07A	Kaiser Tanks A	76
MP-PW-Tank-08	Malojloj Tank	76
MP-PW-Tank-09A	Manenggon Hills Tanks A	76
MP-PW-Tank-12	Pigua Tank	76
MP-PW-Tank-14	Santa Ana Lower Tank	76
MP-PW-Tank-15	Santa Rita Tank	76

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-2. Water System Improvement Project Prioritization (Non-Economic)		
Report Project Number	Report Project Name	Score out of 100
MP-PW-Tank-18A	Ugum Tanks A	76
MP-PW-Tank-20	Windward Hills Tank	76
MP-PW-Pipe-17	Cross Island Highway Piping	74
MP-PW-Well-05	Wellhead Protection Program	73
MP-PW-Misc-05	Leak Detection Assistance	73
MP-PW-Pipe-01	Astumbo Zone Piping	69
MP-PW-Pipe-02	Route 1 Astumbo Zone Piping	69
MP-PW-Pipe-03	Harmon Cliffline Piping to Route 1	69
MP-PW-Pipe-04	Hyundai Well Piping	69
MP-PW-Pipe-05	Kaiser Zone Looping	67
MP-PW-Pipe-06	Mangilao Pressure Zone Realignment	67
MP-PW-Pipe-07	Mataguac BPS Suction Piping	67
MP-PW-Pipe-08	Nimitz Lower BPS Piping	67
MP-PW-Pipe-09	Yigo, Santa Rosa Zone Realignment	67
MP-PW-Pipe-10	Miscellaneous Piping Projects	67
MP-PW-Pipe-11	Miscellaneous Piping Connections	67
MP-PW-Tank-11B	Tumon (Nissan) Tanks B	64
MP-PW-Tank-03B	Astumbo Tanks B	62
MP-PW-Misc-02	Master Meter Implementation and Ongoing Meter Replacement	62
MP-PW-Tank-07B	Kaiser Tanks B	61
MP-PW-Tank-16B	Santa Rosa Tanks B	61
MP-PW-Tank-02B	Airport Tanks B	60
MP-PW-Tank-04	Barrigada Tank	59
MP-PW-Misc-04	OneGuam Program	57
MP-PW-BPS-03	Route 15 BPS	54
MP-PW-BPS-02	Nimitz Hill Upper BPS	51

The highest priority projects within the water system were also recurring projects that will be completed annually or at regular intervals throughout the planning period. These projects include pipe rehabilitation and replacement, tank inspections and well rehabilitation. The following projects cover production improvements for the Ugum SWTP. These projects are necessary to improve the reliability and effectiveness of the water production systems.

Table 11-3 presents a summary of the recommended projects and the non-economic project prioritization with respect to the category of Wastewater System Improvements from highest priority to lowest.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-3. Wastewater System Improvement Project Prioritization (Non-Economic)		
Report Project Number	Report Project Name	Score out of 100
MP-WW-FM-04	Hagåtña WWTP Force Main Rehabilitation/Replacement	100
MP-WW-Pump-01	Lift Station Rehabilitation/Replacement Program	93
MP-WW-Pump-02	Tumon Basin - Fujita Lift Station Analysis	93
MP-WW-Pipe-03	Route 1 Piti Pipe Rehabilitation/Replacement	92
MP-WW-Pipe-04	Southern Link Pump Station Pipe Rehabilitation/Replacement	91
MP-WW-Pipe-05	Gravity Pipe Rehabilitation/Replacement Program	90
MP-WW-Pipe-01	Route 1 Asan Force Main Rehabilitation/Replacement	89
MP-WW-FM-03	Septic/Cesspool System Reduction Program	87
MP-WW-Pipe-27	Force Main Rehabilitation/Replacement Program	87
MP-WW-FM-01	Agana Heights Pipe Replacement	86
MP-WW-Misc-02	I/I and SSES Assessments	86
MP-WW-Pipe-02	Barrigada Pump Station Pipe Rehabilitation/Replacement	85
MP-WW-Pipe-17	Mamajanao Capacity Replacement	85
MP-WW-Pipe-25	Piping Near Bayside Lift Station	85
MP-WW-Misc-04	Fats, Oils, and Grease Study	85
MP-WW-Pipe-24	Umatac-Merizo Capacity Replacement	83
MP-WW-Pipe-26	Finile Drive Rehabilitation - Agat	82
MP-WW-Misc-03	Miscellaneous Wastewater Improvements	82
MP-WW-Pump-03	Replacement of Former Navy Pump Station (Donut Hole)	80
MP-WW-WWTP-01	Hagåtña WWTP Primary Treatment Repair/Rehabilitation Program	77
MP-WW-Pipe-06	Northern District Route 1 Capacity Replacement - Phase 1	76
MP-WW-Pipe-11	Route 16 Capacity Replacement	76
MP-WW-Pipe-12	Barrigada Capacity Replacement	76
MP-WW-MH-01	Manhole Rehabilitation Program	76
MP-WW-WWTP-02	Hagåtña WWTP Secondary Treatment Upgrade	76
MP-WW-WWTP-04	Pago Socio WWTP Pump Station Conversion	76
MP-WW-Pipe-21	Baza Gardens Capacity Replacement - Phase 1	75
MP-WW-WWTP-03	Inarajan WWTP Repair/Rehabilitation Program	75
MP-WW-WWTP-06	Agat-Santa Rita WWTP Repair/Rehabilitation Program	74
MP-WW-Misc-01A	Update Wastewater Collection System Model (Major Update)	74
MP-WW-Pipe-20	Agat-Santa Rita Capacity Replacement - Phase 3	73
MP-WW-FM-02	Replace Yigo Lift Station Force Main	73
MP-WW-Pipe-08	Northern District Route 1 Capacity Replacement - Phase 3	72
MP-WW-Pipe-14	Dededo Capacity Replacement	72
MP-WW-Pipe-16	Yigo Capacity Replacement	72
MP-WW-Pipe-18	Agat-Santa Rita Capacity Replacement - Phase 1	72

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-3. Wastewater System Improvement Project Prioritization (Non-Economic)		
Report Project Number	Report Project Name	Score out of 100
MP-WW-Pipe-19	Agat-Santa Rita Capacity Replacement - Phase 2	72
MP-WW-Pipe-22	Baza Gardens Capacity Replacement - Phase 2	72
MP-WW-Misc-01B	Update Wastewater Collection System Model (Continued)	72
MP-WW-Pipe-07	Northern District Route 1 Capacity Replacement - Phase 2	71
MP-WW-Pipe-09	North Dededo Capacity Replacement - Phase 1	71
MP-WW-Pipe-10	North Dededo Capacity Replacement - Phase 2	71
MP-WW-Pipe-23	Baza Gardens Capacity Replacement - Phase 3	71
MP-WW-WWTP-05	Umatac-Merizo WWTP Repair/Rehabilitation Program	71
MP-WW-WWTP-07	Baza Gardens Cross Island Pipeline - Preliminary Treatment Equipment Repair and Rehabilitation Program	70
MP-WW-Pipe-13	Mangilao Capacity Replacement	69
MP-WW-WWTP-08	Northern District WWTP Completion	66
MP-WW-WWTP-09	Ocean Outfall Inspection Program	56

The highest priority projects in the Wastewater System primarily address critical pump stations, force main replacements and gravity sewer rehabilitation and replacement. These include the Hagåtña WWTP influent force main and recurring lift station improvements project. These are areas with known issues that should be addressed in the near future.

11.2 GWA Capital Improvement Plan

Based on the non-economic project prioritization, project timing as determined by the population projections and hydraulic modeling, and project cost estimates, a base CIP plan was developed for the 20-year planning period.

Table 11-4 shows the baseline program for future GWA planning for the overall system requirements, Table 11-5 indicates the same information for the water system and Table 11-6 for the wastewater system. The tables show the project number, title, total 20-year project cost and the projected time for completion. The costs presented in the tables are in 2017 dollars.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-4. GWA Capital Improvement Plan – Overall System Requirements

Project Number	Project Name	Cost ($ in thousands)																				
		Total	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
MP-Gen-Misc-01	GWA Systems Planning	14,000	-	500	1000	500	1,000	500	1000	500	1,000	500	1,000	500	1,000	500	1,000	500	1,000	500	1,000	500
MP-Gen-Misc-02A	WRMP Update (Comprehensive Update)	5,200	-	-	-	-	1,300	-	-	-	-	1,300	-	-	-	-	1,300	-	-	-	-	1,300
MP-Gen-Misc-02B	WRMP Update (Interim Update)	800	-	-	200	-	-	-	-	200	-	-	-	-	200	-	-	-	-	200	-	-
MP-Gen-Misc-03	Surveying and Property Delineation	2,500	-	250	-	250	-	250	-	250	-	250	-	250	-	250	-	250	-	250	-	250
MP-Gen-Misc-04	Information Technology Improvements	4,000	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
MP-Gen-Misc-05	GWA Infrastructure Improvements	12,500	-	500	-	3,000	-	500	-	500	-	3,000	-	500	-	500	-	3,000	-	500	-	500
MP-Gen-Misc-06	GPWA Fleet Maintenance Facility	500	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-Gen-Misc-07	Mobile Equipment Replacement Program	7,600	-	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
MP-Gen-Misc-08	General Plant Improvements	10,000	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
MP-Gen-Misc-09	Security and Resilience Program	2,700	-	100	100	100	300	100	100	100	100	300	100	100	100	100	300	100	100	100	100	300
MP-Gen-EE-01	SCADA Implementation Phase A2 – Initial Project Completion	12,814	414	1,000	1,000	2,600	2,600	2,600	2,600	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-Gen-EE-02	SCADA Implementation Phase B – Additional Sites	11416	-	-	-	-	-	600	600	2,554	2,554	2,554	2,554	-	-	-	-	-	-	-	-	-
MP-Gen-EE-03	SCADA Implementation Phase C – Additional Instruments	8,326	-	-	-	-	-	-	-	-	-	415	415	1,874	1,874	1,874	1,874	-	-	-	-	-
MP-Gen-EE-04	SCADA System Improvement Program	4,620	-	-	-	-	-	-	330	330	330	330	330	330	330	330	330	330	330	330	330	330
	SCADA/Miscellaneous Totals	**96,976**	**1,114**	**3,950**	**3,400**	**7,550**	**6,300**	**5,650**	**5,730**	**5,534**	**5,084**	**9,749**	**5,499**	**4,654**	**4,604**	**4,654**	**5,904**	**5,280**	**2,530**	**2,980**	**2,530**	**4,280**

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-5. GWA Capital Improvement Plan – Water System

Project Number	Project Name	Cost ($ in thousands)																				
		Total	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
MP-PW-Pipe-01	Astumbo Zone Piping	4,850	-	-	-	-	368	4,482	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-02	Route 1 Astumbo Zone Piping	7,193	-	-	-	-	-	545	3,324	3,324	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-03	Harmon Cliffline Piping to Route 1	424	-	-	-	-	-	424	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-04	Hyundai Well Piping	547	-	-	547	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-05	Kaiser Zone Looping	306	-	-	306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-06	Mangilao Pressure Zone Realignment	344	-	-	344	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-07	Mataguac BPS Suction Piping	733	-	-	-	733	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-08	Nimitz Lower BPS Piping	1,590	-	-	-	-	-	121	1,469	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-09	Yigo, Santa Rosa Zone Realignment	2,342	-	-	-	-	178	2,164	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-10	Miscellaneous Piping Projects	2,082	-	-	694	694	694	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-11	Miscellaneous Piping Connections	582	-	-	194	194	194	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-12	Rehabilitation and Replacement Program	75,585	-	5,000	-	4,140	3,093	-	1,676	1,676	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
MP-PW-Pipe-13	2-Inch Pipe Replacement Program	33,250	-	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750	1,750
MP-PW-Pipe-14	Asbestos Cement Pipe Replacement Program	61,600	-	-	-	-	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850
MP-PW-Pipe-15	PRV Rehab and Replacement	8,808	-	1,468	1,468	1,468	1,468	1,468	1,468	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Pipe-16	Valve Exercise, Repair, and Replacement Program	2,500	250	-	250	-	250	-	250	-	250	-	250	-	250	-	250	-	250	-	250	-
MP-PW-Pipe-17	Cross Island Highway Piping	1,666	-	-	-	127	1,539	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-01	Agat-Umatac Tank	330	330	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-02A	Airport Tanks A	11,900	-	-	5,950	5,950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-02B	Airport Tanks B	12,876	-	-	-	-	-	-	-	-	-	-	-	976	5,950	5,950	-	-	-	-	-	-
MP-PW-Tank-03A	Astumbo Tanks A	1,584	1,584	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-03B	Astumbo Tanks B	9,612	-	-	-	-	-	-	-	-	-	-	-	728	4,442	4,442	-	-	-	-	-	-
MP-PW-Tank-04	Barrigada Tank	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-07A	Kaiser Tanks A	1,716	-	1,716	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-07B	Kaiser Tanks B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-08	Malojloj Tank	990	990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-09A	Manenggon Hills Tanks A	1,716	-	1,716	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-09B	Manenggon Hills Tanks B	9,612	728	4,442	4,442	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-10A	Nimitz Hill Tanks A	479	-	37	221	221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-10B	Nimitz Hill Tanks B	479	-	37	221	221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-11B	Tumon (Nissan) Tanks B	9,612	-	-	-	-	-	-	-	-	-	-	-	728	4,442	4,442	-	-	-	-	-	-
MP-PW-Tank-12	Pigua Tank	990	-	990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-13	Piti Tank	8,870	-	672	4,099	4,099	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-14	Santa Ana Lower Tank	990	-	990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-15	Santa Rita Tank	8,198	4,099	4,099	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-16B	Santa Rosa Tanks B	8,870	-	-	-	-	-	-	-	-	-	-	-	672	4,099	4,099	-	-	-	-	-	-
MP-PW-Tank-17	Sinifa Tank	8,198	4,099	4,099	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-18A	Ugum Tanks A	1,716	-	-	1,716	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-18B	Ugum Tanks B	9,612	-	728	4,442	4,442	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-19	Umatac Subdivision Tank	594	-	594	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-20	Windward Hills Tank	990	990	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-21	Yigo Tanks	1,716	1,716	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-22	Existing Tank Assessment Inspections	428	214	214	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Tank-23	Recurring Tank Inspections	3,852	-	-	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-5. GWA Capital Improvement Plan – Water System																						
Project Number	Project Name	Cost ($ in thousands)																				
		Total	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
MP-PW-BPS-01	Rehabilitate and Replace BPSs	2,968	-	209	209	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
MP-PW-BPS-02	Nimitz Hill Upper BPS	48	-	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-BPS-03	Route 15 BPS	1,136	-	-	-	-	-	-	86	1,050	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-SWTP-01	Ugum SWTP River Intake Cleaning Project	380	-	380	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-SWTP-02	Ugum SWTP Intake Modifications	2,297	174	2,123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-SWTP-03	Ugum SWTP Reliability Improvements	1,980	-	150	1,830	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-SWTP-04	Ugum SWTP 7-Year Improvement Project	6,336	-	-	-	-	-	-	3,168	-	-	-	-	-	-	3,168	-	-	-	-	-	-
MP-PW-Well-01	Well Rehabilitation Program	52,272	-	-	440	5,368	440	5,368	440	5,368	440	5,368	440	5,368	440	5,368	440	5,368	440	5,368	440	5,368
MP-PW-Well-02	Well Equipment Overhaul Program	12,144	-	-	-	-	1,518	-	1,518	-	1,518	-	1,518	-	1,518	-	1,518	-	1,518	-	1,518	-
MP-PW-Well-03	Capacity Enhancement – Well Exploration Program	4,752	-	1,188	-	-	-	-	1,188	-	-	-	-	1,188	-	-	-	-	1,188	-	-	-
MP-PW-Well-04	Capacity Enhancement – Well Development and Construction Program	26,005	-	1,000	-	-	379	4,622	-	379	4,622	-	379	4,622	-	379	4,622	-	379	4,622	-	-
MP-PW-Well-05	Wellhead Protection Program	3,960	-	-	660	-	-	660	-	-	660	-	-	660	-	-	660	-	-	660	-	-
MP-PW-Well-06	Well Repair Program	13,090	350	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	-	-	-	-	-	-	-	-	-
MP-PW-Misc-01	South Guam Water Supply Study	450	450	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Misc-02	Master Meter Implementation and Ongoing Meter Replacement	4,404	-	734	734	734	734	734	734	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-PW-Misc-03	Hydrant Condition Assessment and Maintenance	7,505	-	-	-	-	970	970	970	970	970	531	531	531	531	531	-	-	-	-	-	-
MP-PW-Misc-04	OneGuam Program	550	50	50	50	50	50	50	50	50	50	50	50	-	-	-	-	-	-	-	-	-
MP-PW-Misc-05	Leak Detection Assistance	1,540	-	-	385	-	-	-	-	385	-	-	-	-	385	-	-	-	-	385	-	-
	Water System Totals	**462,149**	**16,024**	**35,708**	**32,440**	**31,829**	**19,113**	**28,846**	**23,579**	**20,440**	**20,748**	**18,187**	**15,406**	**26,437**	**33,021**	**39,343**	**18,454**	**16,332**	**14,739**	**21,999**	**13,172**	**16,332**

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-6. GWA Capital Improvement Plan – Wastewater System

Project Number	Project Name	Cost ($ in thousands)																				
		Total	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
MP-WW-Pipe-01	Gravity Pipe Rehabilitation/Replacement Program	25,962	-	-	173	4,516	5,346	177	6,186	-	33	203	978	-	3,027	1,913	1,913	1,497	-	-	-	-
MP-WW-Pipe-02	Barrigada Pump Station Pipe Rehabilitation/Replacement	5,425	-	-	-	-	411	5,014	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-03	Route 1 Piti Pipe Rehabilitation/Replacement	4,478	-	340	4,138	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-04	Southern Link Pump Station Pipe Rehabilitation/Replacement	711	54	657	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-05	Agana Heights Pipe Replacement	3,228	-	-	-	-	169	3,059	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-06	Northern District Route 1 Capacity Replacement - Phase 1	15,431	-	-	-	-	-	-	1,169	4,754	4,754	4,754	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-07	Northern District Route 1 Capacity Replacement - Phase 2	14,579	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,105	6,737	6,737	-
MP-WW-Pipe-08	Northern District Route 1 Capacity Replacement - Phase 3	11,128	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	843	10,285
MP-WW-Pipe-09	North Dededo Capacity Replacement - Phase 1	9,803	-	-	-	-	-	-	-	-	-	-	743	4,530	4,530	-	-	-	-	-	-	-
MP-WW-Pipe-10	North Dededo Capacity Replacement - Phase 2	12,443	-	-	-	-	-	-	-	-	-	-	-	-	943	5,750	5,750	-	-	-	-	-
MP-WW-Pipe-11	Route 16 Capacity Replacement	7,539	-	-	-	-	-	-	571	3,484	3,484	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-12	Barrigada Capacity Replacement	609	-	-	-	-	-	-	47	562	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-13	Mangilao Capacity Replacement	2,142	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	163	1,979	-
MP-WW-Pipe-14	Dededo Capacity Replacement	3,313	-	-	-	-	-	-	-	-	-	-	251	3,062	-	-	-	-	-	-	-	-
MP-WW-Pipe-16	Yigo Capacity Replacement	22,089	-	-	-	-	-	-	-	-	-	-	-	-	-	837	837	6,805	6,805	6,805	-	-
MP-WW-Pipe-17	Mamajanao Capacity Replacement	5,570	-	-	422	2,574	2,574	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-18	Agat-Santa Rita Capacity Replacement - Phase 1	3,012	-	-	-	-	-	-	-	-	229	2,783	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-19	Agat-Santa Rita Capacity Replacement - Phase 2	4,093	-	-	-	-	-	-	-	-	-	310	3,783	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-20	Agat-Santa Rita Capacity Replacement - Phase 3	5,940	-	-	-	-	-	-	-	-	-	450	2,745	2,745	-	-	-	-	-	-	-	-
MP-WW-Pipe-21	Baza Gardens Capacity Replacement - Phase 1	4,213	-	-	-	-	-	-	320	3,893	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-22	Baza Gardens Capacity Replacement - Phase 2	2,612	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	198	2,414	-	-	-
MP-WW-Pipe-23	Baza Gardens Capacity Replacement - Phase 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-24	Umatac-Merizo Capacity Replacement	2,730	-	-	-	-	-	-	207	2,523	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-25	Piping Near Bayside Lift Station	250	-	-	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-26	Finile Drive Rehabilitation - Agat	830	-	63	767	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pipe-27	Septic/Cesspool System Reduction Program	78,967	-	-	-	-	397	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238	5,238
MP-WW-MH-01	Manhole Rehabilitation Program	3,150	-	-	350	-	350	-	350	-	350	-	350	-	350	-	350	-	350	-	350	-
MP-WW-FM-01	Force Main Rehabilitation/Replacement Program	9,468	-	-	-	120	1,458	-	120	1,458	-	120	1,458	-	120	1,458	-	120	1,458	-	120	1,458
MP-WW-FM-02	Replace Yigo Lift Station Force Main	3,332	-	-	-	253	3,079	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-FM-03	Route 1 Asan Force Main Rehabilitation/Replacement	2,298	174	2,124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-FM-04	Hagåtña WWTP Force Main Rehabilitation/Replacement	7,400	561	6,839	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-6. GWA Capital Improvement Plan – Wastewater System

Project Number	Project Name	Cost ($ in thousands)																				
		Total	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
MP-WW-Pump-01	Lift Station Rehabilitation/Replacement Program	49,896	-	-	420	5,124	420	5,124	420	5,124	420	5,124	420	5,124	420	5,124	420	5,124	420	5,124	420	5,124
MP-WW-Pump-02	Tumon Basin - Fujita Lift Station Analysis	16,940	-	1,694	7,623	7,623	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Pump-03	Replacement of Former Navy Pump Station (Donut Hole)	1,320	-	100	1,220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-WWTP-01	Hagåtña WWTP Primary Treatment Repair/Rehabilitation Program	24,000	-	-	-	-	-	-	-	-	2,400	10,800	10,800	-	-	-	-	-	-	-	-	-
MP-WW-WWTP-02	Hagåtña WWTP Secondary Treatment Upgrade[a]	4,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,000
MP-WW-WWTP-03	Inarajan WWTP Repair/Rehabilitation Program	2,000	-	-	-	-	-	-	-	-	200	1,800	-	-	-	-	-	-	-	-	-	-
MP-WW-WWTP-04	Pago Socio WWTP Pump Station Conversion	3,138	-	-	-	238	2,900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-WWTP-05	Umatac-Merizo WWTP Repair/Rehabilitation Program	4,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	450	4,050	-	-	-
MP-WW-WWTP-06	Agat-Santa Rita WWTP Repair/Rehabilitation Program	13,500	-	-	-	-	-	-	-	-	-	-	-	-	-	1,350	6,075	6,075	-	-	-	-
MP-WW-WWTP-07	Baza Gardens Cross Island Pipeline - Preliminary Treatment Equipment Repair and Rehabilitation Program	2,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250	2,250	-	-	-	-
MP-WW-WWTP-08	Northern District WWTP Completion	17,000	-	-	-	8,500	8,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-WWTP-09	Ocean Outfall Inspection Program	600	-	-	150	-	-	-	-	150	-	-	-	-	150	-	-	-	-	150	-	-
MP-WW-Misc-01A	Update Wastewater Collection System Model (Major Update)	500	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Misc-01B	Update Wastewater Collection System Model (Continued)	800	-	-	200	-	200	-	200	-	200	-	-	-	-	-	-	-	-	-	-	-
MP-WW-Misc-02	I/I and SSES Assessments	2,400	-	-	400	-	-	400	-	-	400	-	-	400	-	-	400	-	-	400	-	-
MP-WW-Misc-03	Miscellaneous Wastewater Improvements	7,128	-	1,188	-	1,188	-	1,188	-	1,188	-	1,188	-	1,188	-	-	-	-	-	-	-	-
MP-WW-Misc-04	Fats, Oils, and Grease Study	150	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Wastewater System Totals	**423,117**	**1,289**	**13,155**	**15,863**	**30,136**	**25,804**	**20,450**	**14,828**	**28,374**	**17,708**	**32,770**	**26,766**	**22,287**	**14,778**	**21,670**	**21,233**	**27,757**	**21,840**	**24,617**	**15,687**	**26,105**

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

At the time of publication, GWA is engaged in a significant amount of CIP implementation financed primarily through GWA bond issuances. Additional funding is provided by OEA grants for projects associated with the military buildup, and US EPA SRF grant funding for other water and wastewater infrastructure improvement projects. These projects are summarized in Table 11-7. It is essential to consider these projects when evaluating future projects for GWA for the next 5 years as GWA will be engaged in the highest level of CIP execution in the history of the organization. When the current CIP projects are included with the proposed projects outlined in Tables 11-4, 11-5 and 11-6, spending for capital improvements is anticipated to exceed $100 million from 2018 through 2022 with a peak of over $135 million in 2019.

The major contributors to the high rate of CIP project implementation are the in-progress WWTP upgrades, infrastructure development required for the military build-up, and the new tank projects necessary to meet court order obligations. Following this intense period of development, annual CIP expenditures are expected to level off at approximately $50 million annually until the work on the HWWTP secondary treatment upgrade is scheduled, shown for illustrative purposes here as beginning in 2034. The financial considerations are described in detail in Section 12.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-7. GWA Current Capital Improvement Program –with Funding Sources							
Project Number	Project Name	Cost ($ in thousands)					
		Total	2018	2019	2020	2021	2022
Current Project Totals (with GWA Funding Allocated)							
PW-05-07	Meter Replacement Program	2,000	2,000	-	-	-	-
PW-05-09	Leak Detection	100	100	-	-	-	-
PW-05-10	Potable Water System Planning	400	400	-	-	-	-
PW-05-15	Rehabilitation of Asan Springs Ground Reservoir	1,157	-	1,157	-	-	-
PW-09-02	Water Wells	500	500	-	-	-	-
PW-09-03	Water Distribution System Pipe Replacement	500	500	-	-	-	-
PW-09-11	Chaot Tank Site (MP-PW-Tank-05)	5,714	2,857	2,857	-	-	-
PW-09-11	Tumon (Nissan) Tank Site (MP-PW-Tank-11A)	8,198	4,099	4,099	-	-	-
PW-09-11	Santa Rosa Tank Site (MP-PW-Tank-16A)	8,198	4,099	4,099	-	-	-
PW-12-05	Tank Major Repair Yigo #1, Mangilao #2, Astumbo #1	500	500	-	-	-	-
PW-12-06	Hyundai Tank Site (MP-PW-Tank-06)	8,198	4,099	4,099	-	-	-
PW-14-01	Fire Hydrant Replacement Program	500	500	-	-	-	-
WW 09-01	Lift Station Upgrades	1,500	1,500	-	-	-	-
WW-09-06	WW Collection System Replacement/Rehabilitation Program	8,600	8,600	-	-	-	-
WW 11-03	Baza Gardens STP Replacement	1,146	1,146	-	-	-	-
WW 12-07	Umatac Merizo STP Replacement	16,000	16,000	-	-	-	-
EE 09-09	SCADA Pilot Project (Implementation Phase A-1)	2,500	2,500	-	-	-	-
MC-09-01 and MC 15-01	General Plant Improvements	1,200	1,200	-	-	-	-
	Current Project Totals (GWA Funded Projects)	**66,911**	**50,600**	**16,311**	**-**	**-**	**-**
DoD/OEA Funded Projects							
CIP DoD-01	NDWWTP Secondary Treatment Capacity	134,800	20,500	38,100	38,100	38,100	-
CIP DoD-02	Northern Systems Wastewater System	30,000	4,000	13,000	13,000	-	-
CIP DoD-03	Rehabilitation and Monitoring Wells	4,500	4,500	-	-	-	-
	DoD/OEA Funded Projects Totals	**169,300**	**29,000**	**51,100**	**51,100**	**38,100**	**-**
SRF Funded Projects							
S15-001/3-EPA	Tumon and Tamuning Hot Spots	7,700	3,000	4,700	-	-	-
S15-002-EPA	Asan-Adelup Route 1 Rehabilitation	6,700	3,350	3,350	-	-	-
S15-002-EPA	Route 1 Pipeline Rehabilitation - Hagåtña	4,410	-	-	3,000	1,410	-
S15-004-EPA	Route 2 Agat Sewer Replacement	5,000	2,500	2,500	-	-	-
S15-006-EPA	Route 4 Sewer Rehabilitation	6,820	4,500	2,320	-	-	-
W15-001-EPA	Groundwater Well Rehabilitation (F-3, A-2,A-7,A-12,D-5)	7,010	3,505	3,505	-	-	-
S15-004-EPA	Talofofo/Chalan Pago Pump Stations	2,793	2,000	793	-	-	-
S15-004-EPA	Water Hydraulic Model (SCADA at Barrigada Tanks)	1,475	1,475	-	-	-	-
	SRF Funded Projects Totals	**41,908**	**20,330**	**17,168**	**3,000**	**1,410**	**-**
Total for GWA Current Capital Improvement Program		**278,119**	**99,930**	**84,579**	**54,100**	**39,510**	**-**

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 11-8 provides a breakdown of project costs (in 2017 dollars) for the different systems and different subprojects within each system.

Table 11-8. CIP Summary

Project Category	Number of New Projects	Estimated Cost WRMPU Proposed CIP	Number of Ongoing Projects	Estimated Cost Current/Ongoing CIP
Water System Improvements				
Pipeline Projects	17	$204,402,000	2	$2,500,000
Storage Tank and BPS Projects	30	$120,082,000	5	$30,808,000
Water Production Projects	10	$123,216,000	3	$8,667,000
Other Water System Projects/Studies	5	$14,449,000	4	$5,500,000
Total Water System Improvements	62	$462,149,000	14	$47,475,000
Wastewater System Improvements				
Gravity Sewer Projects	27	$250,247,000	7	$69,230,000
Force main Projects	4	$22,498,000		
Lift Station Projects	3	$68,156,000	2	$4,293,000
Wastewater Treatment Facilities	9	$71,238,000	3	$151,946,000
Other Wastewater System Projects/Studies	5	$10,978,000		
Total Wastewater System Improvements	48	$423,117,000	12	$225,469,000
General Systems Improvements				
General Facilities / Equipment Improvements	10	$59,800,000	1	
SCADA / Electrical	4	$37,176,000	2	$5,175,000
Total General System Improvements	14	96,976,000	3	$5,175,000
Total (rounded)	124	$982,242,000	29	$278,119,000

124 new capital improvements projects are planned in this WRMPU as shown in Table 11-8 and 29 major projects are currently in progress. The total cost of the 20-year CIP program including current and proposed projects is $1.26 billion in 2017 dollars.

Sixty-two new projects are associated with the water system with a total estimated cost of $509 Million, 48 are for the wastewater system with a total estimated cost of $648 million and 14 are for the overall GWA system infrastructure with a total estimated cost of $102 million. The higher cost for the wastewater system projects is due primarily to the higher capital cost of the wastewater treatment projects required, particularly the Northern District and Umatac WWTP upgrades.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 12
Financial Planning

This section outlines a strategic financial plan for financing the capital project costs outlined in Section 11 – Overall Capital Improvements Summary. This section also reviews potential implications of this WRMP Update with respect to GWA's project financing capabilities and non-rate measures to address low-income water affordability.

12.1 Major Findings and Recommendations

Over the last decade, GWA has increased service rates[1] and capital spending[2] at an extraordinary pace, which has enabled significant improvements to assets, service levels, and environmental performance. These investments have already placed noteworthy, though tenable, burdens on GWA ratepayers. Debt service obligations incurred to finance these investments affect GWA's ability to finance further system improvements.

GWA's proposed Master Plan capital improvements plan outlines a viable schedule for future system improvements that effectively balances system investment needs with financial impacts on GWA ratepayers:

- Residential water and wastewater customers with typical water usage of 7,500 gallons per month currently pay $1,081 annually, or approximately 2.4 percent of estimated median household income (MHI).[3] Projected system-wide (and uniformly applied) rate increases, based on currently identified Master Plan projects (including scheduling of design but not construction of secondary treatment at the Hagatna WWTP within the Master Plan forecast period), will drive water and wastewater bills to just over 3.2 percent of MHI over the forecast period under 'base case' assumptions.
- Limited revisions to base case scenario assumptions, including adjustments to cost escalation assumptions over the scheduled military build-up period, or moderation of rate subsidies benefitting residential customers, could result in water and wastewater bills exceeding 4.1 percent of Median Household Income with current scheduling of Master Plan projects. Additional and extended project deferrals beyond the 20-year Master Plan forecast period, particularly secondary treatment upgrades at the Hagatna WWTP, may ameliorate ratepayer burdens.
- Low-income residential customers currently pay approximately 5.2 percent of their incomes for water and wastewater services, and that amount rises to 7.0 percent over the forecast period, based on currently identified Master Plan projects and base case assumptions. These

[1] See, for example, Series 2016 Consulting Engineer's Report, Table 6-1 H (BC 2016).

[2] GWA's 2006 WRMP contemplated a spending plan of approximately $300 million for the 5-year period FY 2007-12; a $404 million spending plan is delineated in GWA's Series 2016 Bond Issue.

[3] This MHI value of $44,591 was derived by applying the U.S. Consumer Price Index to the MHI value of $39,052 reported in the 2010 U.S. Census.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

percentages suggest that GWA may be well served to implement programmatic measures to address low-income water affordability.[4]

- The GWA Master Plan capital improvement plan calls for approximately $1.61 billion of capital spending ($1.26 billion in 2017 dollars) over the 2018–2037 forecast period under base case cost escalation assumptions. Of this amount, approximately $424 million has already been raised or is anticipated to be externally funded, requiring GWA to finance as much as $1.19 billion in capital project spending over the forecast period. Project deferrals and alternative financing strategies (e.g., revised debt and equity funding proportions) may be required in the event that cost escalation rates exceed base case assumptions.[5]
- Financing the Master Plan capital program will result in substantial increases in debt service obligations (from $31.7 million per annum in FY 2018 to $80.9 million per annum by FY 2037) and required annual service revenues (from approximately $112.0 million in FY 2018 to more than $247.6 million in FY 2037), given a targeted minimum debt service coverage of 1.50x. Debt service requirements are projected to represent approximately 33 percent of service revenues by the end of the Master Plan forecast period; pay-as-you-go funding of capital expenditures will reach approximately $50 million.

12.2 Strategic Financial Planning Model

Financial implications of GWA's Master Plan capital improvement plan were evaluated by updating a Strategic Financial Planning (SFP) model that was originally developed to support GWA's Financial Capability Assessment. This modeling provides "additional information" allowed for in EPA's Guidance on Financial Capability Assessments (U.S. EPA February 1997) where EPA's guidance recognized that its matrix of financial indicators:

> *…might not present the most complete picture of a permittee's financial capability to fund combined sewer overflow (CSO) controls . . . permittees are encouraged to submit any documentation that would create a more accurate and complete picture of their financial capability. (p. 7)*

GWA's SFP model is a cash flow forecasting model that may be used to determine system-wide water and wastewater service rate adjustments required to fund utility operations and projected capital spending while ensuring compliance with key financial policies. The model, in Microsoft Excel, is composed of a series of integrated spreadsheets specifically designed to represent GWA cash flows. A list of individual calculation spreadsheets, explanations of the operation of these spreadsheets, and typical output is provided in Appendix E.

12.3 Base Case Scenario

The base case scenario financial plan presented here was developed to provide GWA stakeholders–including governing boards, regulators and credit market participants–projections of GWA's financial position over the long-term 20-year Master Plan horizon. The cash-flow forecast, summarized in a Pro Forma Fund Summary, presents projections of revenues, operating expenses, debt service expenses

---

[4] The scope of this WRMPU does not include a review of information on low-income affordability programs and rate structures.

[5] While the specific cost escalation impacts of scheduled military spending remain uncertain, the extraordinary volume of military capital construction work scheduled over the next decade make the base case cost escalation assumptions of typical 3 percent per annum inflation perhaps the most tenuous of all such assumptions. See Guam Military Construction Workload and Island-Wide Construction Labor needs forecasts provided by NAVFAC Marianas (2/22/18).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

and fund balances based on decisions related to rate increases, bond issuances, and pay-as-you-go capital funding. The base case was constructed by projecting the uniform system-wide rate increases necessary to enable funding of the project schedule and costs delineated in this WRMP Update. Rate increases were determined to ensure that GWA's projected financial performance will meet or exceed critical targets.

For master planning purposes, these targets include ensuring that traditionally calculated debt service coverage meets or exceeds a target of 1.50x, conservatively above GWA's covenanted requirements of 1.25x.[6] Assumed minimum operating fund balances provide for 90 days of operating expenses as well as 50 percent of subsequent year debt service, which also exceeds amounts prescribed to be held in GWA's operating fund and working capital reserve account.

Debt financing assumptions for the base case scenario largely mirror GWA's historical debt management practices. Revenue bond issues, totaling $585 million, are assumed to be made using a structure with both a 2-year capitalized interest period and 2 years of deferred principal payments. In the first five years of the forecast period, debt issues are scheduled in FY 2019 and FY 2020, and again in FY 2022 and FY 2023; thereafter, debt issues are scheduled once every three years. More frequent, paced incurrence of debt obligations between FY 2019 and FY 2023 permits stable rate increases of 4.5 percent per annum through FY 2024. These revenue bond issues are the primary mechanism for funding the GWA capital program, particularly in the post-FY 2021 period with the completion of DoD/OEA and specified SRF grant funded projects. SRF grant funding is assumed to be limited to $8 million/year in this time frame. Section 12.5 provides a detailed review of the base case scenario which outlines projections of service and non-rate revenues, O&M and debt service expenses, and financial performance metrics.

The base case scenario is also constructed using a number of assumptions characterizing general economic conditions including general cost inflation, account and household income growth rates; price elasticity of demand; and interest earnings rate on fund balances. Variances in these assumptions may give rise to changes in the scheduling of Master Plan projects and the program financing identified herein.

12.4 Master Plan vs. Short-Term Financial Planning

While the cash-flow analysis of the Master Plan capital improvement plan provides important information for policy decision-makers and may help define expectations related to future rate increase requirements, prospective financial burdens, and GWA's credit standing, these projections will vary from GWA's budget and 5-year financial plans developed for near term rate-setting, bond issues, and financial reporting purposes. GWA's 5-year financial plans involve updating detailed revenue and O&M expense projections (based on, for example, prior period actual to budget performance) and use of debt service projections based on current credit market conditions, bond structure issuance decisions, and updated capital program schedule and cost estimates. Five-year financial and rate increase planning will also give rise to re-evaluation of planned use of debt and current revenues to fund capital expenditures. Accordingly, the cash-flow analysis for the Master Plan capital program discussed in this section may serve as a benchmark and reference for GWA's prospective budget, bond issuance, and 5-year rate plans.

[6] The traditionally calculated debt service coverage target also provides for coverage exceeding the 1.75x minimum delineated by the PUC using a coverage calculation that includes GWA's bond reserve funds.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

12.5 Cash-Flow Analysis for Master Plan Capital Program

GWA's SFP model was used to program financing for projects specified through the GWA Master Plan process.[7] These financing requirements are in nominal terms using CIP project cost escalation factors.[8] This section reports on the base case scenario that contemplates issuance of approximately $585 million of revenue bonds, and $604 million of current revenue ("PAYGO") funding. The cash-flow analysis is developed to forecast system-wide water and sewer rate increases that will be required to finance the GWA Master Plan capital improvement plan while meeting financial performance targets established to ensure the financial integrity of the GWA systems. In particular, for purposes of the cash flow analysis, financial performance targets include compliance with a traditional debt service coverage[9] ratio target of 1.50x and a minimum O&M fund balance of 90 days expenses (exclusive of GWA's Working Capital O&M Reserve Account) plus one payment of subsequent year debt service requirements.[10] Figure 12-1 shows the capital program expenditures for FY 2018–2037 developed for this WRMP Update.

[7] For O&M Fund cash flow projections, a beginning balance of approximately $5.7 million was used based on GWA's MFR 2017 True Up submittal to the PUC. For capital financing projections, a $0 beginning balance was used as a construct to reflect the fact that the SFP model is used here to determine prospective project financing requirements. In so doing, the $0 beginning balance assumption excludes funds already raised or to be generated externally to fund a projected $69.4 million of current project totals with bond funding allocated and $182.8 million of DoD/OEA-funded projects. All SRF-funded projects are also assumed to be in the form of grants and an assumption of $8 million per annum in SRF grants was assumed for the post FY 2021 period. See Appendix E for selected sheets from the SFP model.

[8] Capital project cost escalation factors are assumed over 5-year increments and listed in the assumptions sheet of the SFP model. In general, default escalation factors of 3 percent per year are assumed. Scenario analyses reflecting alternative assumptions related to cost escalation, particularly over the pending military build-up period, may be developed for future 5-year rate plans and bond offering documents as well as for negotiations with USEPA regarding scheduling of planned capital improvements.

[9] The traditional Debt Service Coverage Ratio (DSCR) is calculated as operating revenues (including system development charges and legislative charges) less operating expenses divided by senior lien debt service. This contrasts the PUC DSCR, which includes debt service reserves. Note that GWA's bond indenture excludes System Development Charges, a variance calculated to marginally reduce coverage values by approximately 0.01 over the forecast period.

[10] This fund balance provision, like the debt service coverage calculation, is more conservative than the GWA's current use of a Working Capital Reserve Account due to the inclusion of 50 percent of subsequent year debt service requirements.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

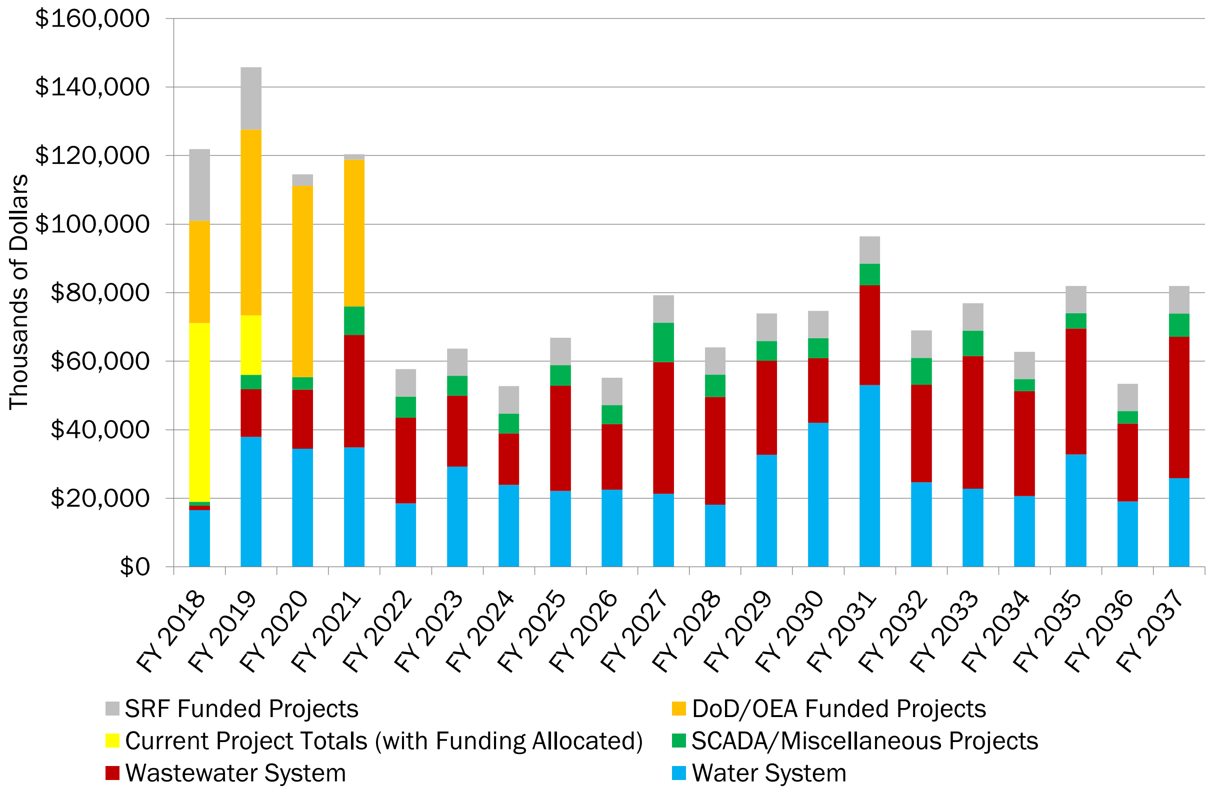


Figure 12-1. GWA Master Plan Capital Program Expenditures, FY 2018–2037

Note: For the post-2021 period, proportional reductions in project costs were applied to water, wastewater and SCADA/miscellaneous project categories to reflect assumed $8 million per year SRF grant funding.

The GWA Master Plan capital program calls for approximately $1.61 billion of capital spending ($1.26 billion in 2017 dollars) over the 2018–2037 forecast period. This budget is composed of potable water system, wastewater system, SCADA and miscellaneous projects, and other project categories as listed in Table 12-1 with total projected spending in nominal and current dollar terms.

Table 12-1. GWA Master Plan Capital Program Total Project Costs in Nominal and Current Dollar Terms, FY 2018–2036

Project Category	Projected Costs – Nominal Dollars ($ in millions)	Projected Costs – 2017 Dollars ($ in millions)
Water system	$608.4	$462.1
Wastewater system	$579.4	$423.1
SCADA/miscellaneous projects	$128.8	$97.0
Current project totals (with bond funding allocated)	$69.4	$66.9
DoD/OEA-funded projects	$182.8	$169.3
SRF-funded projects (FY 2018–2022)	$44.0	$41.9
Total	$1,612.9	$1,260.4

Note: SRF-funded grants are assumed to fund $128 million of project costs in the first three categories listed above in the post-2021 period. Slight differences in value totals are due to rounding.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This capital program will require incurrence of substantial debt on a regular basis throughout the forecast period. Debt service requirements are projected to increase 2.55 times during the forecast period, from under $31.7 million per annum to $80.9 million per annum by FY 2037, as shown in Figure 12-2.

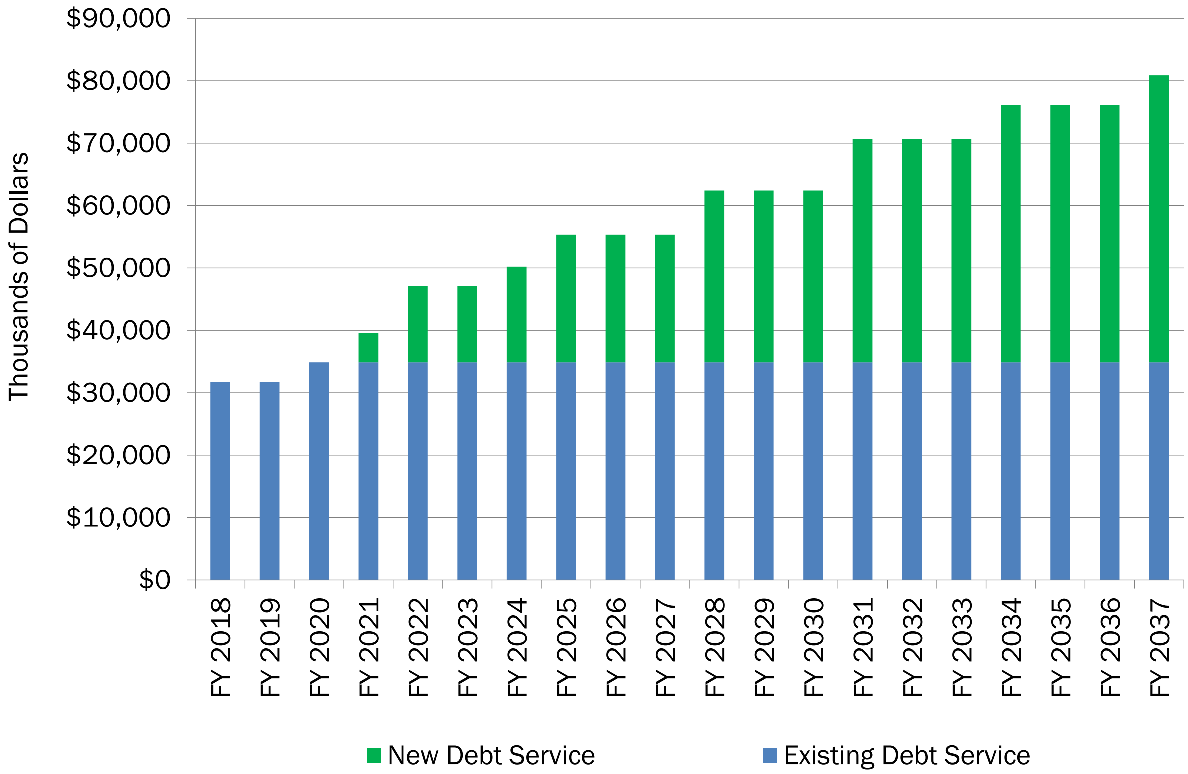


Figure 12-2. GWA Projected Debt Service Requirements, FY 2018–2037

Similarly, service revenues (to support these debt issuances) are projected to increase substantially over the forecast period, from approximately $112 million in FY 2018 to over $247.6 million in FY 2037, as shown in Figure 12-3.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

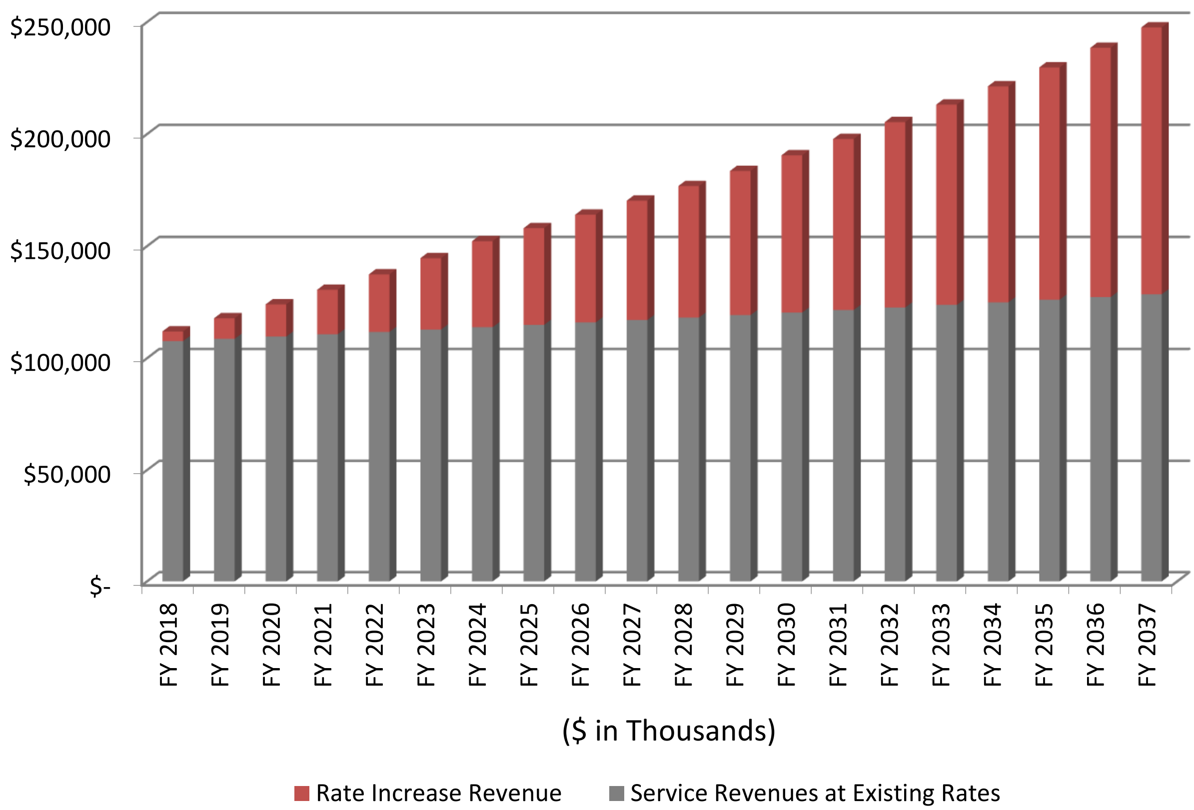


Figure 12-3. GWA Service Revenue Forecast, FY 2018–2037

Notably, because of the need to build revenue capacity to support higher GWA-funded capital spending, the pace of service revenue increase is marginally greater in the initial six years. During these years, system-wide rate increases are projected to exceed assumed general cost inflation or income growth rates (assumed at 3.0 percent and 2.0 percent, respectively) and result in a cumulative 35.4 percent increase over the FY 2018–2024 period. By FY 2037, the cumulative increase is 99.0 percent under the base case scenario.

This base case scenario also assumes that rate increases will be set marginally higher – specifically, 0.5 percent higher per year – than absolutely required beginning in FY 2032 to initiate funding of a Rate Stabilization Fund. This fund would be established whereby revenues transferred to the fund are recognized in the year they are applied to capital program funding, rather than in the year collected for debt service coverage calculation purposes. Fund transfers are scheduled to increase from $5 million in FY 2032 to $15 million by FY 2037, yielding a fund balance in excess of $50 million by the end of the forecast period. The Rate Stabilization Fund could substantially limit rate adjustments required to fund capital projects scheduled beyond the forecast period – including, most notably, secondary treatment upgrades at the Hagatna WWTP, or projects deferred in response to an atypically high construction cost escalation. Establishing the Rate Stabilization Fund beginning in FY 2032 is not projected to require rate increases that exceed assumed general cost escalation rates.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

12.6 Alternatives Analysis

GWA's Program Management Team, working with GWA staff, developed the base case capital improvement plan and supporting strategic financial planning model. These analyses are structured to enable evaluation of capital program alternatives and different approaches to capital program financing. All scenarios developed to assess the financial implications of the Master Plan project implementation schedule (or alternatives thereto) provide for compliance with established financial management targets, including maintenance of adequate fund balances and debt service coverage levels. Nevertheless, a variety of alternative scenarios are possible through different scheduling of debt versus equity financing, revised project scheduling and operating cost containment, or other debt structure revisions.

Of particular note are the significant increases in annual capital spending that would be required for secondary treatment upgrades at the Hagatna WWTP that are scheduled to occur outside of the 20-year Master Plan forecast period. As noted earlier, to mitigate against potential impacts on customer bills, the SFP modeling incorporates the funding of a Rate Stabilization Fund beginning in FY 2032. This structuring would help avoid relatively large rate increases beyond the close of the Master Plan forecast period. Several alternative approaches to scheduling and financing secondary treatment at the Hagatna WWTP will inform the financial capability assessment of GWA's Master Plan capital program (as discussed further in Section 12.9).

12.7 Water Affordability

Though GWA may elect to modify its Master Plan project implementation schedule, the base case analysis offers some important insights into prospective claims of GWA's water and wastewater bills on residential customer incomes and on GWA's financial capabilities to finance the currently identified Master Plan projects.

While financial capability assessments properly rely on a host of financial indicators, the indicators that have garnered the most attention center on future residential water and sewer bills as a percentage of household income metrics. Figure 12-4 illustrates projected bills under the base case scenario for customers with the GWA MHI and for those at the threshold of the lowest quintile of the U.S. Census income distribution.[11] These projections indicate that financing the Master Plan program, as currently defined, will drive water and wastewater bills from roughly 2.4 percent of MHI to 3.23 percent over the forecast period.

[11] The lowest income quintile customer is assumed to consume 80 percent of the 7,500 gallons per month consumption level assumed for the typical MHI customer.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

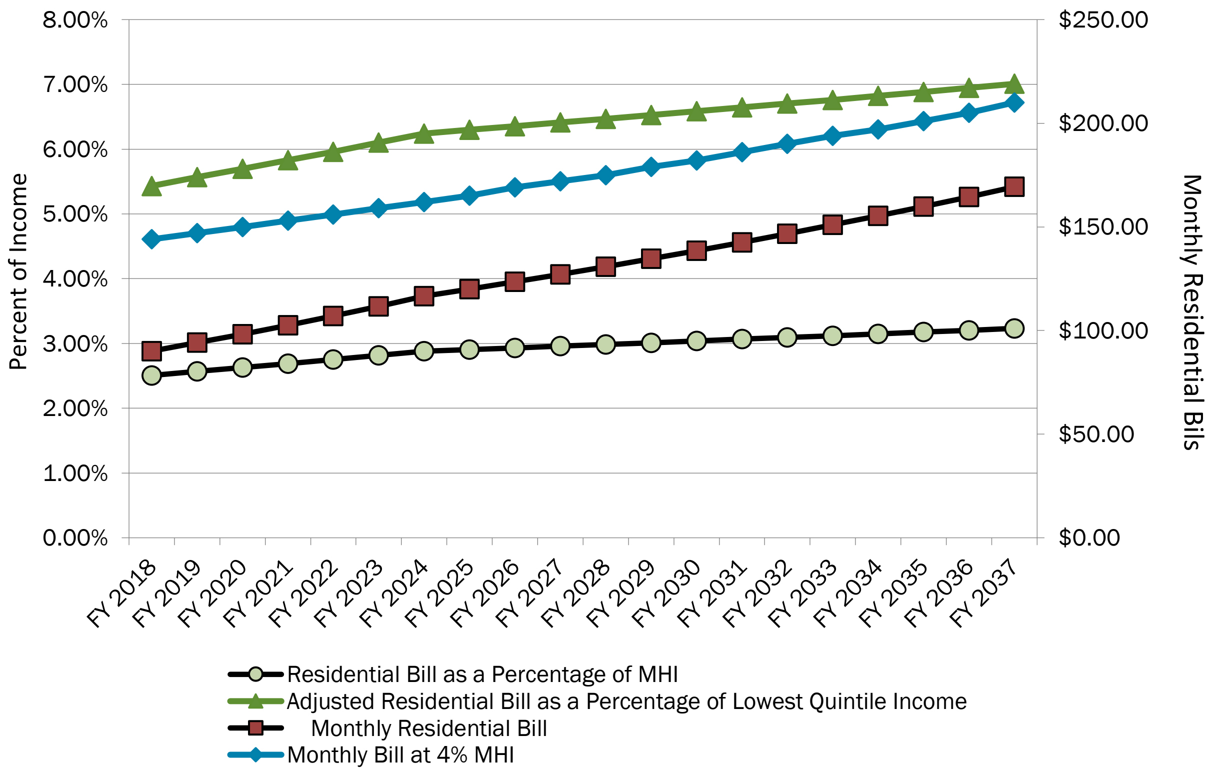


Figure 12-4. GWA Projected Residential Bills as Percentage of Median and Lowest Quintile Household Income, FY 2018–2037

For customers at the lowest quintile household income, projected system-wide rate increases would push projected water and wastewater bills from 5.2 percent to 7.0 percent of household income.

EPA's guidance methodology employs a threshold of 2 percent of MHI for their determination of a "High Burden" for wastewater service. Informal benchmarks offer a range of 4–4.5 percent of MHI for combined water and wastewater billings. As a result, the Master Plan program may be viewed as presenting a significant yet manageable financial burden for the GWA residential population in general under the regular rate increases projected. At the same time, the metrics associated with impacts on low-income customers suggest that their burden is already high, and GWA may be well served to implement programmatic measures[12] to complement its lifeline rate structure to address low-income water affordability.

The projected impacts of the WRMPU capital program on residential customer bills are also limited by the (tenuous) assumption that current overall shares of revenue responsibilities between residential and non-residential customers will be preserved. To enable alignment to industry best practices, and to address prospective regulatory reviews, GWA anticipates conducting Cost of Service Analyses and potentially modifying respective shares of revenue responsibilities over the forecast period. The moderation of rate subsidies benefitting residential customers could result in water and

[12] See references in footnote 4 in Section 12.1.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

wastewater bills exceeding 4.1 percent of Median Household Income with current scheduling of Master Plan projects.

The base case rate increase pattern, as shown in Figure 12-5, results from an effort to smooth rate increases while building financial capacity for annual spending levels in the range of $50–80 million. This will also position GWA to finance additional capital investments beyond the forecast period, potentially including secondary treatment upgrades at the Hagåtña WWTP or projects deferred due to atypical cost escalation.

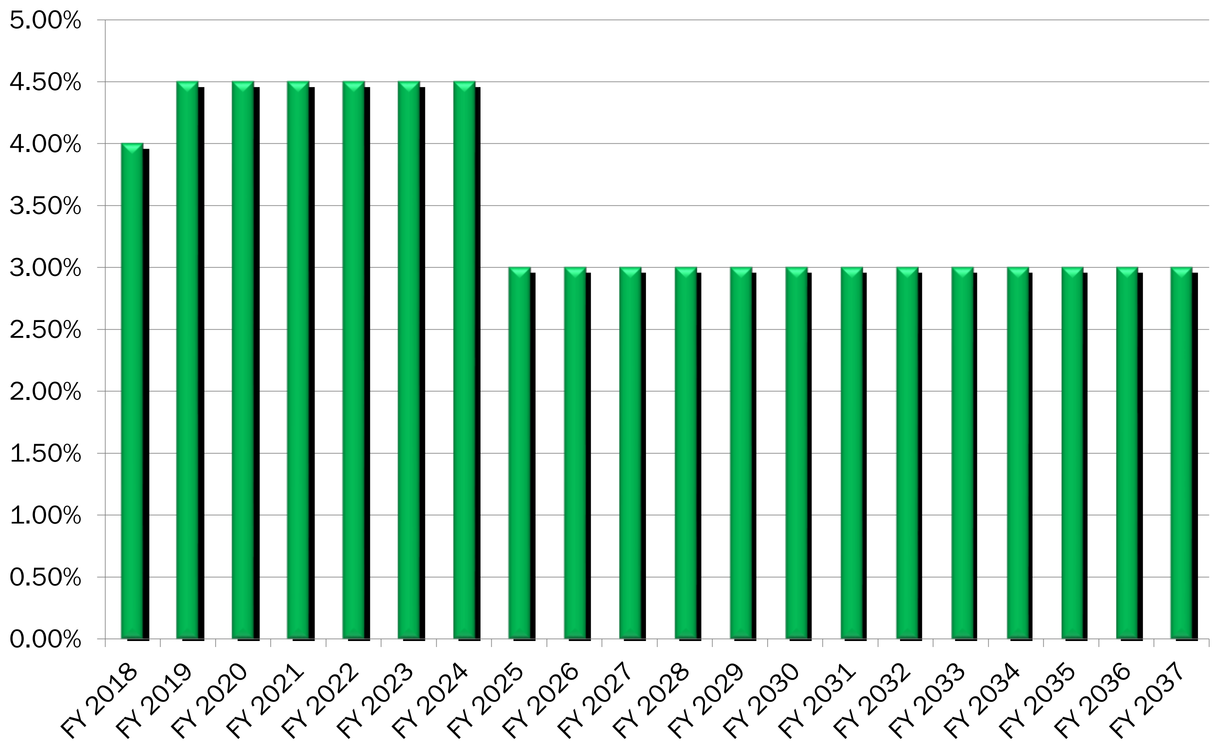


Figure 12-5. GWA Projected Water and Wastewater Service Rate Increases, FY 2018-2037

12.8 Debt Management

As shown above, GWA's financial program to implement Master Plan-defined projects contemplates <u>annual</u> rate increases, at or exceeding projected inflation rates, for much of the forecast period, as is characteristics of communities that are under Consent Decrees and are effectively re-building their systems. In addition, the plan requires regular accessing of the municipal credit markets.

The base case analysis assumes that GWA will issue revenue bond debt in four of the next five years and every third year thereafter. Continuing its historical practice, GWA will obtain SRF grants of $8

Use of contents on this sheet is subject to the limitations specified at the end of this document.

million per annum, and will increase current revenue funding of capital to almost $50 million by the end of the forecast period, as shown in Figure 12-6.[13]

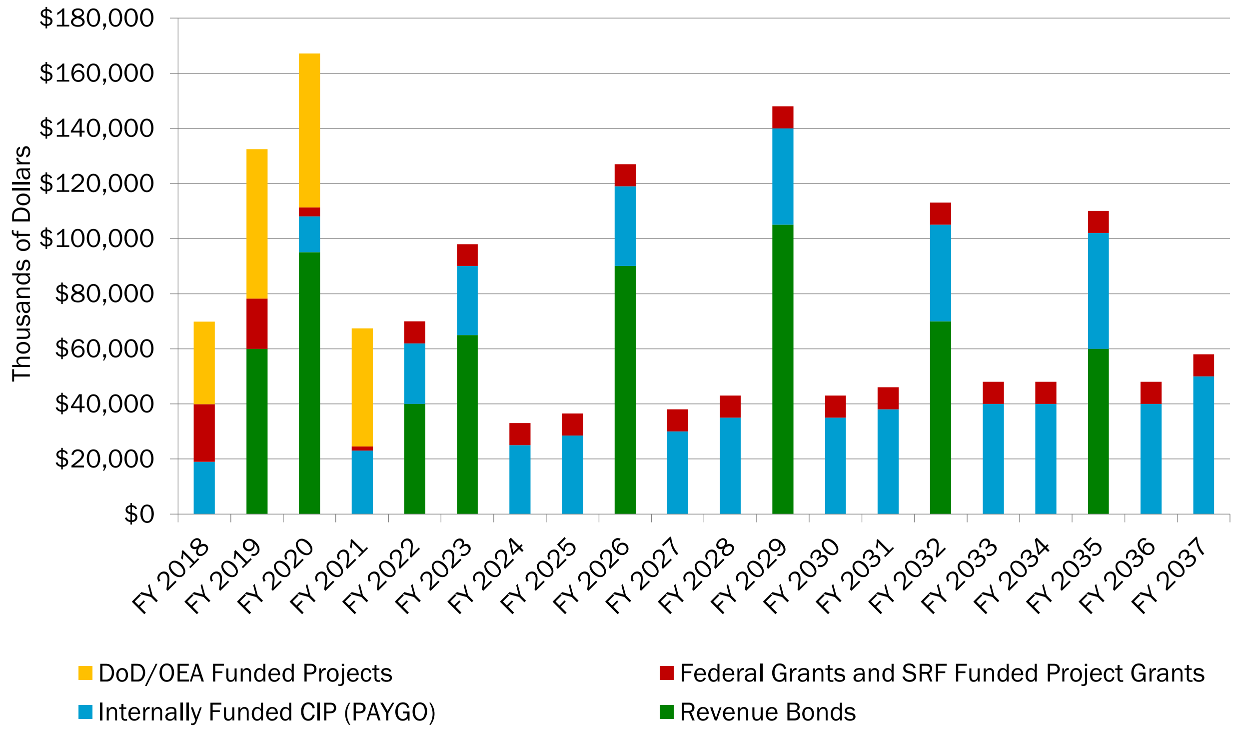


Figure 12-6. GWA Capital Program Funding Sources, FY 2018–2037

This forecast also assumes that GWA's revenue bonds are issued under GWA's current, relatively less advantageous, borrowing terms (5.0 percent annual interest, 6.0 percent funded bond reserve, no insurance) that reflects its relatively low credit ratings.[14]

Given the forecasted need to issue $585 million over the 20-year forecast period, GWA would be well served by improvements to the credit ratings under which it issues municipal debt obligations. In a nearer term time horizon, this may be possible by securing bond insurance if available and economic. Over the longer term, GWA's actions to enhance its credit rating will be particularly important.

Toward that end, the strategic financial plan outlined in this section uses a more stringent (and traditional) debt service coverage ratio calculation. The SFP model assumes a GWA commitment to annual rate adjustments. Forecasted O&M expense increases recognize the need to enhance operations, while the Master Plan capital improvement plan includes not only the minimum

[13] As noted, the base case also provides for the accumulation of approximately $50 million in a Rate Stabilization Fund that may be used to fund capital projects beyond the Master Plan forecast period.

[14] Fitch Ratings assigned a rating of "BBB-"; Moody's Investors Services assigned a rating of "Baa2"; Standard & Poor's assigned a rating of "A-" for GWA's Series 2017 revenue bond issue. GWA Series 2016 Official Statement, p. 56.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

requirements for compliance with regulatory requirements, but also needed system reinvestments and upgrades to sustain high quality utility performance over the long term.

While GWA's credit standing is undoubtedly impacted by general Government of Guam debt and uncertainties surrounding U.S. territorial credits, GWA's strategic financial plan is designed to position the Authority well in financial terms (that will ultimately be recognized by the credit markets).

12.9 Implications for Financial Capability Assessment

The base case plan to structure financing of the Master Plan capital improvements highlights annual rate increases will be required throughout the forecast period, with their regular increase of burdens borne by residential customers. With such regular, stable and generally modest rate increases, Master Plan improvements may be financed largely as scheduled within Guam's financial capabilities (as assessed by reference to EPA guidance and other permittees' entered Consent Decrees).[15] A Rate Stabilization Fund may enable scheduling of secondary treatment construction at the Hagatna WWTP immediately beyond the Master Plan forecast period and/or funding of projects requiring deferral due to atypical cost escalation.

The substantial cumulative rate and residential bill impacts that are projected, and yet are anticipated to be within GWA's financial capabilities, rely on base case financial forecast assumptions that will require monitoring over the forecast period. Two such assumptions[16] illustrate the need for project scheduling flexibility and recognition of Guam's financial capability limitations:

- Preservation of the subsidy of residential customers under GWA's current lifeline rate structure.
- Application of typical 3.0 percent per annum cost escalation factors throughout the Master Plan forecast period.

GWA's current lifeline rate structure effectively provides a relatively significant subsidy to Guam's residential customers, particularly for wastewater service. As rates continue to increase to support Master Plan improvement financing, these subsidies may require adjustment in response to economic competitiveness concerns and/or regulatory review. Revising the base case scenario only to substantially reduce, but not entirely eliminate,[17] this subsidy results in projections of residential bills that exceed 4.0 percent of MHI. This burden may be ameliorated with project schedule relief.

Likewise, the potential impacts of atypical construction cost escalation induced by the planned military build-up could have project scheduling implications. If construction costs during the military build-up escalate substantially more rapidly than the 3.0 percent per annum default assumption used in the base case scenario, other project deferrals may be necessitated.

The base case scenario helps gauge Guam's financial capability limitations and may be viewed as estimating the boundaries of GWA's overall capital project spending capacity, in nominal terms, during the Master Plan forecast period. In the event that projects scheduled early in the forecast period cost substantially more than projected, less financial capacity will be available to fund subsequent improvements.

---

[15] See, for example, Consent Decrees entered for the City and County of Honolulu, Hawaii (2010); Northeast Ohio Regional Sewer District (2010); and the extension granted for the City of Atlanta, Georgia (2012).

[16] Revisions of which may inform GWA's financial capability assessment filing to be used to specify project completion milestone dates under GWA's prospective Consent Decree with USEPA.

[17] As to be discussed further in GWA's financial capability assessment filings, the referenced scenario simply eliminates 80.0 percent of the residential subsidy over a 10-year period without any other adjustments to the base case financial plan.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The uncertainties that prevail for GWA's Master Plan implementation – illustrated by these two examples – have profound implications for the establishment of project milestone commitments and underscore the need for flexibility in project scheduling. Beyond offering the additional information delineated in GWA's base case strategic financial plan, GWA's financial capability assessment will also highlight the importance of project scheduling flexibility to respond to evolving economic conditions.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 13

Limitations

This document was prepared solely for GWA in accordance with professional standards at the time the services were performed and in accordance with the contract between GWA and Brown and Caldwell dated February 6, 2012, and the Work Authorization 2015–07 dated July 10, 2015. This document is governed by the specific scope of work authorized by GWA; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by GWA and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

Further, Brown and Caldwell makes no warranties, express or implied, with respect to this document, except for those, if any, contained in the agreement pursuant to which the document was prepared. All data, drawings, documents, or information contained this report have been prepared exclusively for the person or entity to whom it was addressed and may not be relied upon by any other person or entity without the prior written consent of Brown and Caldwell unless otherwise provided by the Agreement pursuant to which these services were provided.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 14
References

AECOM Technical Services Inc., *Guam Water Well Testing Study to Support U.S. Marine Corps Relocation to Guam,* Naval Facilities Engineering Command Pacific, 2011.

American Society of Civil Engineers (ASCE), *Guidelines for the Physical Security of Water Utilities, ASCE/EWRI 56-10 and Guidelines for the Physical Security of Wastewater-Stormwater Utilities ASCE/EWRI 57-10*, 2011.

American Water Works Association, *Process Control System Security Guidance for the Water Sector,* 2017.

American Water Works Association, *J100-10 (R13): Risk and Resilience Management of Water and Wastewater Systems (RAMCAP)*, 2010.

American Water Works Association, "Water Loss Control Terms Defined", 2012, www.awwa.org/portals/0/files/resources/water%20knowledge/water%20loss%20control/water-loss-control-terms-defined-awwa-updated.pdf

Ayers, Jerry F. and Russell N. Clayshulte, *Feasibility Study of Developing Valley-Fill Aquifers for Village Water Supplies in Southern Guam*, Technical Report No. 41, University of Guam Water and Energy Research Institute of the Western Pacific, 1983.

Barrett Consulting Group, *Guam Surface Water Development Study*, Prepared for the Public Utility Agency of Guam, 1994.

Bendixson, V. M., *The Northern Guam Lens Aquifer Database*: WERI Technical Report No. 141, University of Guam Water and Environmental Research Institute of the Western Pacific, 2013.

Bradford L. Blake, Gary A. Brown, and Eric Rothstein, "Model Water Utility Affordability Programs," *Journal AWWA*, 109:8, August 2017.

Bredehoeft, John D. *The Water Budget Myth Revisited: Why Hydrogeologists Model*, Groundwater Vol. 40, No. 4, pages 340–345, July–August 2002.

Brown and Caldwell, *Consulting Engineer's Report Prepared for Guam Waterworks Authority Water and Wastewater System Revenue Bonds, Series 2016*, Section 7, "Capital Improvement Plan", 2016.

Brown and Caldwell, *Water Resources Master Plan*, Guam Waterworks Authority, 2006.

Brown and Caldwell, *Disinfection By-Product (DBP) Reduction Study for Navy Water Sources, Production and Treatment, and Distribution Systems, Guam: Final Report,* Prepared for NAVFAC Pacific, 2014.

Bureau of Economic Analysis, "National Income and Product Accounts Gross Domestic Product, second quarter 2013 (advance estimate); Comprehensive Revision: 1929 through 1st quarter 2013", http://bea.gov/newsreleases/national/gdp/2013/gdp2q13_adv.htm (accessed March 31, 2016).

Bureau of Economic Analysis, News Release BEA 15-59, U.S. Department of Commerce, December 2, 2015, http://www.bea.gov/newsreleases/general/terr/2015/guamgdp_120215.pdf (accessed February 28, 2016).

Bureau of Labor Statistics, "Current Employment Statistics–September 2015", http://bls.guam.gov/ (accessed March 2, 2016).

Bureau of Labor Statistics, "Employment Projections", http://bls.guam.gov/employment-projections/ (accessed March 10, 2016).

Bureau of Labor Statistics, "The Unemployment Situation on Guam: March 2015", http://bls.guam.gov/unemployment-situation-on-guam (accessed December 31, 2015).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Bureau of Labor Statistics, “The Unemployment Situation on Guam Summary History: 1974–2014”, http://bls.guam.gov/unemployment-situation-on-guam (accessed December 31, 2015).

California Department of Transportation, *Storm Water Monitoring & Data Management Discharge Characterization Study Report,* 2003.

Camp, Dresser, McKee, *Final Report, Northern Guam Lens Study, Groundwater Management Program*, 1982.

Central Intelligence Agency, “Guam”, https://www.cia.gov/library/publications/the-world-factbook/geos/gq.html (accessed December 29, 2015).

Department of Defense, “Economic Adjustment Committee Implementation Plan Supporting the Preferred Alternative for the Relocation of Marine Corps Forces to Guam”, https://bordallo.house.gov/sites/bordallo.house.gov/files/wysiwyg_uploaded/EAC%20Implementation%20Plan.PDF (accessed June 11, 2016).

EA Engineering, Science, and Technology, Inc., Guam *Drinking Water Source Assessment and Protection Program and Wellhead Protection Plan,* Guam Waterworks Authority, 2015.

Federal Register Vol 78 No 33 2013, “Executive Order 13636—Improving Critical Infrastructure Cybersecurity”, http://www.awwa.org/Portals/0/files/legreg/security/EO13636.pdf (accessed November 14, 2017).

Full Employment and Balanced Growth Act, 1978.

Gingerich, S.B., *Hydrologic Resources of Guam: U.S. Geological Survey Water-Resources Investigations Report 03-4126*, 2 Plates, 2003.

Gingerich, S.B., *The effects of withdrawals and drought on groundwater availability in the Northern Guam Lens Aquifer, Guam: U.S. Geological Survey Scientific Investigations Report, 2013-5216*, http://dx.doi.org/10.3133/sir20135216, 2013.

Guam Economic Development Authority Bureau of Statistics and Plans, “Guam Comprehensive Economic Development Strategy (CEDS) 2011”, http://bsp3.guam.gov/wp-content/uploads/CEDS.2011.pdf (accessed January 5, 2016).

Guam Power Authority, “April–June 2015 Compliance Reports”, http://guampowerauthority.com/operations/documents/Compliance%20Report%20end%20Jun2015.pdf (accessed January 12, 2015).

Guam Visitors Bureau, “L’Estoria: Guam Visitors Bureau 2014 Annual Report”, https://www.guamvisitorsbureau.com/research-and-reports/reports/annual-report (accessed December 24, 2015).

Guam Visitors Bureau, “Tourism 2020”, http://www.investguam.com/userfiles/files/Guam%20Tourism%202020%20Strat%20Plan%20Final.pdf (accessed December 24, 2015).

Guam Visitors Bureau, *Tourism Satellite Account Calendar Year 2010: The Economic Impact of Tourism in Guam*, 2012.

Guam Waterworks Authority, *Annual Water Quality Reports*, 2007–2015.

Guam Waterworks Association, “GWA History”, guamwaterworks.org/gwa-history/ (accessed December 2016).

Guam Waterworks Authority, *Potable Water Production Enhancement Plan*, 2010.

Guam Waterworks Authority, *Water Resources Master Plan*, Chapter 6, “Population and Land Use Forecast”, 2006.

Guam Workforce Development Board, *Guam Workforce Integrated Plan*, Department of Labor, Government of Guam Agency for Human Resources Development, 2013.

GWA and NAVFACPAC, *Framework for an Integrated Water System for Guam*, 2016.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Habana, N. C., Salvacion, J. L., Jenson, J. W. and J. D. Rouse *VADOCHARGE-N: A Vadose Flow and N-Transport Simulation Model for the Northern Guam Lens Aquifer*, International Journal of Environmental Engineering Science and Technology Research, Volume 1(11), 268–287, 2013.

Heitz, Leroy, *Synopsis Report Water Treatment Assessments and Groundwater Under the Direct Influence of Surface Water Determinations for GWA Wells located in the Northern Aquifer of Guam,* University of Guam Water and Environmental Research Institute of the Western Pacific, July 2014.

HIREGUAM, http://www.hireguam.com (accessed December 29, 2015).

Johnson, AG, *A Water-Budget Model and Estimates of Groundwater Recharge for Guam: U.S. Geological Survey Scientific Investigations Report 2012-5028*, 2012.

Khosrowpanah, Sharam and John Jocson, *Environmental Assessment for Non-Point Sources of Pollution for Ugum Watershed*, Technical Report No. 109, University of Guam Water and Environmental Research Institute of the Western Pacific, 2005.

Khosrowpanah, Sharam Mark Lander et. al, *Assessment of Turbidity in the Geus River Watershed in Southern Guam,* Technical Report No. 156, University of Guam Water and Environmental Research Institute of the Western Pacific, 2015.

Khosrowpanah, Sharam, Leroy Heitz, et.al, *Developing a GIS-Based Soil Erosion Potential Model of the Ugum Watershed,* Technical Report No. 117, University of Guam Water and Environmental Research Institute of the Western Pacific, 2007.

Marianas Business Journal, December 28, 2015.

Marineau, M.D., and Wright, S.A, 2015, *Storage capacity of the Fena Valley Reservoir, Guam, Mariana Islands, 2014: U.S. Geological Survey Scientific Investigations Report 2015-5128*, http://dx.doi.org/10.3133/sir20155128 (accessed October 16, 2016).

McDonald, M. *Nitrate-Nitrogen Concentrations in the Northern Guam Lens and Potential Nitrogen Sources,* Technical Report No. 95 of the Water and Environmental Research Institute of The Western Pacific, 2002.

McDonald M. and John W. Jenson, *Chloride History and Trends of Water Production Wells in the Northern Guam Lens Aquifer*, the Water and Environmental Research Institute of The Western Pacific, 2003.

Mchenry, Timothy, "GEDA Approves Qualifying Certificates for Two New Hotels in Tumon", http://www.pacificnewscenter.com/local/7648 (accessed March 3, 2016).

Mink, John F, *Groundwater Resources of Guam: Occurrence and Development. Technical Report No. 1.,* University of Guam Water and Energy Research Institute of the Western Pacific, 1976, Reprinted 1991.

Naval Facilities Engineering Command Pacific, *Environmental Impact Assessment Study–Guam and CNMI Military Relocations,* Joint Guam Program Office, 2010.

Naval Facilities Engineering Command Pacific, *Socioeconomic Impact Assessment Study–Guam and CNMI Military* Relocations (2012 Roadmap Adjustments), Joint Guam Program Office, 2014.

Naval Facilities Engineering Command Pacific, *Supplemental Environmental Impact Assessment Study–Guam and CNMI Military Relocations (2012 Roadmap Adjustments)*, Chapter 4 "Environmental Consequences", Joint Guam Program Office, 2015.

National Institute of Standards and Technology, *Framework for Improving Critical Infrastructure Cybersecurity*, 2014

National Pollutant Discharge Elimination System Permit Fact Sheet, Ugum Surface Water Treatment Plant, GU0020371, 2016.

Office of the Governor of Guam, "Invest in a World Class Destination–Guam", http://www.investguam.com/userfiles/files/Guam-Investment-Booklet-2013.pdf (accessed December 29, 2015).

Organization for Economic Co-operation and Development, "Labour Force Participation Rate", https://data.oecd.org/emp/labour-force-participation-rate.htm (accessed January 3, 2016).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Parsons Brinkerhoff, *Master Plan Update 2013*, "Section 6–Financial Analysis", Port Authority of Guam, pages 6-35 to 6-40, 2013.

Roush, Martin, *Potable Water Production Enhancement Plan (2010)*, GWA, 2010.

Simard, C.A., *Analysis of Salinity in the Northern Guam Lens Aquifer: M.S. Thesis*, University of Guam, 2012.

Todd, D.K., *Groundwater Hydrology*, 1980.

Tourism Economics, "The Economic Impact of Tourism in Guam–Tourism Satellite Account Calendar Year 2010", 2012 https://www.guamvisitorsbureau.com/research-and-reports/research (accessed January 11, 2016).

U.S. Census Bureau, "American Factfinder", http://factfinder2.census.gov (accessed January 5, 2016).

U.S. Census Bureau, "Economic Census of Island Areas 2012", http://www.census.gov/econ/islandareas/historical_data.html#guam (accessed February 26, 2016).

U.S. Census Bureau, Geography Division MAF/TIGER Database TAB 2010 Census Tract, Reference Maps 20606601-0001 through -0004. http://tigerweb.geo.census.gov/tigerwebmain/Files/tab10/tigerweb_tab10_tabblock_2010_gu_010.html (accessed March 6, 2016).

U.S. Census Bureau, Geography Division Census Block Reference Maps http://www2.census.gov/geo/maps/dc10map/GUBlock/st66_gu/county/c66010_guam/ (accessed March 6, 2016).

U.S. Census Bureau International Database, http://www.census.gov/population/international/data/idb/region.php (accessed January 5, 2016)

U.S. Citizenship and Immigration Services, Department of Homeland Security "Cap Count for H2-B nonimmigrants", https://www.uscis.gov/working-united-states/temporary-workers/cap-count-h-2b-nonimmigrants (accessed February 28, 2016)

U.S. Department of Agriculture Natural Resources Conservation Service Pacific Basin, *Management Plan for Ugum Watershed Territory of Guam*, 1995.

U.S. Department of Homeland Security and U.S. Environmental Protection Agency, *Water and Wastewater Systems Sector-Specific Plan*, 2015.

U.S. Department of Homeland Security, *NIPP 2014 Partnering for Critical Infrastructure Security and Resilience,* 2013.

U.S. Department of the Interior National Parks Service Historic American Engineering Record, *Asan Spring Reservoir Photographs, Written Historical and Descriptive Data*, HAER No. GU-10, 2015.

U.S. Department of the Interior National Parks Service Historic American Engineering Record, *Tumon Maui Well (USGS Well No. 80) Photographs, Written Historical and Descriptive Data*, HAER No. GU-8, 2012.

U.S. Environmental Protection Agency, "ARRA Grant Workplan 2009–2012", http://epa.guam.gov/wp-content/uploads/2011/08/Water_Division_ARRA_Workplan_July2011.pdf (accessed October 17, 2016).

U.S. Environmental Protection Agency, "Combined Sewer Overflows — Guidance for Financial Capability Assessment and Schedule Development," EPA 832-B-97-004, February 1997.

U.S. Environmental Protection Agency, "Six-Year Review 3 of Drinking Water Standards", https://www.epa.gov/dwsixyearreview/six-year-review-3-drinking-water-standards (accessed September 19, 2017), 2017.

U.S. Environmental Protection Agency, "Superfund Site: Andersen Air Force Base, Yigo, GU", https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0902825 (accessed October 16, 2016).

U.S. Environmental Protection Agency, "Superfund Site: Ordot Landfill, Agana, GU", https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0902814 (accessed October 16, 2016).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

U.S. Environmental Protection Agency, "Technical Fact Sheet: Perchlorate", https://www.epa.gov/sites/production/files/2014-03/documents/ffrrofactsheet_contaminant_perchlorate_january2014_final.pdf (accessed June 28, 2016), 2014.

U.S. Environmental Protection Agency Office of Water, *Technical Assistance Document: Guide to Groundwater Supply Contingency Planning for Local and State Government* (accessed from nepis.epa.cov, October 4, 2016) 1990.

U.S. Geological Survey Pacific Islands Water Center and University of Guam Water and Environmental Research Institute of the Western Pacific, *Proposal: Groundwater Resources Program for the Northern Guam Lens Aquifer, 2016–2025*, 2014.

U.S. Geological Survey, stream gauge 16854500 Annual 7-day lowest flow and daily flow, http://waterwatch.usgs.gov/index.php?sno=16854500&ds=wy07d_min&btnGo=GO&m=sitempnn (accessed August 30, 2016).

Vann, D., et al, *Topography of the Basement Rock Beneath the Northern Guam Lens Aquifer and its Implications for Groundwater Exploration and Development*, Technical Report No. 142, University of Guam Water and Environmental Research Institute of the Western Pacific, 2014.

Walski, Thomas M, *Water Supply Analysis for the Guam Comprehensive Study*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Prepared for U.S. Army Engineer District, Honolulu Fort Shafter HI 96868 and Office Chief of Engineers, U.S. Army, Washington D.C., 1982.

Water and Environmental Research Institute of the Western Pacific, "Estimating the Natural Limits of the Northern Guam Lens Aquifer: A First Step Toward Sustainable Management", http://www.weriguam.org/pdf/research-projects/guam/2014-approved-projects/LanderJenson14-EstimatingNaturalLimitsNGLA.pdf.

Water Sector Coordinating Council Cyber Security Working Group (WSCCCSWG), *Roadmap to Secure Controls System in the Water Sector,* sponsored by AWWA and USDHS, 2008.

Wikipedia, "H-2B visa", https://en.wikipedia.org/wiki/H-2B_visa (accessed 2/28/2016).

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Appendix A

Asset Management Documentation

- **Appendix A-1. AMPE Gap Chart (updated 2016)**
- **Appendix A-2. AM Implementation Maturity Grid Scoring Rubric**
- **Appendix A-3. Asset Life Cycle Flow Diagram**
- **Appendix A-4. CIP Finance/Accounting Process Flow**
- **Appendix A-5. List of Standard Operating Procedures (SOPs)**

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GWA Asset Management Program Evaluation (AMPE)

Updated October 2016

		1.0 Corporate Asset Management Program																							2.0 Customer Service and Risk Management																	3.0 Asset Planning																							
		1.1 Vision and Support					1.2 Resource Management									1.3 Strategic Asset Management Plan					1.4 Communication				2.1 Levels of Service							2.2 Peformance and Quality Management					2.3 Risk Management					3.1 Asset Development													3.2 Asset Financing and Reporting										
Attribute	Score	Support From Policy Body	Management Direction	Organizational Commitment	Corporate AM Goals And Objectives	**Overall Rating**	Allocation of Resources	Asset Manager Responsibility	Establishment of AM Team	AM Program Overview	AM Program Development	Resources and Progress	Roles and Responsibilites	Employee Development	**Overall Rating**	Assessment of Current Practices	Development of Vision	Analysis of Gaps	Preparation of SAMP	**Overall Rating**	Communications Plan	AM Strategy Awareness	Communication of SAMP	**Overall Rating**	Documented Levels of Service	Measurable Levels of Service	Alignment with Customer Service	Customer's Perspective	Regulatory Compliance Strategy	Regulatory Reporting	**Overall Rating**	Key Performance Indicators	Continual Improvement	AM Program Audit	Exception Reporting	**Overall Rating**	Risk Policy	Risk Identification	Risk Analysis	Risk Mitigation	**Overall Rating**	Origination	Scope for Projects	Alternatives	Life-cycle Costs	Delivery Methods	Operability and Maintainability	Design Requirements	Construction Requirements	Asset Reliability and Assessment Updates	Operating Manuals, Procedures, and Guarantees	Asset Tracking	Process Review	**Overall Rating**	Growth Needs	R&R Needs	Funding Plan	Funding Policies	Historical Trending	Consistency in Reporting	Change Management	Comprehensive Reporting	Budgeting with Objectivity	Cost Forcasting	**Overall Rating**
Optimizing	**100**																																																																
	90																																																																
	80																																																																
Managed	**70**																																																															
	60																																																																
	50																																																																
Defined Approach	**40**																																																															
	30																																																																
Initial	**20**																																																															
Unaware	**10**																																																															
Target Practice Score (1)						####									####					####				####							####					####					####													####											####
Current Score(2) 2016		32	34	35	25	**32**	24	32	35	29	35	25	20	25	**28**	35	19	18	15	**22**	23	22	18	**21**	31	28	24	22	41	62	**35**	24	21	16	16	**19**	16	40	28	23	**27**	27	25	26	26	44	38	34	32	25	53	40	24	**33**	32	29	34	38	34	41	33	36	40	33	**35**
Gap		-32	-34	-35	-25	####	-24	-32	-35	-29	-35	-25	-20	-25	####	-35	-19	-18	-15	####	-23	-22	-18	####	-31	-28	-24	-22	-41	-62	####	-24	-21	-16	-16	####	-16	37	-28	-23	####	-27	-25	-26	-26	-44	-38	-34	-32	-25	-53	-40	-24	####	-32	-29	-34	-38	-34	-41	-33	-36	-40	-33	####
Criticality(3)		4	4	4	4	**4**	4	4	4	4	4	4	4	4	**4**	4	4	4	4	**4**	5	5	5	**5**	5	5	5	5	5	5	**5**	4	4	4	4	**4**	3	5	4	3	**3.75**	5	5	3	4	3	5	4	4	5	5	4	3	**4.17**	5	5	3	3	3	4	3	2	2	2	**3.2**
Weighted Gap (Criticality x Gap)		-128	-136	-140	-100	####	-98	-128	-140	-116	-140	-100	-80	-100	####	-140	-78	-72	-62	####	-113	-112	-92	####	-154	-142	-122	-112	-205	-310	####	-96	-83	-64	-65	####	-48	185	-111	-68	####	-137	-126	-78	-103	-131	-191	-135	-129	-124	-264	-160	-71	####	-160	-145	-103	-114	-103	-164	-98	-72	-80	-66	####
Priority Ranking		3	3	3	3	####	3	3	3	3	3	3	3	3	####	3	3	3	3	####	3	3	3	####	3	3	3	3	3	3	####	3	3	3	3	####	3	1	3	3	####	3	3	3	3	3	3	3	3	3	3	3	3	####	3	3	3	3	3	3	3	3	3	3	####

Optimizing: Continual improvement, refinement of processes, standards and procedures

Managed: Quantitative measurements are defined for processes and quality standards

Defined Approach: Defined repeatable approach that is documented and communicated within the organization

Initial: Reactionary and without a systematic approach

Unaware: Total unawareness within organization

=>150 Priority 1

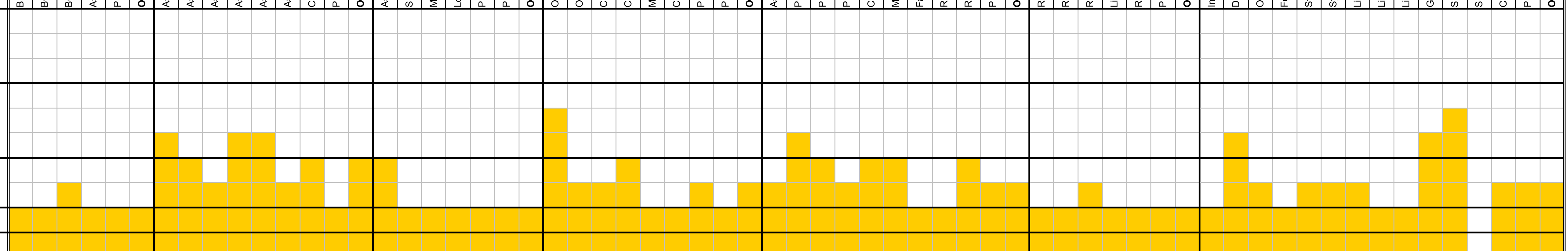
=>90 and < 150 Priority 2

<90 Priority 3

Cells populated with "##" indicate an error in the formulas due to the lack of "vision" scores from GWA.

GWA Asset Management Program Evaluation (AMPE) Updated October 2016

Attribute	Score
Optimizing	100
	90
	80
Managed	70
	60
	50
Defined Approach	40
	30
Initial	20
Unaware	10



3.0 Asset Planning (continued) — 3.3 Business Case Evaluation

Attribute	Business Case Evaluation (BCE)	BCE Process	BCE Training	Asset Decisions	Process Review	**Overall Rating**
Target Practice Score (1)						###
Current Score(2) 2016	26	24	36	27	20	**27**
Gap	-26	-24	-36	-27	-20	###
Criticality(3)	5	4	4	3	3	**3.8**
Weighted Gap (Criticality x Gap)	-131	-96	-144	-81	-61	###
Priority Ranking	3	3	3	3	3	###

4.0 Asset Acquisition — 4.1 Asset Knowledge

Attribute	Asset Detail	Asset Criticality	Asset Classes	Asset Hierarchies	Asset Identification	Asset Inventory	Configuration Management	Process Review	**Overall Rating**
Target Practice Score (1)									###
Current Score(2) 2016	53	48	38	50	51	38	45	28	**44**
Gap	-53	-48	-38	-50	-51	-38	-45	-28	###
Criticality(3)	5	5	4	3	5	5	5	3	**4.4**
Weighted Gap (Criticality x Gap)	-263	-240	-152	-150	-255	-190	-225	-85	###
Priority Ranking	3	3	3	3	3	3	3	3	###

4.0 Asset Acquisition — 4.2 Asset Plans

Attribute	Asset Plans	Short-interval Activities	Maintenance Levels	Long-interval Activities	Project Prioritization	Process Review	**Overall Rating**
Target Practice Score (1)							###
Current Score(2) 2016	48	24	29	24	26	23	**29**
Gap	-48	-24	-29	-24	-26	-23	###
Criticality(3)	3	3	3	3	3	3	**3**
Weighted Gap (Criticality x Gap)	-144	-71	-88	-72	-77	-68	###
Priority Ranking	3	3	3	3	3	3	###

5.0 Asset Operations — 5.1 Operations Strategy

Attribute	Operational Procedures	Operations Costs	Condition Monitoring Methodology	Condition Tracking	Maintenance Scheduling	Corrective Actions	Predictive Maintenance	Process Review	**Overall Rating**
Target Practice Score (1)									###
Current Score(2) 2016	60	34	39	40	27	27	32	24	**35**
Gap	-60	-34	-39	-40	-27	-27	-32	-24	###
Criticality(3)	5	3	4	3	4	3	5	3	**3.8**
Weighted Gap (Criticality x Gap)	-300	-102	-156	-120	-108	-82	-160	-71	###
Priority Ranking	3	3	3	3	3	3	3	3	###

6.0 Asset Maintenance — 6.1 Maintenance Strategy

Attribute	Asset Plan Utilization	PM Definition	PM Scheduling	Predictive Maintenance	Corrective Maintenance	Maintenance Costs	Failure Codes Defined	Root Cause Analysis	Risk and Backlog	Process Review	**Overall Rating**
Target Practice Score (1)											###
Current Score(2) 2016	35	52	42	32	49	49	24	30	43	35	**39**
Gap	-35	-52	-42	-32	-49	-49	-24	-30	-43	-35	###
Criticality(3)	3	4	4	5	5	5	4	4	4	3	**4.1**
Weighted Gap (Criticality x Gap)	-105	-208	-168	-160	-245	-245	-95	-119	-171	-105	###
Priority Ranking	3	3	3	3	3	3	3	3	3	3	###

7.0 Asset Replacement and Rehabilitation — 7.1 Asset Renewal Strategy

Attribute	R&R Planning	R&R Alternatives	R&R Analysis	Life Extensions	R&R Costs	Process Review	**Overall Rating**
Target Practice Score (1)							###
Current Score(2) 2016	25	29	31	22	25	23	**26**
Gap	-25	-29	-31	-22	-25	-23	###
Criticality(3)	5	3	3	3	3	3	**3.3**
Weighted Gap (Criticality x Gap)	-123	-88	-93	-67	-74	-68	###
Priority Ranking	3	3	3	3	3	3	###

8.0 Business Support Tools — 8.1 Information Systems

Attribute	Information System Plan	Data Collection Tools	Operational Data	Forecasting Tools	Standards and Protocols	System Integration Plan	Linked to Inventory/Stores	Linked to Budget/Performance Reporting	Linked to F/A System	GIS Functionality	Supports GASB 34 Depreciation Method	Supports GASB 34 Modified Approach	Change Management Process	Process Review	**Overall Rating**
Target Practice Score (1)															###
Current Score(2) 2016	26	52	35	21	35	35	35	23	24	55	62	0	38	36	**34**
Gap	-26	-52	-35	-21	-35	-35	-35	-23	-24	-55	-62	0	-38	-36	###
Criticality(3)	5	3	4	5	5	2	3	1	1	3	2	1	3	3	**2.9**
Weighted Gap (Criticality x Gap)	-129	-156	-140	-105	-175	-70	-105	-23	-24	-165	-124	0	-115	-107	###
Priority Ranking	3	3	3	3	3	3	3	3	3	3	3	3	3	3	###

Optimizing: Continual improvement, refinement of processes, standards and procedures

Managed: Quantitative measurements are defined for processes and quality standards

Defined Approach: Defined repeatable approach that is documented and communicated within the organization

Initial: Reactionary and without a systematic approach

Unaware: Total unawareness within organization

=>150 Priority 1

=>90 and < 150 Priority 2

<90 Priority 3

Cells populated with "##" indicate an error in the formulas due to the lack of "vision" scores from GWA.

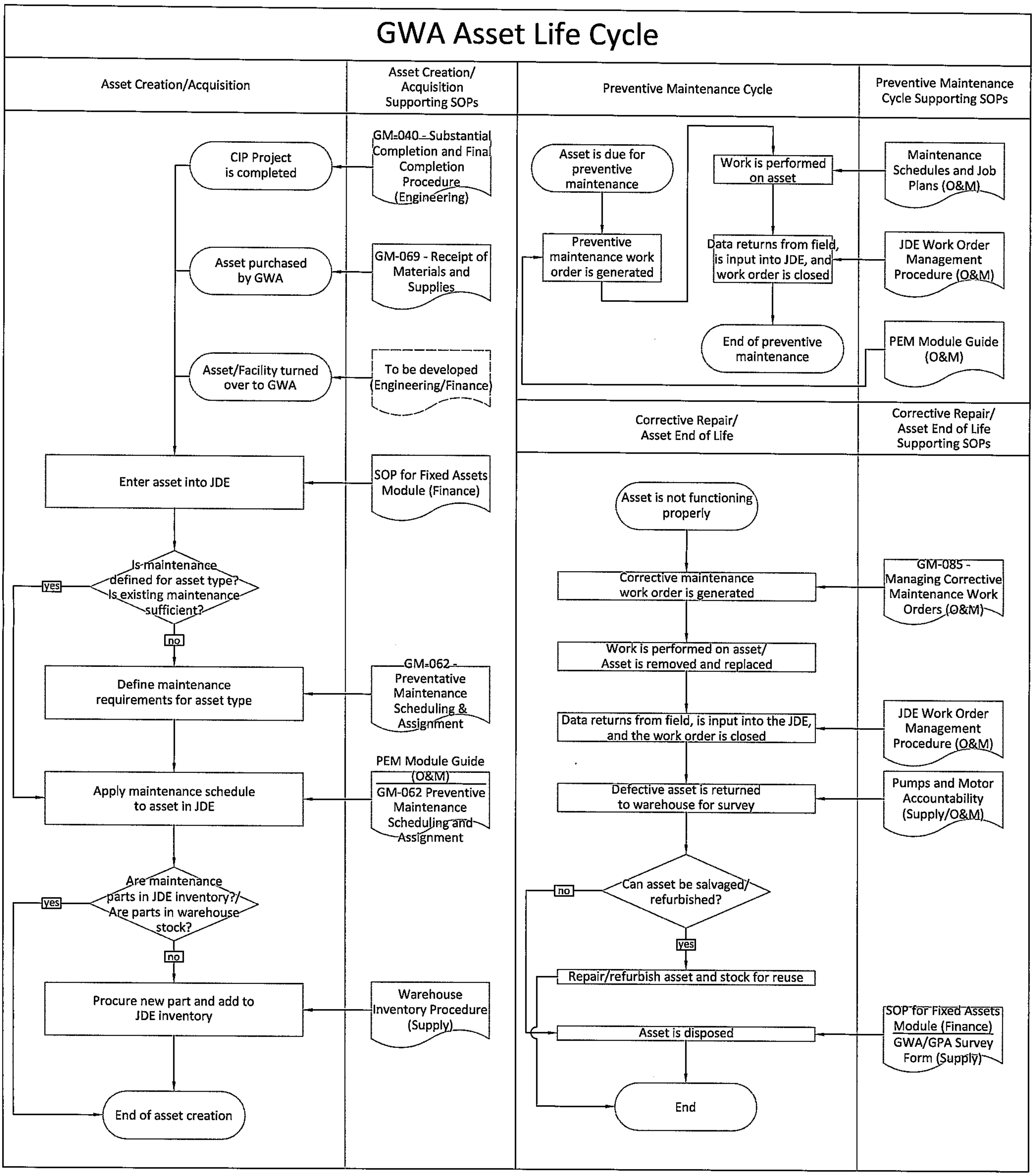
Asset Management Maturity Grid

	Maturity Level				
	Initiation	Developing	Implementing	Maturing	Optimizing
AM Element	1	2	3	4	5
1. Develop levels of service (LOS)	The concept of Levels of Service (LOS) has been discussed and preliminary LOS have been established.	LOS have been demonstrably established and data sources and calculations identified.	LOS are established and data structures, IT solutions, and related work processes to compile data to support LOS metric calculations are in place.	Historical data on LOS is available and compiled. LOS metrics are reviewed at least annually.	Trend analysis on LOS data is performed and correlated to targets with stated AM objectives and investment strategies.
2. Define operating procedures	Basic and/or ad hoc operating standards are established for O&M.	SOPs address planning, operations and maintenance for system capacity, and quality. Basic engineering and construction standards are established to validate material and construction standards for procurement.	Data structures, IT solutions, and related work processes to compile data to support operating metrics are in place. Conformance to operating standards is assessed on a set schedule.	Design and construction standards are established and enforced to manage the physical/functional configuration and placement of assets. Adequate training is provided for GWA staff to support system processes.	Trend analysis of asset life-cycle functionality are recorded and shared. Lessons learned (success and failures) are shared
3. Establish asset definitions	Establish the definition of an asset by policy.	Asset hierarchy is established and inventory data structure established.	Asset definition has been incorporated into GWA's IT systems, and inventory data throughout the water and wastewater systems has been assessed and verified.	Asset definition is reviewed regularly (at least annually) asset inventory is updated as needed.	Annual asset audits are established to validate inventory data in GWA IT systems consistent with current definition of an asset.
4. Organize inventory data	Asset hierarchy outline has been established. Organizational data logic is defined to include the definition of an asset as well as spatial, and functional details.	Asset hierarchy is established and inventory data structure established.	Incorporate the asset hierarchy into GWA's database structure and consistently use this framework to configure a comprehensive inventory acquisition and validation activity.	Asset inventory data structure is evaluated regularly for appropriateness and IT systems are kept up to date.	Permanently establish and exercise rigorous audits on a recurring annual basis to ensure inventory data maintained in GWA IT systems fully complies with the approved asset hierarchy.

	Maturity Level				
	Initiation	Developing	Implementing	Maturing	Optimizing
AM Element	1	2	3	4	5
5. Build an asset inventory	Understand the requirements for identifying and tracking water and wastewater assets	Measure the comprehensiveness, accuracy, and validity of data currently existing in GWA's IT systems.	Commission and complete comprehensive inventory acquisition and validation initiatives using the asset definition and hierarchy established in Steps 3 & 4.	Asset inventory is updated and verified regularly	Obtain a clean audit based upon an inventory of all physical assets in the field used to deliver safe, compliant water and wastewater services on Guam.
6. Establish asset criticality and deficiency criteria	Understand the use of asset condition information with asset criticality to prioritize actions.	Establish SOP to perform asset assessments using operating, engineering, and maintenance standards to determine asset deficiencies. Establish SOP to perform a criticality assessment, linked to organizational objectives. Asset criticality is tied to established levels of service (LOS) and consequence of failure	A comprehensive criticality assessment of all assets has been performed with results stored in a central database. An IT tool to store, analyze, and report on this data making it accessible for decision making, including management of resources is available	Asset criticality data is used systematically to prioritize repair and replace decisions and develop responsible investment strategies.	Criticality data is used optimize and harmonize GWA's growing body of formal operating, engineering, and maintenance standards reducing risk through organizational learning incorporated into continuously improved enterprise-wide standards.
7. Collect deficiency information	The use of asset deficiency criteria based on failure mode criticality and assessment criteria is recognized.	Process to assess assets based on criticality is in place.	A comprehensive assessment of all assets has been conducted and deficiency data recorded in a central database.	Asset assessment data is used to systematically prioritize O&M and CIP resource decisions.	AM lessons learned are used to improve AM processes, the PM program, and an updated deficiency data baseline.

	Maturity Level				
	Initiation	Developing	Implementing	Maturing	Optimizing
AM Element	1	2	3	4	5
8. Develop an O&M program	The need for SOP defining the AM practices and requirements for a centrally managed O&M Program are recognized and an action plan identified.	A core set of SOP defining the AM practices and requirements for a centrally managed O&M Program are established and documented.	Enrollment of all "critical assets" into a formal PM Program. IT systems are installed and configured for efficient collection and reporting of maintenance data. Implementing SOP for - Routine assessments - Criticality assessment of assets - Asset criticality use in resource prioritization - Economic analysis for asset life cycles.	Enrollment of "critical assets" and 75% of all asset types into a formal PM Program. O&M SOPs are expanded as needed to address managerial objectives and facilitate the continuous improvement process. A comprehensive O&M requirements-based budget is defined.	Develop, implement, and continuously improve a systematic process of optimizing O&M investment strategies and harmonizing them with CIP investment strategies.
9. Advance capital improvement program (CIP)	There is general awareness of expected active service life for assets.	Process to establish and capture asset service life is developed. Procedures and transactional processes have been identified to integrate finance and accounting, budgeting, engineering cost estimating and maintenance cost accounts.	Capital improvement plans consider O&M data regarding replacement requests. Procurement/bid specifications include requirements for life cycle cost analysis (component materials, expected lifetime, warranties, etc). Assets placed in service are entered into inventory.	O&M data used to develop capital renewal plans, including strategic allocation of resources.	Develop, implement, and continuously improve a systematic process of optimizing CIP investment strategies and harmonizing them the O&M investment strategies.

	Maturity Level				
	Initiation	Developing	Implementing	Maturing	Optimizing
AM Element	1	2	3	4	5
10. Integrate O&M and CIP activities	CIP decisions incorporate O&M data inputs. One or more KPI integrating O&M and CIP objectives are defined.	KPIs are defined to harmonize O&M and CIP investment strategies including: % services that comply with operating standards across the customer base. (Operational Availability) % assets that comply with engineering and maintenance standards across the customer base (Affordable Readiness)	Methods to calculate performance data based on activity-based costing and asset-based costing criteria are implemented leveraging data conventions used in GWA's IT systems. CIP performance achieving optimal asset service life in measured.. IT solution is implemented to streamline the collection and reporting asset service life data.	Use of business case analysis using activity-based costing and asset-based costing criteria. Performing trend analysis to evaluate CIP Program performance using established KPIs. Developing IT solutions for data capture and reporting.	Identify, develop, install, and optimize IT solutions to perform a systematic comparison of O&M and CIP programs including comparison of combined O&M and CIP investment strategies over time and in the current year comparing requirements-based budget, the funded budget, and the budget actually expended.
11. Monitor performance	An AM program manager is identified and an AM steering committee is operating at a strategic level.	Performance is monitored in terms of inputs, such as evaluating progress implementing the proposed AM Program.	Operational improvements include a sustained reduction in the number of leaks or a progressive decrease in corrective work orders.	Monitor performance in terms of outputs, such as completing a comprehensive asset inventory, criticality assessment products, and the list of deficiencies produced by the comprehensive asset assessment.	Performance is monitored in terms of outcomes, such as through increasing utilization of operational availability and affordable readiness metrics as part of routine time series analyses.
12. Continual Improvement	The asset management road map and progress plan have been created.	The road map and progress plan have been reviewed within the past year. Performance data collection plan is created.	Performance data is collected, analyzed and evaluated by senior management over the past year and the AM implementation plan has been adjusted accordingly.	Performance data and senior management decisions to modify system elements are documented and communicated to staff with appropriate training provided.	Performance data is shared with key stakeholders and improvement plans are collaboratively developed.

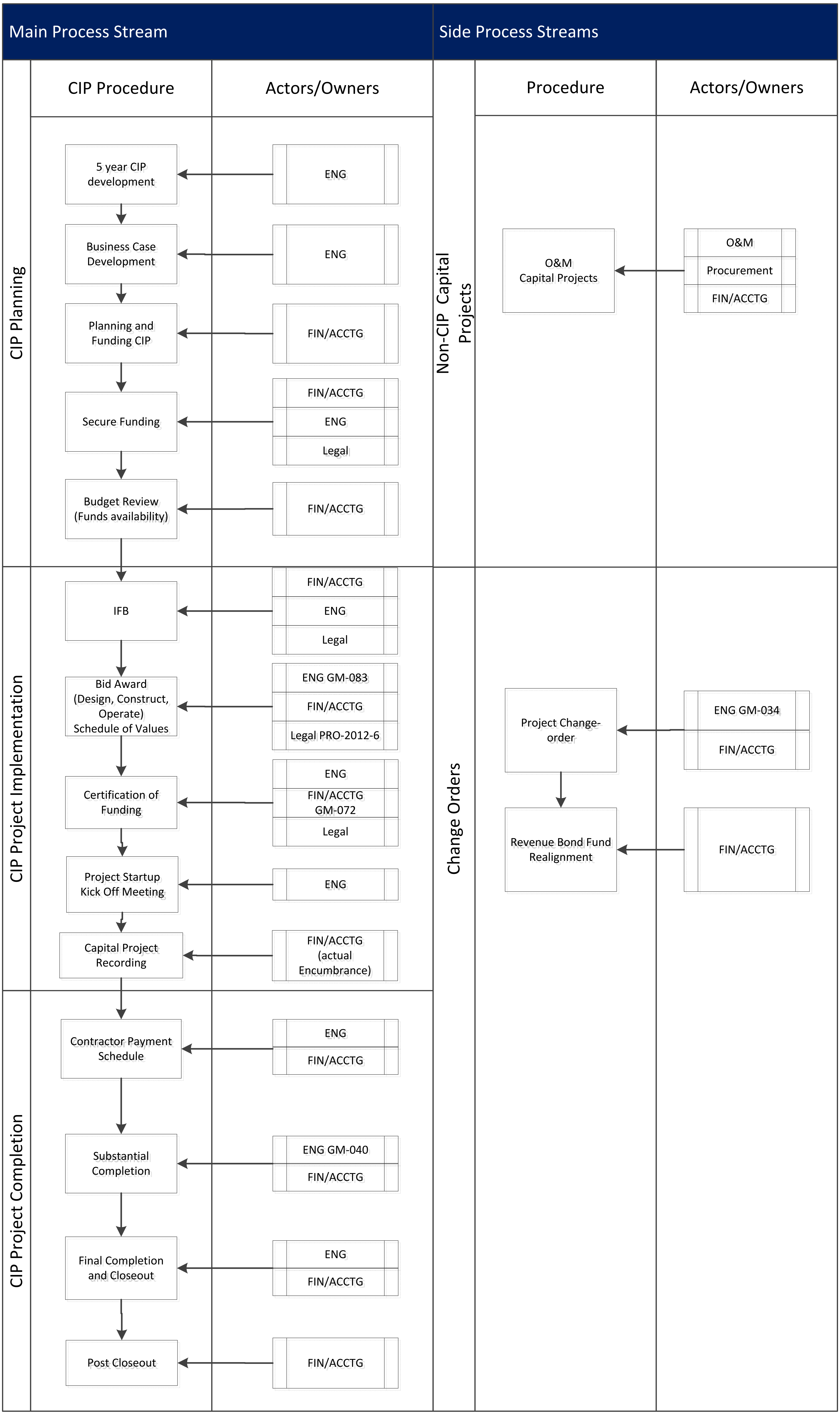


GWA Asset Life Cycle
Asset Creation/Acquisition
Asset Creation/ Acquisition Supporting SOPs
Preventive Maintenance Cycle
Preventive Maintenance Cycle Supporting SOPs
CIP Project is completed
GM-040 - Substantial Completion and Final Completion Procedure (Engineering)
Asset purchased by GWA
GM-069 - Receipt of Materials and Supplies
Asset/Facility turned over to GWA
To be developed (Engineering/Finance)
Enter asset into JDE
SOP for Fixed Assets Module (Finance)
Is maintenance defined for asset type? Is existing maintenance sufficient?
yes
no
Define maintenance requirements for asset type
GM-062 - Preventative Maintenance Scheduling & Assignment
Apply maintenance schedule to asset in JDE
PEM Module Guide (O&M)
GM-062 Preventive Maintenance Scheduling and Assignment
Are maintenance parts in JDE inventory?/ Are parts in warehouse stock?
yes
no
Procure new part and add to JDE inventory
Warehouse Inventory Procedure (Supply)
End of asset creation
Asset is due for preventive maintenance
Preventive maintenance work order is generated
Work is performed on asset
Maintenance Schedules and Job Plans (O&M)
Data returns from field, is input into JDE, and work order is closed
JDE Work Order Management Procedure (O&M)
End of preventive maintenance
PEM Module Guide (O&M)
Corrective Repair/ Asset End of Life
Corrective Repair/ Asset End of Life Supporting SOPs
Asset is not functioning properly
Corrective maintenance work order is generated
GM-085 - Managing Corrective Maintenance Work Orders (O&M)
Work is performed on asset/ Asset is removed and replaced
Data returns from field, is input into the JDE, and the work order is closed
JDE Work Order Management Procedure (O&M)
Defective asset is returned to warehouse for survey
Pumps and Motor Accountability (Supply/O&M)
Can asset be salvaged/ refurbished?
no
yes
Repair/refurbish asset and stock for reuse
Asset is disposed
SOP for Fixed Assets Module (Finance)
GWA/GPA Survey Form (Supply)
End

This page is intentionally left blank.

GWA CIP Finance/Accounting Life Cycle

GUAM WATERWORKS AUTHORITY



Draft July 2, 2015

This page is intentionally left blank.

General Manager's Standard Operating Procedures – Index of SOPs			
Tab No.	SOP No.	SOP Date	SOP Title
1	SP3010-18 GWA	06/09/11	Standard Technical and Temporary Pavement Specification for Roadway Repair
2	SP0310-19 GWA	08/09/11	Substantial Change in Water System
3	GM-001 GWA	10/06/11	Consolidated Commission on Utilities Agenda Timelines
4	GM-002 GWA	10/06/11	Resolutions to Consolidated Commission on Utilities
5	GM-003 GWA	10/06/11	General Manager's Commission Communications
6	GM-004 GWA	01/19/12	Planned Water Outages
7	GM-005 GWA	01/19/12	Mayors' Council Liaison Program
8	GM-006 GWA	02/21/12	Dispatch Control Center
9	GM-007 GWA	02/21/12	Project Management Monthly Report
10	GM-008 GWA	05/07/12	Inventory Obsolescence Policy
11	GM-009 GWA	01/24/13	Tools Accountability
12	GM-010 GWA	01/22/13	Overtime
13	GM-011 GWA	02/14/13	Approvals Required to Utilize Capital Improvement Project Funds
14	GM-012 GWA	04/01/13	Official Vehicle and Key Accountability
15	GM-013 GWA	04/08/13	Pump and Motor Accountability (Note: This SOP will be superseded by SOP No. GM-108)
16	GM-014 GWA	04/18/13	Employees at Dispatch Setting the Messages on the Answering Machine at the Dispatch Office
17	GM-015 GWA	10/30/13	24 Hour Official Vehicles
18	GM-016		Intentionally left blank – per GM Martin Roush's instructions
19	GM-017		Intentionally left blank – per GM Martin Roush's instructions

20	GM-018		Intentionally left blank – per GM Martin Roush's instructions
21	GM-019		Intentionally left blank – per GM Martin Roush's instructions
22	GM-020		Intentionally left blank – per GM Martin Roush's instructions
23	GM-021		Intentionally left blank – per GM Martin Roush's instructions
24	GM-022		Intentionally left blank – per GM Martin Roush's instructions
25	GM-023		Intentionally left blank – per GM Martin Roush's instructions
26	GM-024		Intentionally left blank – per GM Martin Roush's instructions
27	GM-025		Intentionally left blank – per GM Martin Roush's instructions
28	GM-026		Intentionally left blank – per GM Martin Roush's instructions
29	GM-027		Intentionally left blank – per GM Martin Roush's instructions
30	GM-028		Intentionally left blank – per GM Martin Roush's instructions
31	GM-029		Intentionally left blank – per GM Martin Roush's instructions
32	GM-030		Intentionally left blank – per GM Martin Roush's instructions
33	GM-031 CDM Smith	07/09/12	Constructability, Operability, and Review Procedure
34	GM-032 CDM Smith	07/09/12	Quality Management Procedure
35	GM-033 CDM Smith	07/09/12	Schedule Management During Construction Procedure
36	GM-034 CDM Smith	07/09/12	Change Order Procedure
37	GM-035 CDM Smith	07/09/12	Risk Management Procedure
38	GM-036 CDM Smith	07/09/12	Communications management Procedure
39	GM-037 CDM Smith	07/09/12	Commissioning Procedure

40	GM-038 CDM Smith	07/09/12	Schedule of Values and Construction Contractor Payment Procedure
41	GM-039 CDM Smith	07/09/12	Inspection Procedure
42	GM-040 CDM Smith	07/09/12	Substantial Completion & Final Completion Procedure
43	GM-041 CDM Smith	07/09/12	Capital Project Nomination Procedure
44	GM-042 CDM Smith	07/09/12	Business Case Procedure
45	GM-043 CDM Smith	07/09/12	Annual CIP Development Procedure
46	GM-044 CDM Smith	07/09/12	CIP Approval Procedure
47	GM-045 CDM Smith	07/09/12	Unplanned Projects Procedure
48	GM-046 CDM Smith	07/09/12	Design and Construction Management Cost Management Procedure
49	GM-047 CDM Smith	07/09/12	Construction Cost Estimate Close-Out Assessment Procedure
50	GM-048 CDM Smith	07/09/12	Construction Cost Estimating for CIP Procedure
51	GM-049 CDM Smith	07/09/12	Construction Cost Estimating for Planning Procedure
52	GM-050 CDM Smith	07/09/12	Construction Cost Estimating for Design Procedure
53	GM-051 CDM Smith	07/09/12	Preconstruction Kick-Off Meeting Procedures
54	GM-052 CDM Smith	07/09/12	Construction Contract Management Procedure (where is original?)
55	GM-053 CDM Smith	07/09/12	Request for Information (RFI) Management Procedure
56	GM-054 CDM Smith	07/09/12	Change Order Management for Consulting Service Procedure
57	GM-055 CDM Smith	07/09/12	Engineers Reporting Procedure
58	GM-056 CDM Smith	07/09/12	Construction Contractor Performance Evaluation Procedure
59	GM-057 CDM Smith	07/09/12	Construction Manager Performance Evaluation Procedure

60	GM-058 CDM Smith	04/25/13	O&M Program Management Requirements
61	GM-059 CDM Smith	04/25/13	Asset Inventory Management
62	GM-060 CDM Smith	04/25/13	Asset Inventory Management QA/QC
63	GM-061 CDM Smith	04/25/13	Preventative Maintenance Program
64	GM-062 CDM Smith	04/25/13	Preventative Maintenance Scheduling & Assignment
65	GM-063 CDM Smith	04/25/13	Maintenance History Analysis
66	GM-064 CDM Smith	04/25/13	O&M Requirements-Based Budget Development
67	GM-065 CDM Smith	04/25/13	O&M Performance Management
68	GM-066 CDM Smith	04/25/13	O&M Program Key Performance Indicators
69	GM-067 CDM Smith	05/22/13	Preparation of Requisition for Materials and Supplies (PRO2012-1)
70	GM-068 CDM Smith	05/20/13	Preparation of Purchase Order (PRO2012-2)
71	GM-069 CDM Smith	05/20/13	Receipt of Materials and Supplies (PRO2012-3)
72	GM-070 CDM Smith	05/20/13	Preparation of Blanket Purchase Agreements (PRO2012-4)
73	GM-071 CDM Smith	05/06/13	Preparation or Emergency Purchase Order (PRO2012-5)
74	GM-072 CDM Smith	05/06/13	Funds Certification for Professional Services and Construction (PRO2012-7)
75	GM-073 CDM Smith	05/22/13	Advertisement for RFP and IFB Procurement (PRO2012-8)
76	GM-074 CDM Smith	05/22/13	Documentation of Procurement (PRO2012-9)
77	GM-075 CDM Smith	05/24/13	Pre-proposal Meeting for Professional Services (PRO2012-11)
78	GM-076 CDM Smith	05/22/13	Receipt of Proposals (PRO2012-12)
79	GM-077 CDM Smith	05/24/13	Conducting Interviews for Professional Services Proposals (PRO2012-14)

80	GM-078 CDM Smith	05/24/13	Professional Services Contracts Negotiations (PRO2012-15)
81	GM-079 CDM Smith	05/24/13	Preparation of Invitation for Bid for Construction (PRO2012-17)
82	GM-080 CDM Smith	05/24/13	Pre-Bid Meeting for Construction (PRO2012-18)
83	GM-081 CDM Smith	05/20/13	Receive Construction Bids (PRO2012-19)
84	GM-082 CDM Smith	05/24/13	Construction Bid Evaluation (PRO2012-20)
85	GM-083 CDM Smith	05/22/13	Construction Bid Award (PRO2012-21)
86	GM-084 CDM Smith	06/03/13	Professional Services Proposal Evaluation (PRO2012-13)
87	GM-085 CDM Smith	09/16/13	Managing Corrective Maintenance Work Orders (PRO2013-01)
88	GM-086 CDM Smith	09/13/13	Legal Review Procurement (PRO2012-6)
89	GM-087 CDM Smith	09/03/13	Preparation of Request for Proposal for Professional Services (PRO2012-10)
90	GM-088 CDM Smith	09/03/13	Award Professional Services Contract (PRO2012-16)
91	GM-089 GWA	07/14/14	Recovery for Damages Incurred by Contractors and Private Individuals
92	GM-090 GWA	12/22/14	Dispatch Control Center
93	GM-091 GWA	Draft 03/13/15	Resolution of Chronic Customer Water and Wastewater Issues
94	GM-092 GWA	Draft 04/08/15	Turnaround time for documents
95	GM-093 GWA	09/29/15	Procedures and Operators' Responsibility During the Use of Gov't. Vehicles and GWA Driving Safety Policy
96	GM-094 GWA	D1-5/5/15 D2-8/5/16	Regulatory Requirements, Filing of Petitions, Financial Reporting, and Other Submissions to the PUC
97	GM-095 GWA		Security and Access Control (Zina)
98	GM-096 GWA		Overtime (Ann)
100	GM-097 GWA		GIS (Ann and Geigy)

101	GM-098 GWA		Tracking Vehicles (?)
102	GM-099 GWA		Chlorine Hazards (?)
103	GM-100 CDM Smith	10/01/15 pending	Conducting Routine Assessments (Joe Tadeo) GM had suggested changes – 07.25.16
104	GM-101 CDM Smith	10/01/15 pending	Determination of Criticality and Assessment of Risk (Joe Tadeo) GM had suggested changes – 07.25.16
105	GM-102 CDM Smith	10/01/15 pending	Asset Repair or Replacement Decision Process (Joe Tadeo) GM had suggested changes – 07.25.16
106	GM-103 CDM Smith	10/01/15 pending	Receiving Infrastructure Assets from 3rd Party (Joe Tadeo – still being reviewed by AM team)
107	GM-104 CDM Smith	10/01/15 pending	Economic Analysis of Asset Portfolio (Joe Tadeo) GM had suggested changes – 07.25.16
108	GM-105 GWA	01/22/16	GWA SCC Reports
109	GM-106 GWA	01/22/16	GWA Full Day Tank Level by Zones Report
110	GM-107 GWA	01/22/16	GWA Daily Storage Facilities Log Report
111	GM-108 GWA	12/30/15 pending	Pump & Motor Accountability Route to SCC (This will supersede SOP No. GM-013 - pending)
112	GM-109 CDM Smith	pending	Secure Revenue Bond Funds (pending GM review and signature)
113	GM-110 CDM Smith	04/06/16	Revenue Bond Fund Reprogramming
114	GM-111 CDM Smith	04/06/16	Fund Availability for Professional Services and Construction – Budget Review Only
115	GM-112 CDM Smith	04/06/16	Funds Certification for Professional Services and Construction
116	GM-113 CDM Smith	pending	Change Order Accounting (pending GM review and signature)
117	GM-114 CDM Smith	pending	O&M Capital Procedure (per GM, as requested by Finance to be revised and sent to Procurement)
118	GM-115 CDM Smith	04/09/16	CIP Project – Payment
119	GM-116 CDM Smith	04/11/16	CIP Project – Substantial Completion Payment
120	GM-117 CDM Smith	pending	Final Completion Payment (Per GM, to be edited and revised)

121	GM-118 CDM Smith	04/11/16	CIP Project – Closeout Accounting
122	GM-119 CDM Smith	04/11/16	CIP Project – Reporting
123	GM-120 GWA	04/09/2016	Physical Security & Access Control System (Keys and keycards)
124	GM-121 GWA	HOLD 08/05/2016	Government Claims Policy and Procedures
125	GM-122		

Highlighted SOP indicate that they are under revision or review.

This page is intentionally left blank.

Appendix B

SCADA Field Assessment

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Section 1

SCADA Field Assessment

1.1 Assessment Methodology

It should be noted that the GWA 2014 SCADA master plan field investigated only about 25% of the remote sites and 2006 WRMP included site assessments of the majority of GWA's sites. No formal field assessment was done as part of this master plan update since only a small sample of sites were available for site visits. Never the less, the same methodology to rate the field site condition was used.

The methodology used consisted of observations of the existing SCADA and control equipment. The 2006 WRMP rating scale was used and is presented in Table 1-1.

Table 1-1. Assessment Rating Scale

System Rating	Description of Equipment State
0	Required equipment is missing or not present. Equipment is not operating or repairable. New equipment is required.
1	Equipment is present but in poor condition. Equipment is not operating but may be repairable. If repaired, it probably has a short remaining life.
2	Equipment is present and in fair condition. Equipment may be operational but require other elements of the system to be functional. Equipment requires maintenance and repairs.
3	Equipment is present and in moderate condition. Equipment is operational. Routine maintenance being performed.
4	Equipment is present and in like new condition. Equipment is operational and newly installed.

Each pump station was divided into separate subsystems, to which a weighted value was assigned. The total was then added to arrive at a station assessment value. The maximum value for any station would be 4. Only whole integers were used to compile the assessment, whereas the weighted average value was computed to the nearest decimal ten. The final value for each station was rounded to the nearest tenth.

A summary and an explanation of the ratings for each type of the station are presented in the following subsections. These ratings can be used as a comparative reference in future assessments.

1.1.1 Assessment Weighting Factors

Weighting factors for each area of the pump station or system were assigned based on their importance from a control standpoint. Factors that affect the operation of the station were given higher consideration while those that provide a supporting role, although important to the end product, were given lesser consideration.

The presence and condition of the elements needed to form a complete control system were also a factor in the evaluation process. Equipment that was intact (i.e., sealed from the environmental elements) and likely to be easily repaired was rated higher.

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

The percentage weight assigned to a subsystem is shown in parenthesis in Section 1.1.2. This is the value assigned to that portion in comparison to the whole.

1.1.2 Water System Assessment Explanation

At the well and booster water pump stations, the pump controls, chlorination system controls, and pump bypass controls and SCADA PLC were assessed. A value of zero through four was assigned and weighted as follows:

1.1.2.1 Pump Controls – 50% of Station Value

- Automatic Pump Controls (30%) – This value is based on the ability of the control system to operate automatically through an external system such as the SCADA system. The rating is higher if all elements of the system are intact and operational.
- Manual Pump Controls (15%) – This value is based on the ability of the control system to operate in a manual mode through a local control switch. This rating is higher if the local control or mechanical bypass means are available and can be safely operated by non-electrical personnel.
- Motor Protection Controls (5 %) – This value is based on the application of motor protective devices at the station, such as Class 10 overload protection, phase monitor, motor protective devices, surge protection and motor thermal switches. The rating is higher when a higher degree of protection is provided, without any protective device being bypassed or removed.

1.1.2.2 Chlorination System Controls – 25% of Station Value

- Automatic Pump Controls (10%) – This value is based on the ability of the control system to operate automatically. The controlling items are the field instrumentation of flow switches and being interlocked with the main pump starter.
- Manual Pump Controls (10%) – This value is based on the value of the control system to operate safely through a local control device. The rating is higher if this local device is protected and interlocked with the main pump controller.
- Chlorination Control Valves (5 %) – This value is based on the ability of the chlorination system to shut off any chlorine flow when the system is shut down. A valve or other device to prevent such flow will improve the rating.

1.1.2.3 Pump Bypass Controls – 10% of Station Value

- Valve Controls (5%) – This value is based on the bypass system having the essential elements for operation from the electrical controls to the valve, limit switch and control piping. Having all the elements improves the rating.
- Automatic Valve Actuator (5 %) – This value is based on the presence and condition of the valve actuator. Lack of corrosion and the degree of maintenance improve this rating.

1.1.2.4 SCADA PLC – 15% of Station Value

- SCADA PLC (5 %) – In the 2006 WRMP, this value was based on the presence and condition of the Motorola RTU unit. In this update, the presence of a local PLC will be reviewed instead. The essential elements of the power supply, control module, input and output modules and wiring affect the rating.
- SCADA Antenna and Cabling (2.5 %) – This value was based on the presence and condition of the RTU antenna and communication cabling. Antennas and communications cabling are not present in the current systems.

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

- Enclosure (2.5 %) - This value is based on the condition and location of the PLC (originally RTU) enclosure. Installations within the generator building or under the eave score higher. Those located on the building exterior or exposed to the elements are rated lower because of the heavy corrosion on the protective enclosure.
- Flow meter and Sensor (2.5 %) – This value is based on the condition of the flow transmitter and receiver. The value is higher when the unit is operational and lower when one element is missing. Stations where the newer flow meters with signal output capability were installed, but are not yet operational, were rated lower.
- Pressure Transducer and Alarm (2.5 %) – This value is based on the presence and condition of the pressure transducer and pressure switch and their integration into the SCADA system. A higher rating was given to those stations where the transducer is located downstream of the wellhead rather than at the wellhead. The presence of a pressure transducer with intact wiring also improved the rating.

1.1.3 Wastewater Pump Station Assessment Overview

The evaluation format used at the wastewater pump stations was similar to that used for the water pump stations. The pump controls, sump pump and SCADA RTU elements were considered and assessed:

1.1.3.1 Pump Controls – 70% of Station Value

- Automatic Pump Controls (40%) – This value is based on the station's use of an operational level control system for pump control. The condition of the wiring, motor starter, control relays and control cabinet affect the rating. A higher value was given to those stations where all elements of a newly installed pump control cabinet were operational. A lower value was assigned to stations with cabinets that contained modified wiring or control equipment.
- Manual Pump Controls (20%) – This value is based on the ability of the control system to operate safely through a manual selector at a local control device. This function requires operator intervention to maintain the wet well level.
- Motor Protection Controls (10%) – This value is based on the application of motor protective devices at the station, such as thermal overload protection, phase monitor, surge protection and motor winding thermal switches. The rating is higher when a higher degree of protection is implemented, without any protective device being bypassed or removed.

1.1.3.2 Sump Pump – 10% of Station Value

- Control Cabinet (5 %) – The operational condition and location of the control cabinet affect this rating. Locating the control cabinet in the drywell decreases this rating.
- Level Control (5 %) – The presence of a float or other level control device is essential for automatic operation. Stations where a sump pump was manually operated were rated lower.

1.1.3.3 SCADA PLC (was RTU) – 20% of Station Value

- SCADA PLC (10%) – This rating is based on the presence and condition of the essential elements of the SCADA PLC. Items such as the power supply, control and input/output modules and wiring affect this rating.
- SCADA Antenna and Cabling (5 %) – This value is based on the presence and condition of the SCADA antenna and cabling.

Enclosure (5 %) – This value is based on the condition and location of the PLC equipment enclosure. Units installed within a building or under the building eave were scored higher than those located on the windward side of the building or completely exposed to the environment.

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

1.2 SCADA & Control System Site Observations

Site visits were made to a small selection of water wells, a booster pump station, the Ugum Water Plant and to one of the wastewater pump stations. The observations noted during these visits are discussed below.

1.2.1 SCADA Observations

1.2.1.1 SCADA General Observations

During the field visits, only a single existing Motorola SCADA system was seen at the wastewater pump station. The Motorola radio system is no longer being used for SCADA data and most of the Motorola RTUs have been removed from the sites that were visited in August 2016.

1.2.1.2 Water Pump Stations

The following is a summary of existing SCADA system observations relating to the system in place at the water pump stations A-1, A-18, A-21. These were located in the Northern and Central Districts.

- The analog input signals (flow and pressure) were wired to the analog input module. Discrete status input points (e.g., pump run, generator run, power fail and chlorine detection) were not wired at most stations although wiring was present at the PLC.
- At most of the sites, the well pressure transducer was present; however; the pressure switch had deteriorated.
- The field wiring and raceways were intact at many well location sites.
- The chlorination and pump system leak detection were not monitored by the SCADA system at any of the observed locations.

1.2.1.3 Water Booster Stations

The water booster pump stations generally serve to transfer water from one reservoir or area to a higher reservoir or tank. The following observations relate to the water booster pump stations:

- The booster pump stations were located in areas where the gravity tanks could not provide the needed line pressure.
- The pump motors were the horizontal air cooled type.
- Generator backup power was provided.

1.2.2 Control System Observations

1.2.2.1 Water Well Pump Stations

Most of the deep well water pump stations (A-1, A-18, A-21) are currently operating in the manual control mode and do not utilize inputs from the instrumentation. Changes to the equipment operation are made when operators visit the site.

At Puag Chaot A-1 Station, a SCADA Pack 334 PLC is installed with a Comtrend DSL modem and the auto mode is controlled via the Chaot Reservoir.

A-18 has an alarm panel but A-21 has no control panel.

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

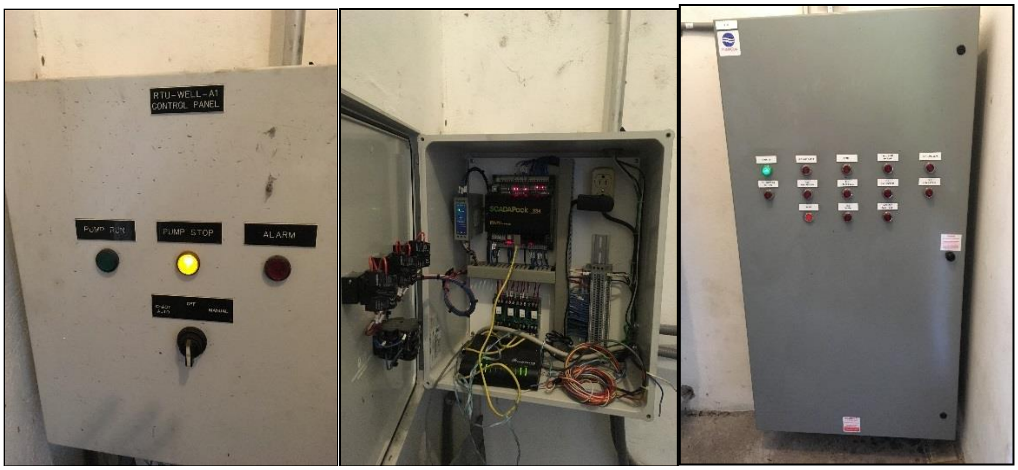


Figure 1-1. Control Panels at Wells A-1 and A-18

Pump Bypass Valve

The original piping and pump control system incorporates a process for the automatic divergence of the initial pump output to a bypass line. There was evidence that this automatic start procedure was operational or could be made operational at the newer well stations. Without such an automatic process in place, injection of mud and debris or chlorine slugs could be injected into the potable water system.

The control system is designed so that the bypass control valve will be in the normally open position when the pump is not operational. When the pump becomes operational, the valve actuator solenoid is energized by the pump control system, thereby allowing pump flow to be directed to the closing diaphragm of the valve. The initial pump output is diverted to the bypass line. The duration of this bypass flow is set by the timing valve. When the bypass valve is closed, the pump output is forced into the line through the check valve.

The opposite is true when the pump is turned off. In that case, the flow is diverted to the bypass line, allowing the check valve to gently close to reduce the effect of water hammer on the system. When the bypass valve is partially opened to actuate the limit switch on the valve, the motor is turned off.

The site at A-1 has a manual bypass (without electric actuation), site A-18 has a bypass valve with a solenoid, but it is corroded and in need of repair, and site A-21 has a manual bypass (without electric actuation).

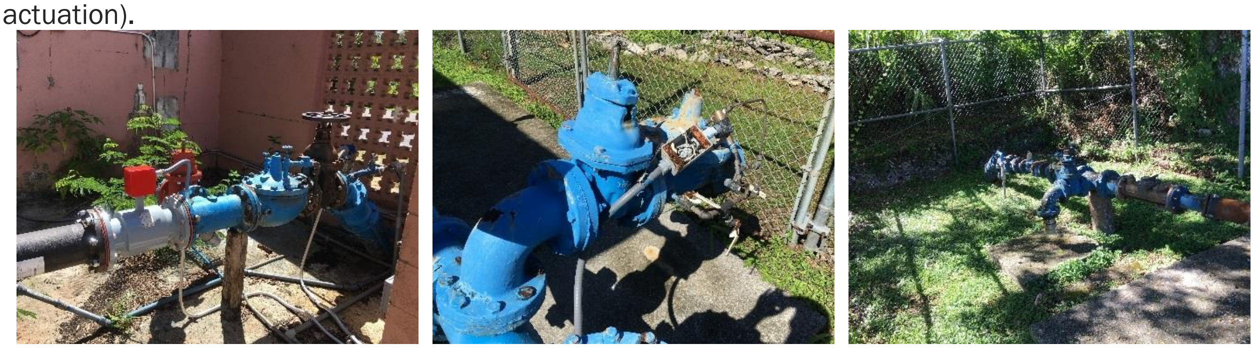


Figure 1-2. Well Discharge Piping at Wells A-1, A-18, and A-21

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

Pump Controls

The well pump control system is designed for external control through the SCADA system while in the automatic mode of operation. This setup provides input from the associated tank level controller programmed to the SCADA computer or through remote operator intervention. Since the SCADA system is not operational, the wells have been functioning in manual mode.

The A-1 site automatic mode is through Chaot. Both site A-18 and site A-21 had no automatic mode.

Chlorination Controls

The chlorination of the well water relies on manual monitoring and setting of the chlorine injection control valve. A chlorination pump is used to inject a chlorine solution into the well discharge line that is based on the well flow rate.

In automatic mode, the chlorine pump controls were found to be interlocked to be dependent on the well pump operation controls; however, the operation of the well pump is independent of the chlorination pump. At one of the stations, the chlorination pump operated when in HAND control mode, without the well in operation. This feature needs to be reconfigured with a spring return operator to allow for temporary operation to check for motor rotation and testing; otherwise, chlorination liquid could be injected into the line or the pump will attempt to pump “dry”.

Pump Instrumentation

Lack of monitoring water pressure also reduces system effectiveness and efficiency. Since there are no control communications in place between the reservoirs and their respective pump stations, it is impossible for the pump stations to cycle at the proper times to maintain a desired reservoir level.

The following is a list of instrumentation and related devices that should be operational at all deep well water pump stations to operate the system properly, safely and efficiently.

- <u>Wellhead pressure monitoring</u>: Used to protect the pump from excessive pressures resulting from valve failure or blockage and also to confirm that the pump is operating within design pressure range.
- <u>Water flow meter</u>: Used to meter total water produced which becomes a part of the calculation to determine system water losses.
- <u>Bypass valve solenoid</u>: Used to operate the bypass valve to purge the system at the start of the pump cycle.
- <u>Water flow switch</u>: Used to confirm water flow and initiate the operation of the chlorination control logic.
- <u>Water pump starter</u>: Used to start and stop the deep well pump motor and protect it from overloads and also to monitor pumps status (overload trip, on and off conditions).
- <u>Pump motor protector</u>: Used to provide added protection for voltage and current unbalance, over and under current, phase loss or reversal and motor over-temperature with adjustable time delays.
- <u>Chlorination pump starter</u>: Used to start and stop the chlorination injection pump motor and protect it from overloads.
- <u>Chlorine supply line solenoid:</u> Used to protect the system from accidental injection of chlorine when pump is off.
- <u>Chlorine gas leak detector</u>: Used to provide local and SCADA alarm if chlorine gas is detected.

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

Note: The system will work properly only if the associated mechanical equipment is also operational. Most of the diaphragm-actuated bypass valves require maintenance or replacement. (The assessment of the condition of mechanical equipment is not under the scope of this section.)

A-1 has the following components:

- A new Badger Magnetic flowmeter with the transmitter plugged into a power outlet
- System Sensor Flow switch in the chlorine booster pump flow is a sprinkler type and internal parts are corroding causing it to fail
- A Hach chlorine and turbidimeter
- Capital Controls Chlorine sensor and Model 1640 alarm.
- A blind Foxboro well head pressure transmitter with a mechanical pressure gauge
- Blind Foxboro discharge pressure transmitter with a mechanical pressure gauge

A-18 has the following components:

- A Hach chlorine and turbidimeter (unplugged)
- SS Mag Flowmeter (Box being used as a junction box) and transmitter (mjk.com)
- Small blind pressure transmitter and pressure gauge
- Chlorine Booster pump flow switch (sprinkler type)
- Chlorine sensor and alarm

A-21 has the following components:

- A Hach chlorine and turbidimeter (unplugged)
- Sensus Propeller Flowmeter
- Small blind pressure transmitter and pressure gauge
- Chlorine Booster pump flow switch (sprinkler type)
- Chlorine sensor and alarm

Generator

All of the deep well water pump stations visited were linked to an emergency generator. In the event of a power failure, the generator should automatically start and after a pre-determined delay period, the transfer switch automatically transfers the station load to the generator. Upon power restoration, the control panel monitors for voltage stability, transfers the station back to utility power and allows the generator to go through a cool-down cycle. No UPS connections to the automatic transfer switch were observed.

The following are a list of recommended input points for monitoring the generator to enhance the system operation:

- Generator run/standby
- Generator fault
- Voltage unbalance
- Power fail
- Battery voltage
- Fuel tank level
- Day tank level
- Transfer switch position

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

Note: While there are other generator and transfer switch input points that can be monitored, the list above represents the minimum necessary for effective remote monitoring by a SCADA system.

The SCADA Master Plan (2014) added an intrusion alarm to the list.

1.2.2.2 Booster Pump Stations (WBP-18)

Most of the water booster pump stations are currently operating in manual mode and do not incorporate the benefits of the instrumentation and automatic control.

The Booster pump station has a Grundfos pump controller for two of the three pumps. It provides automation operation based on discharge pressure. The plan is to update this with a controller that will handle all three pumps.

Pump Instrumentation

Monitoring of system pressures and flow is essential to efficient operation. Also, alternation of pump operation evens out the mechanical wear on the equipment. In addition, two or more pumps could be called into service in the event of high demand or low pressure, depending on the design and capacity of the water distribution system.

The Booster pump station has the following components:

- Suction pressure transducer
- Dual Discharge pressure transducer and gauge
- McCrometer Discharge mag flowmeter
- Sensus flow totalizer for pumps 1 & 2

The following is a list of instrumentation and related devices that should be operational at every potable water booster pump station in order for the station to operate properly, safely and efficiently:

- <u>Inlet pressure transmitter</u>: Used to monitor pump suction pressure to avoid cavitation and initiate an alarm condition.
- <u>Outlet pressure transmitter</u>: Used to monitor head pressure for control logic and alarm initiation.
- <u>Water flow meter</u>: Used to quantify volume of water pumped and to calculate water losses.
- <u>Water flow switch</u>: Used to confirm water flow and for control system interlocks and alarm initiation.
- <u>Water pump starters</u>: Used to start and stop the booster pump motors and protect them from overloads and also to monitor pump motor status (overload trip, on and off conditions).
- <u>Pump motor protector</u>: Used to provide additional protection for conditions of over and under voltage and phase loss or reversal.

The SCADA Master Plan (2014) also included Reservoir level monitoring and intrusion alarm.

Control interlocks between the reservoir levels and the operation of the deep well pumps and booster pump stations were not evident. Lack of process controls and instrumentation interlocks might result in the following undesirable situations:

- Low or high (overflow) reservoir level
- Low or no system pressure (line breakage)
- High system pressure

Generator

The comments regarding the generator controls included in Section 1.2.1.2 also apply to the water booster pump stations. Earlier comments regarding mechanical equipment condition also apply.

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

Reservoir (Chaot) – WR11

The reservoir site has SCADA Pack 357 PLC and a Comtrend DSL modem, booster water pumps, chlorine gas tanks, detection, residual, and a flowmeter in vault. No external communications were observed.

The following is a list of instrumentation and related devices that should be operational at every reservoir in order for the station to operate properly, safely and efficiently:

- Reservoir tank Level monitoring (Siemens HydroRanger 200)
- Inlet Flow monitoring (Sensus electronic, 16" Accumag)
- Outlet Flow monitoring (Sensus electronic, 12" Accumag)
- Chlorine leak detection and alarm
- Booster pump controls
- Site electric power monitoring
- Intrusion monitoring (control panel, tank hatches, building, etc.)

1.2.2.3 Ugum SWTP

The Ugum SWTP is the only water treatment facility operated by GWA. At the time of the site visit, most of the plant appeared to be operating in automatic mode.

Plant Instrumentation

A Siemens S7-400 PLC SCADA system, commissioned in 2012, provides a functional plant control system. It is located at the plant using Profibus to connect to field equipment. No upgrade at this site is planned until the end of the useful life of Siemens PLC, perhaps as late as 2025. Planning for the PLC replacement should start when the manufacturer announces the end of sale or service of the S7-400 model.

1.2.2.4 Wastewater Pump Stations (Route 16)

The wastewater pump station has a Motorola SCADA RTU installed but was in poor condition and did not appear to be used. The RTU was located in the building's interior.

Pump Operation

Two types of pump station designs used at the GWA pump stations are wet wells with one or more submersible pumps or wet wells with multiple centrifugal pumps located in an adjacent dry well.

The larger wastewater pump stations have pumps located in the dry wells. In those stations, it is important to have a fully functional sump pump and high dry well level float switch to provide an alarm initiation in the event of a flood condition.

The minimum I/O process controls for wastewater pump stations with multiple pumps are:

- High dry well level float switch
- High wet well level float switch
- Wet well level sensor
- Power failure
- Pump starters
- Generator run/standby status
- Redundant pump start/stop controls

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

The following additional I/O process devices would enhance the operation, maintenance and alarm capabilities of all types of wastewater pump stations.

- Communicator control monitoring (where applicable)
- Wet well low level indication
- Wet well level transmitter
- Station flow metering
- Motor moisture and winding thermal detector
- Motor load and condition
- Motor overload status
- Phase monitoring
- Pump variable speed controller (where applicable)

Generator

The wastewater pump station was equipped with an emergency generator. The operation of the wastewater generators is similar to that covered in the discussion of generators for water pump stations in Section 1.2.1.2.

The following is a list of recommended additional input points for monitoring the generator:

- Generator run/standby
- Generator fail
- Voltage unbalance
- Battery voltage
- Fuel tank level
- Generator fuel leak detector
- Day tank level
- Transfer switch position (i.e. power fail)

Note: While there are many more generator and transfer switch input points that can be monitored, the list above represents the minimum necessary for effective remote monitoring by a SCADA system.

1.2.2.5 Hagatna Wastewater Treatment Plant (WWTP)

The control systems were assessed at the Hagatna WWTP Plant. In general, most of the plants' operational functions were being operated manually with the exception of the wet well level control and associated motor alternation and control.

Even though the plants can be, or are currently being, operated manually, it is a challenge to operate them at peak efficiency. Automated systems enable plants to operate at peak performance with minimal manpower.

Two SCADA servers running Wonderware HMI software and Rockwell AB PLC, and two Ace RTUs were located in the Control room, Gallery and Centrifuge areas.

High temperatures occurring on site because of air conditioner failures is a concern and has already led to some VFD equipment damage. Prolonged high temperatures will shorten the life span of electronics and may lead to premature failures.

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

Plant Controls

The major unit process areas that require properly operating automation systems to achieve peak plant performance are listed below.

- Headworks
- Clarifiers
- Pump gallery (e.g., sludge, recirculation, scum pumps)
- Centrifuges
- Blowers
- Digesters
- Odor control systems
- Chlorination
- Effluent pumps
- Plant generator

In general, the control systems for the wastewater treatment plants should be designed to operate independently (i.e., without outside communications) using the last set points received from the operator HMI. However, the operation of the plants must be monitored from a central SCADA system since none of the wastewater treatment plants have a 24-hour staff. A communication system linking the treatment plants to a central SCADA system is necessary to accomplish this monitoring. In addition, it is advantageous to have each treatment plant monitor the status of all pump stations associated with that plant.

Generator

The comments regarding the generator controls presented in Section 1.2.1.2 – Water Pump Stations, Generator also apply to the wastewater treatment plants. Comments regarding mechanical equipment condition also apply.

1.2.3 Assessment Summary

Table 1-2 and Table 1-3 summarize the findings and ratings for the water and wastewater pump systems visited, respectively. This evaluation is based solely on the condition of the equipment in place at the GWA facilities when the site visit was made.

At that time, most of the equipment was running in manual operation, thereby bypassing the automatic process controls. Most of the other systems were operating in manual mode. In general, the condition of the sites was rated between 1 and 3 on the assessment scale shown in Table 1-1.

Table 1-2. Water Pump Stations SCADA Assessment Totals

Station Name	Pump Controls (0 - 2.00)	Chlorination (0 – 1.00)	Pump Bypass (0 – 0.40)	SCADA PLC (0 – 0.60)	Assessment Total (0 - 4.0)
A-01	1.70	0.60	0.00	0.58	2.9
A-18	0.15	0.50	0.25	0.20	1.1
A-21	0.15	0.50	0.05	0.25	1.0

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table 1-3. Wastewater Pump Station SCADA Assessment Aggregated Totals				
Station Name	Pump Controls (0 - 2.80)	Sump Pump (0 - 0.40)	SCADA PLC (0 – 0.80)	Total (0 - 4.0)
Route 16	2.10	0.25	0.30	2.7

DRAFT for review purposes only. Use of contents on this sheet is subject to the limitations specified at the end of this document.

Appendix C

2006 WRMP Projects

This appendix gives additional details for the system accomplishments summarized in Section 2. Tables C-1 and C-2 are similar to Tables 2-1 and 2-2 except that they give additional information. Several water projects from Volume 2, Section 9 of the 2006 WRMP were composed of multiple sub-projects. Tables C-3 through C-5 summarize the status of those sub-projects.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-1. 2006 WRMP Water System Projects Status												
Number	2006 WRMP Volume 2 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
1	9-2	PW 09-10	Water Reservoir Internal/External Corrosion Assessment Program	Develop and implement a corrosion assessment program for all steel water reservoirs to determine extent of internal and external reservoir corrosion and necessary course of action to rehabilitate or replace the impacted reservoirs.	Ongoing	55%	Project 07-002-LOC. Inspected 17 Tanks by DCA. 31 Tanks to be done. In some cases, new tanks must be constructed before existing tank inspection can be completed. Some tanks have also been demolished.	2007	$125,000	$125,000	$738,180	Y
2	9-3	PW 09-10	Water Reservoir Internal/External Corrosion Rehabilitation Program	Based on the results of the corrosion assessment program for all steel water reservoirs, program the rehabilitation of designated reservoirs over a 4-year period as a phased project.	Ongoing	63%	Project 07-002-LOC. Cortex completed two tanks under minor repairs. In some cases, repairs to existing tanks cannot be completed before new tanks are constructed. Some tanks have also been demolished.	2008-2011	$2,000,000	$2,000,000	$1,540,500	Y
3	9-4	PW 09-01	Ugum Water Treatment Plant Membrane Filtration	This project will replace the existing sand filters at the Ugum Water Treatment Plant with submerged membrane filters.	Complete	100%	$7.7M contract in 2007 for the refurbishment of plant	2007	$8,500,000	$8,500,000	$7,700,000	N
4	9-5	PW 11-02	Ugum Water Treatment Plant Reservoir Replacement	This project will provide a 2.0 million gallon finished water reservoir at the Ugum Water Treatment Plant. The existing reservoir shows significant damage to the cover as a result of a series of typhoons. The damage has contributed to corrosion which could result in premature failure. This reservoir is the sole source of finished water for most of the Southern Water System. Failure of this reservoir would result in a significant hardship on customers in the system. The new reservoir would allow the existing reservoir to be taken off-line and refurbished.	Ongoing	5%	Funds allocated -$3,672,000 from 2010 Series Bond. Currently under design (30% Design Completed). On hold until property issue resolved.	2009	$8,700,000	$8,700,000	$435,000	Y
5	9-6	PW 09-01	Ugum Water Treatment Plant Intake Modifications	This project would improve the intake structure for the Ugum Water Treatment Plant to minimize siltation and to provide more reliable raw water supply during low river flow conditions.	Not Started	0%	No CIP design work has occurred that meets the WRMP project description. Basket has been installed around the intake.	2007	$550,000	$550,000	--	Y
6	9-7	PW 09-03	Water Distribution System Pipe Replacement	In addition to specific pipe replacement projects identified through hydraulic modeling, there is an ongoing need for pipe replacement to address leak, failure and age issues. This project meets that need. The basis for this reserve is about 13,500 linear feet of pipe replaced per year through 2015 and 2,000 feet of pipe replaced per year thereafter.	Ongoing	88%	$10.23M encumbered for four (4) line replacement contracts which started in 2012. Approximate length of pipe involved with the four phases is 108,000 linear feet. Length planned to 2016 = 13,500'/year x 9 years plus 2,000'/year x 1 years =123,500 ft.	2007-2026	$53,140,000	$45,740,000	$40,386,400	Y
7	9-8	PW 09-08	Mechanical/Electrical Equipment Replacement	Reserve for routine mechanical/electrical equipment replacement due to age, capacity, or failure. This reserve includes well pumps, booster pumps, valves, emergency generators and other items associated with the Northern, Central and Southern Water Systems.	Ongoing	19%	$1.6M from 2010 and 2013 Bond "spent" to purchase various pumps and motors	2008-2026	$17,670,000	$8,370,000	$1,590,300	N
8	9-9	PW 09-03	Southern System Water Distribution System 2005 Improvements	The 2005 CIP hydraulic model for GWA's Southern Water System has identified deficiencies in water pipe sizes required to provide adequate fire flow. The series of projects listed in Table 9-9 of the 2006 WRMP identify the location, pipe diameter and length to address this issue.	Not Necessary See Appendix C for a summary of original projects	N/A	GWA current emphasis is to provide reliable water service with respect to available flow, pressure, reduced outages, etc. Fire flow is a long-term planning goal.	2008-2017	$23,000,000	$11,700,000	--	N[c]
9	9-10	PW 09-06	Central System Water Distribution System 2005 Improvements	The 2005 hydraulic model for GWA's Central Water System identified deficiencies in pumping capacity and pipe size to provide adequate fire flow and pressure, and reduce high velocities and friction losses. The series of projects listed in table 9-11 of the 2006 WRMP identify the location, pipe diameter, length, and pumping needs to address these issues.	Not Necessary See Appendix C for a summary of original projects	N/A	GWA current emphasis is to provide reliable water service with respect to available flow, pressure, reduced outages, etc. Fire flow is a long-term planning goal.	2008-2017	$6,000,000	$5,400,000	--	N[c]
10	9-11		Northern System Water Distribution System 2005 Improvements	The 2005 hydraulic model for GWA's Northern Water System identified deficiencies in pumping capacity and pipe size to provide adequate fire flow and pressure, and reduce high velocities and friction losses. The series of projects listed in Table 9-11 of the 2006 WRMP identify the location, pipe diameter, and length to address these issues.	Not Necessary See Appendix C for a summary of original projects	N/A	GWA current emphasis is to provide reliable water service with respect to available flow, pressure, reduced outages, etc. Fire flow is a long-term planning goal.	2008-2017	$26,000,000	$23,400,000	--	N[c]
11	9-12	PW 09-04	Pressure Zone Realignment/Developme	The hydraulic modeling of the water system identified areas with inadequate service pressures and flows. Installations of PRV/PSV stations are required at strategic locations to facilitate the development of discrete pressure zones,	Ongoing	11%	PRVs on Rt. 1 and 3 completed. Pressure Zone Realignment Report completed. Approximately $900,000 spent to date. Where possible PRV's are being included in	2008-2010	$8,100,000	$8,100,000	$891,000	Y

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-1. 2006 WRMP Water System Projects Status

Number	2006 WRMP Volume 2 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
			nt 2005 Improvements and the Water Model	and improve circulation of flow from a higher pressure zone to a lower pressure zone. See projects listed in Table 9-12 of the 2006 WRMP.			tank construction and other larger projects. Hydraulic model has been updated and new PRV analysis supersedes 2006 MP recommendations.					
12	9-13	PW 09-06	Water Booster Pump Station 2005 Improvements	The 2005 hydraulic model for GWA's three water systems identified deficiencies in water booster pumping capacity to provide adequate supply to areas in two systems. The projects listed in Table 9-13 of the 2006 WRMP are intended to address these limitations.	Not Necessary See Appendix C for a summary of original projects	N/A	Extensive updates have been performed on the water system hydraulic model since 2006. Booster pump station requirements have been revised for 2016.	2008-2009	$1,200,000	$1,200,000	--	Y
13	9-14	PW 09-11	Water System Reservoirs 2005 Improvements	The 2005 hydraulic model for GWA's three water systems identified deficiencies in reservoir capacity. The projects listed in Table 9-14 of the 2006 WRMP are intended to address these deficiencies.	Complete Some projects completed, some are not necessary, see Appendix C for a summary of projects	100%	GWA has constructed two 2-MG tanks at Barrigada. 12 reservoir designs (Tumon No. 1, Tumon No. 2, Pulantat, Manenggon, Piti, Chaot No. 2, Hyundai, Inarajan, Sinifa, Santa Rosa, Santa Rita, Ugum) are currently underway. Yigo No. 1, Yigo No, 2, Yigo Elevated, and Astumbo No. 1 construction projects are ongoing. Mangilao No. 2 steel tank major repair completed. Malojloj Elevated reservoir was demolished and replaced with a refurbished pump station. Project status complete because planned cost has been met.	2008-2016	$25,200,000	$25,200,000	$36,986,740	Y
14	9-15	PW 11-01	Northern System Raw Water Transmission Lines	GWA currently operates a combined transmission/distribution system, which requires treatment (chlorination) at most of the individual wells. To provide more reliable and fewer points of treatment, transmission lines separate from distribution are needed. The projects listed in Table 9-15 of the 2006 WRMP are intended to address this need. The transmission lines will transport well water to a reservoir(s) where chlorination facilities will be located.	Ongoing Some projects completed, some not necessary, see Appendix C for a summary of projects	<10%	Two transmission lines have been completed. The remaining projects were recommended to pump wells along transmission lines to storage tanks and centralized treatment locations. Due to the large cost of implementing these projects and the additional infrastructure constructed for these projects that would need to be maintained, they are not recommended for this WRMPU.	2007-2020	$123,800,000	$104,800,000	--	N
15	9-16		Water System Supply Wells 2025 Improvements	The 2025 hydraulic model for GWA's three water systems identified deficiencies in groundwater supply wells. The projects listed below are intended to address these deficiencies.	Not Scheduled Project not scheduled for start before 2017	N/A	There are two current well projects each for 5 wells. D-series is under construction and A-F Series is under design. These are rehab projects, but wells are currently down and have been for a while. GWA completed design for three new wells (AG-10, AG-12 and Y-8) in 2013. Hydraulic model and associated demand requirements have been updated and vary from 2006.	2024	$5,000,000	$0	--	Y
16	9-17		Southern System Water Distribution System 2025 Improvements	The 2025 hydraulic model for GWA's Southern Water System has identified deficiencies in water pipe sizes required to provide adequate fire flow. The series of projects listed in Table 9-17 of the 2006 WRMP identify the location, pipe diameter, and length to address this issue.	Not Scheduled Project not scheduled for start before 2017 See Appendix C for a summary of projects	N/A	The GWA water system hydraulic model has been continuously updated since 2006. The proposed future CIP projects will therefore supersede the 2006 WRMP recommendations.	2024- 2026	$10,000,000	$0	--	Y
17	9-18		Northern System Water Distribution System 2025 Improvements	The 2025 hydraulic model for GWA's Northern Water System identified deficiencies in pumping capacity and pipe size to provide adequate fire flow and pressure, and reduce high velocities and friction losses. The series of projects listed in Table 9-18 of the 2006 WRMP identify the location, pipe diameter, and length to address these issues.	Not Scheduled Project not scheduled for start before 2017 See Appendix C for a summary of projects	N/A	The GWA water system hydraulic model has been continuously updated since 2006. The proposed future CIP projects will therefore supersede the 2006 WRMP recommendations.	2017- 2026	$57,000,000	$0	--	Y
18	9-19		Water Booster Pump Station 2025 Improvements	The 2025 hydraulic model for GWA's three water systems identified deficiencies in water booster pumping capacity to provide adequate supply to areas of the respective system. The projects listed in Table 9-19 of the 2006 WRMP are intended to address these limitations.	Not Scheduled Project not scheduled for start before 2017 See Appendix C for a summary of projects	N/A	The GWA water system hydraulic model has been continuously updated since 2006. The proposed future CIP projects will therefore supersede the 2006 WRMP recommendations.	2025	$1,600,000	$0	--	Y

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-1. 2006 WRMP Water System Projects Status												
Number	2006 WRMP Volume 2 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
19	9-20		Water System Reservoirs 2025 Improvements	The 2025 hydraulic model for GWA's three water systems identified deficiencies in reservoir capacity. The projects listed in Table 9-20 of the WRMP are intended to address these deficiencies.	Not Scheduled Project not scheduled for start before 2017 See Appendix C for a summary of projects	N/A	The GWA water system hydraulic model has been continuously updated since 2006. The proposed future CIP projects will therefore supersede the 2006 WRMP recommendations.	2018-2022	$27,700,000	$0	--	Y
20	9-21		Northern System GWUDI Filtration Compliance	This project would provide membrane filtration for all Northern Lens groundwater assuming all aquifers have been designated GWUDI of surface water. Note the assumption that all groundwater will be designated is a worst-case scenario.	Not Necessary	N/A	Northern LENS determined not to be GWUDI.	2013-2022	$145,000,000	$0	--	N
21	9-22	EE 09-03	Electrical Upgrade - Water Booster Stations (Pago Bay, etc.)	This project is for the electrical upgrade at the Pago Bay, Brigade, and Windward Hills Water Booster Stations by replacing existing equipment, motor, motor control centers, etc. This project includes a detailed engineering assessment and preparation of design engineering plans	Complete	100%	Electrical upgrades completed under Water System CIP due to a larger funding source. Project status complete because planned cost has been met.	2007	$650,000	$650,000	$650,000	N
22	9-23	EE 09-03	Electrical Upgrade - Water Booster Stations (Gayinero, etc.)	This project is for the electrical upgrade at the Water Booster Stations by replacing existing equipment, motor, motor control centers, etc. Included is a detailed engineering assessment and preparation of design engineering plans and specifications.	Complete	100%	Gayinero - Pumps have been replaced. Project status complete because planned cost has been met.	2008	$350,000	$350,000	$350,000	N
23	9-24	EE 09-03	Electrical Upgrade - Water Booster Stations (Other WBPS)	This project is for the electrical upgrade at the other Water Booster Stations such as Yigo Elevated Tank, Pale Kieran, etc. Project scope includes replacing existing equipment, motor, motor control centers, etc.	Complete	100%	Completed (Malojloj Line, Windward Hills). Project status complete because planned cost has been met.	2009	$250,000	$250,000	$250,000	N
24	9-25	EE 09-02	Electrical Upgrade - Water Wells	This project is to upgrade the electrical system at each of the water wells as recommended in the Electrical Assessment of the 2006 WRMP Report.	Ongoing	75%	Current authorized project cost is $3,700,000	2007	$2,000,000	$2,000,000	$1,500,000	Y
Water System Totals									$553,535,000	$257,035,000	$93,018,120	

a. Costs are listed as reported in the 2006 WRMP.

b. Costs are listed as reported in the 2006 WRMP through 2016. Projects scheduled after 2016 are not included in the total.

c. New projects for expansion or demand capacity replacement will be designed for fire flow.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-2. 2006 WRMP Wastewater and Electrical Systems CIP Project Status												
Number	2006 WRMP Volume 3 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
Wastewater Collection System												
1	9-2		Northern District STP Rte 16 PS Overflow Study	Assess opportunity to modify the Route 16 PS overflow to avoid excess wet weather flow diversion to Hagåtña STP. Alternatively, increase station reliability.	Complete	100%	Project has been addressed. Improvements to the facility pumping have minimized operations concerns regarding use of the overflow.	2007	$50,000	$50,000	$50,000	N
2	9-3		Northern District STP Eliminate Flow Split	Eliminate the flow split that occurs in the sewer manhole that collects flow from Andersen AFB and Navy Housing east of the North District STP to divert all flow to the 42-inch gravity sewer.	Complete	100%	Work being done under SRF. Work reevaluated based on CCTV data-may not match the 2006 MP. The segment of sewer where the flow split occurs is part of the interceptor sewer project funded by OEA. Improvements to this segment should account for eliminating the split if it still exists.	2007	$50,000	$50,000	$50,000	N
3	9-4		Northern District STP Priority 1 Sewer Upgrades	5,100 feet of sewers upstream of the Fujita pump station and just downstream of flow meters 7, 8, and 38 (Buena Vista) were found to be surcharged excessively both in the metering and modeling. These sewers have been assigned priority 1 for correction.	Ongoing (Investigation Stage)	15%	GWA completed SSES studies in this area and a “hot spots” project design is in progress for the Fujita Area. A preliminary engineering report “Fujita Pump Station Service Area Improvements” has also been completed.	2010	$2,400,000	$2,400,000	$400,000 +	Y
4	9-5		Northern District STP Priority 2 Sewer Upgrades	Two short sections of pipe in the ND STP area were prioritized at level 2 for improvement in the future as population and sewered area grows.	Not Scheduled Project not scheduled for start before 2017	N/A	One pipe section is planned for lining on Route 9 and the other no longer shows up as a deficiency in the model.	2020	$280,000	$0	$0	N
5	9-6		Northern District STP Priority 3 Sewer Upgrades	9,000 feet of sewer were given a priority of 3. These sewers received this priority because there is some uncertainty as to the accuracy of the modeling or in the actual pipe parameters (diameter, connectivity and slope). The pipe parameters should be verified. There is also a large un-metered flow entering the split manhole between the FM 5 and 11 sites. Monitoring of this flow and discovering its source will allow flows in this area to be redistributed.	Not Scheduled Project not scheduled for start before 2017	N/A	The priority 3 piping had questions on accuracy. The current, more accurate model was used for new recommendations for this WRMP update.	2025	$4,500,000	$0	$0	N
6	9-7		Hagåtña STP Priority 1 Sewer Upgrades	5,100 feet of sewers in the Hagåtña STP service area were identified as Priority 1 for upgrade.	Ongoing	60%	Project intent per the 2006 WRMP was to increase pipe diameter sizes at identified locations. GWA is completed engineering analysis to improve the collection system and revised the required scope. There are 2 projects to cover this area, one on Route 1 to the Asan lift station and one on Route 4. Both are in design.	2010	$4,000,000	$4,000,000	$2,400,000	Y
7	9-8		Hagåtña STP Priority 2 Sewer Upgrades	16,000 feet of sewers in the Hagåtña STP service area were identified as Priority 2 for upgrade.	Not Scheduled Project not scheduled for start before 2017	N/A	Some of the Priority 2 sections will be covered in the Route 1 and Route 4 projects currently in progress	2020	$17,000,000	$0	$0	Y
8	9-9		Hagåtña STP Priority 3 Sewer Upgrades	17,000 feet of sewers in the Hagåtña STP service area were identified as Priority 3 for upgrade. The pipe parameters and flows require verification before constructing the identified upgrade.	Not Scheduled Project not scheduled for start before 2017	N/A	The priority 3 piping had questions on accuracy. The current, more accurate model was used for new recommendations for this WRMP update.	2025	$11,000,000	$0	$0	N
9	9-10		Hagåtña STP Pump Station Upgrades	Three pump stations in the Hagåtña STP service area were found to have insufficient capacity to deliver the projected peak flows: the Hagåtña influent pump station, the Asan pump station, and the Tepungan (Piti) pump station. Evaluation of re-siting the Hagåtña SPS to the STP or other site will be included in this project.	Not Started	0%	Project intent per the 2006 WRMP was to increase pumping capacity at identified lift stations. This has not occurred. Hagåtña Main lift station has undergone refurbishment work only. Asan and Tepungan lift station has not undergone any major rehabilitation work nor work related to increase pumping capacity. This WRMP update gives updated recommendations for improvements for lift station capacity upgrades.	2010-2023	$55,660,000	$6,160,000	$0	Y
10	9-11		Agat-Santa Rita STP Priority 1 Sewer Upgrades	1,720 feet of sewer were assigned priority 1 for upgrade to avoid overflows as population growth occurs.	Ongoing	5%	Project intent per the 2006 WRMP was to increase pipe diameter sizes at identified locations. GWA has completed an SSES investigation and re-prioritized work in Agat. One project is complete Southern SSES Phase 1, One project is	2010	$1,200,000	$1,200,000	$1,800,000	Y

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-2. 2006 WRMP Wastewater and Electrical Systems CIP Project Status												
Number	2006 WRMP Volume 3 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
							in construction Southern SSES Phase 2, and 1 is in design for Route 2. Total length is approximately 5000 feet.					
11	9-12		Agat-Santa Rita STP Priority 3 Sewer Upgrades	6,300 feet of sewer were assigned priority 3 for upgrade. These sewers where found to surcharge to near the ground surface in the model. They have been assigned lower priority to await field study of I/I sources and correction activities.	Not Scheduled Project not scheduled for start before 2017	N/A	Some of the Priority 3 areas have been upgraded to Priority 1 based on field investigations and work is included in the Route 2 project.	2025	$4,500,000	$0	$0	N
12	9-13		Baza Gardens STP Priority 1 Sewer Upgrades	1,600 feet of sewers have been assigned a Priority 1 ranking for improvement in the Baza Gardens STP service area to respond to growth in the connected population. These sewers should be addressed when areas in the Talofofo pump station service area that have currently unconnected sewers are brought on-line. The Talofofo pump station capacity should be examined at the same time.	Ongoing	60%	Project intent per the 2006 WRMP was to increase pipe diameter sizes at identified locations. GWA has not started any sewer design work to address WRMP requirements. The Southern SSES Phase 2 project covers some pipe rehabilitation in Baza Gardens and Talofofo, and the Talofofo Pump Station project is under design. This WRMP updates gives updated recommendations for improvements for this area.	2010	$650,000	$650,000	$400,000	Y
13	9-14		Baza Gardens STP Priority 2 Sewer Upgrades	2,600 feet of sewers have been assigned a Priority 2 ranking for improvement in the Baza Gardens STP service area to respond to growth in the connected population. These sewers should be addressed as growth occurs.	Not Scheduled Project not scheduled for start before 2017	N/A	This WRMP updates gives updated recommendations for improvements for this area.	2020	$580,000	$0	$0	N
14	9-15		Inarajan STP Pressure Sewer Upgrades	The GIS database includes an 8-in sewer in Chagamin Ave. with low-lying manholes which may overflow in the event of a problem at the Inarajan Main pump station. The water depths measured during the August 31, 2005 monitoring exceeded the apparent elevation of manholes between Chalan Tun Juan Street and the pump station. Conversion of this 1600 feet segment of sewer to a pressure sewer would avoid potential overflows. The reliability of the pump station should be examined.	Not Started	0%	Project may not be necessary. GWA has not started any sewer design work to address WRMP requirements	2010	$1,200,000	$1,200,000	$0	N
Wastewater Collection System – Unsewered Areas												
15	9-16		NDSTP and Hagåtña STP Unsewered Properties – Sewer Hookups[c]	843 accounts were identified by WERI (see Chapter 3-6) that are within 200 feet of existing sewers and within 1000 feet of a water supply well which have water accounts but no sewer accounts. Research these properties and provide hook-ups to the existing sewers were no connection exists.	Not Started	0%	No sewer design work has been initiated to address WRMP requirements. This WRMP update gives updated recommendations for unsewered properties.	2012-2016	$6,500,000	$6,500,000	$0	N
16	9-17		NDSTP and Hagåtña STP Unsewered Properties - New Sewers[c]	563 properties were identified by WERI per Table 9-16 of the 2006 WRMP that are within 1000 feet of deep wells but not near existing sewers that have water accounts but not sewer accounts. Research these properties and provide new sewers as necessary to provide service. Estimated lengths by deep well are given in Table 9-16a. (Also reference Table 6-9 in Volume 3, Chapter 6.)	Not Started	0%	No sewer design work has been initiated to address WRMP requirements. This WRMP update gives updated recommendations for unsewered properties.	2012-2026	$40,500,000	$13,500,000	$0	N
17	9-18		NDSTP and Hagåtña STP Unsewered Properties – Additional Sewer Hook-ups[c]	The stipulated order calls for hook-ups of all unsewered properties within 200 feet of existing sewers via a sewer hook-up revolving fund. There are 1963 properties identified by WERI in the North and Hagåtña service areas with water accounts but no sewer account.	Not Started	0%	No sewer design work has been initiated to address WRMP requirements. This WRMP update gives updated recommendations for unsewered properties.	2015-2026	$15,000,000	$2,500,000	$0	N
18	9-19		South System Sewer Hook-ups[c]	945 properties were identified by WERI in the south systems with water accounts but not sewer accounts, which are within 200 feet of existing sewers. The stipulated order specifies that a sewer hook-up revolving fund be established to provide connections to existing sewers. As water supply protection is not involved, these are scheduled late in the program.	Not Scheduled Project not scheduled for start before 2017	N/A	No sewer design work has been initiated to address WRMP requirements.	2022-2026	$7,500,000	$0	$0	N
Wastewater Collection System – Other Projects												
19	9-20		Manhole Frame Seal Repair	Repair the manhole cover & frame to barrel/cone seal at multiple manhole locations identified by manhole inspections: 53 in Agat	Complete	100%	Project description as noted in the 2006 WRMP is intended to occur with improvement works as described in the Wastewater Collection System	2007	$84,000	$84,000	$84,000	N

Brown AND Caldwell

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-2. 2006 WRMP Wastewater and Electrical Systems CIP Project Status												
Number	2006 WRMP Volume 3 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
				5 in Yigo 4 in Hagåtña			Replacement/Rehabilitation Program. Requirements were rolled into Projects 41 & 42-Therefore complete.					
20	9-21		Agat Manhole Rehabilitation	Rehabilitate four (4) manholes that were identified to have active infiltration by manhole inspection	Complete	100%	Manhole Rehabilitation completed as part of the Southern SSES Phase 1 Project	2007	$54,000	$54,000	$48,600	N
21	9-22		Wastewater Collection System Recurring Inspection Program	Inspect approximately 1/8 (12%) of the collection system each year by CCTV, manhole inspections, or smoke testing. Based on Guam EPA regulation, all of the sewers within 1,000 feet of a potable water supply well or within the groundwater protection zone must be inspected every 5 years regardless of its priority rating	Ongoing	50%	Some scope as identified in the WRMP has occurred as part of the first round of I/I and SSES assessment and operations CCTV work assignments. Inspection work will continue with the CCTV Inspection Section under the Wastewater Collection Division.	2007-2026	$12,200,000	$6,100,000	$6,100,000	Y
22	9-23		Wastewater Collection System Replacement/Rehabilitation Program	Annual recurring design and construction project to replace/rehabilitate 3/4% of the total collection system (~8,600 feet) per year. This would focus on the worst condition pipes not already scheduled for hydraulic related rehab or replacement. The cost is estimated at $240 per foot which assumes an average pipe diameter of 10 inches and does not include the cost of potential traffic control.	Ongoing	50%	Some scope as identified in the WRMP has occurred as part of the first round of I/I and SSES assessment however the goal of 8,600 feet per year has not been met. This project has been modified using the risk analysis in Volume 3 of this WRMP update.	2007-2026	$37,300,000	$18,650,000	$18,650,000	Y
Wastewater Facilities												
23	9-24		Facilities Plan/Design for the Agat-Santa Rita STP Replacement	Planning and design for new wastewater treatment facilities to meet existing and future flow capacity and reliably achieve regulatory compliance. The new facilities will incorporate provisions for redundancy to improve reliability and facilitate operations and maintenance activities.	Complete	100%	New plant design completed, and construction is in progress.	2008-2010	$3,200,000	$3,200,000	$3,200,000	N
24	9-25	WW 11-08	Agat-Santa Rita STP Replacement	Construction of new wastewater treatment facilities to meet existing and future flow capacity and reliably achieve regulatory compliance.	Ongoing	25%	In the construction phase. (Cost $68,587,245) Partial completion achieved in early 2017 with plant in operation. Remainder of work scheduled to be completed in December 2017.	2012	$30,000,000	$30,000,000	$17,146,811	N
25	9-26	WW 09-08	Facilities Plan/Design for the Baza Gardens STP Replacement	Planning and design for new wastewater treatment facilities to reliably meet secondary treatment limits. Due to strict effluent limits impose by the stream discharge, and difficulty in operating complex treatment systems to reliably meet these limits, an alternative means of disposal should be considered in the Facility Plan.	Completed	100%	WWTP will be converted to an EQ tank and Pump Station to transfer flow to the new Agat WWTP. Design is completed.	2007-2009	$2,000,000	$2,000,000	$1,240,000	N
26	9-27	WW 11-03	Baza Gardens STP Replacement	Construction of new wastewater treatment facilities to reliably meet secondary treatment limits. In order to achieve regulatory compliance, it is assumed that a new means of disposal will be constructed.	Ongoing	0%	In the construction phase. (Cost $19,334,980) Project revised-WWTP will be converted to Screening & EQ before Pumping to Agat WWTP. Construction to commence in 2017 with completion in 2018.	2011	$18,000,000	$18,000,000	$0	Y
27	9-28	WW 12-03	Facilities Plan/Design for the Hagåtña STP Improvements & Effluent WWPS	Planning and design for wastewater treatment plant improvements. The following improvements should be considered: at least one additional primary clarifier, new headworks equipment and a new effluent pump station for the disposal of future flows at high tide conditions.	Complete	100%	Primary treatment upgrade completed in 2013.	2013	$1,900,000	$1,900,000	$1,900,000	N
28	9-29	WW 12-03	Hagåtña STP Improvements & Effluent WWPS	Provide a new primary clarifier to meet current and future wastewater capacity and redundancy requirements. Provide screenings and grit removal for wastewater treatment plant improvements. The new headworks equipment will improve performance, reduce wear on equipment, and improve reliability. The new equipment includes screenings, grit removal and effluent WWPS sized for current and future (Year 2015 projected flow).	Complete	100%	Primary treatment upgrade completed in 2013. Upgrade included new screens at the WWTP, and grit removal at the Hagåtña WWPS.	2015	$18,000,000	$18,000,000	$24,942,000	N

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-2. 2006 WRMP Wastewater and Electrical Systems CIP Project Status												
Number	2006 WRMP Volume 3 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
29	9-30		Facilities Plan/Design for Inarajan STP Expansion	Planning and design to improve process performance and enhance O&M requirements We recommend that the Facility Plan consider addition of mechanically cleaned bar screens to enhance performance and reduce O&M requirements.	Complete	100%	Completed as part of the Layon Landfill leachate project.	2016	$190,000	$190,000	$0	N
30	9-31		Inarajan STP Expansion	Construction of plant improvements identified in the Facilities Plan to improve process performance and enhance O&M requirements We recommend the addition of mechanically cleaned bar screens to enhance performance and reduce O&M requirements.	Not Scheduled Project not scheduled for start before 2017	N/A	Completed as part of the Layon Landfill leachate project. Bar screens were not included.	2018	$420,000	$420,000	$0	N
31	9-32	WW 12-02	Facilities Plan/Design for the Northern District STP – Biosolids	Planning and design for repairs to the biosolids stabilization facilities (digesters) and dewatering system (centrifuges) for present and future flows. Project assumed to be built in two phases.	Ongoing	20%	NDWWTP Facility Plan has been completed. Some work as described in the WRMP has been completed as part of the primary treatment upgrades however the plant will be ultimately upgraded to meet secondary treatment standards and will be part of the plant improvements work under the OEA grant project which has a completion deadline of 2021.	2007-2016	$2,300,000	2,300,000	$460,000	Y
32	9-33		Northern District STP Expansion - Biosolids	Construction of repairs to the biosolids stabilization facilities (digesters) and dewatering system (centrifuges) for present and future flows. Design will be based on Facilities Plan recommendations. Master Plan construction budget is based on repairs to existing anaerobic digesters, construction of one additional digester tank to provide redundancy and new centrifuge facilities to serve as\ a centralized facility for treating GWA biosolids. Project assumed to be built in two phases.	Ongoing	0%	Some work as described in the WRMP has been completed as part of the primary treatment upgrades, however the plant will be ultimately upgraded to meet secondary treatment standards and will be part of the plant improvements work under the OEA grant project which has a completion deadline of 2021.	2009-2017	$21,000,000	$5,000,000	$0	Y
33	9-34		Facilities Plan/Design for the Northern District STP Expansion	Planning and design for a new primary clarifier to meet current and future wastewater capacity and redundancy requirements. In addition, planning should consider replacement of existing comminutors with mechanically cleaned screens.	Complete	100%	Completed as part of CEPT upgrade project. Upgrades did not include new primary clarifier.	2013	$1,200,000	$1,200,000	$1,200,000	N
34	9-35	WW 12-01	Northern District STP Expansion	Construction of a new primary clarifier to meet current and future wastewater capacity and redundancy requirements. Replacement of comminutors with mechanically cleaned screens.	Complete	100%	Renovation/improvements in 2012 to the NDWWTP brought the plant into compliance with primary limits through chemical enhanced primary treatment process.	2015	$10,000,000	$10,000,000	$23,500,000	N
35	9-36	WW 11-04	Facilities Plan/Design for the Umatac-Merizo STP Improvements	Planning and design for new mechanically cleaned bar screen facilities to improve reliability and facilitate operations and maintenance requirements.	Ongoing	100%	A preliminary design for the plant upgrade is complete. Project proceeding as design build. Design Build procurement documents complete.	2012	$140,000	$140,000	$140,000	Y
36	9-37		Umatac-Merizo STP Improvements	Construction of new mechanically cleaned bar screen facilities to improve reliability and facilitate operations and maintenance requirements.	Ongoing	0%	Work as describe in WRMP will be part of the plant improvements work under the design build contract underway. Design-build project construction to be completed by 12/31/2018. Construction Cost $18,000,000	2013	$420,000	$420,000	$0	Y
37	9-38		Pago Socio STP Conversion	The Pago-Socio STP was built by a developer to serve 16 homes and was dedicated to GWA for operation and maintenance. It is a Class II facility as designated by Guam EPA. It consists of a packaged aerated treatment unit and a series of six subsurface percolation pits. Currently, the aeration system is not operating. This project includes constructing a new pump station and force main to convey the flow to the Hagåtña collection system for treatment at the regional facility.	Not Started	0%	No work has been initiated to date on this project.	2016	$3,700,000	$3,700,000	$0	Y
Electrical / SCADA Projects												
38	9-39		Electrical Upgrade – Agat-Santa Rita STP	This project is for the electrical upgrade at the Agat STP to replace the existing Main Distribution Board, Auto Transfer Switch, Motor Control Center, and other electrical equipment and install new underground duct	Ongoing	25%	Project underway as part of the Agat-Santa Rita WWTP	2007	$400,000	$400,000	$0	Y

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-2. 2006 WRMP Wastewater and Electrical Systems CIP Project Status												
Number	2006 WRMP Volume 3 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
				from the Plant Building to the Generator Building. Included are a detailed engineering assessment and the preparation of design plans for the work involved.								
39	9-40		Electrical Upgrade – Baza Garden STP	This project is for the electrical upgrade at the Baza Gardens STP to replace the existing Main Distribution Board and Auto Transfer Switch, upgrade with premium efficiency motors and replace other electrical equipment. Included is a detailed engineering assessment and preparation of design plans.	Ongoing	0%	The Baza Gardens WWTP will be replaced by an EQ tank and pump stations to the Agat WWTP. Electrical upgrade will be completed as part of this project.	2011	$300,000	$300,000	$0	Y
40	9-41		Electrical Upgrade – Northern District STP	This project is for the electrical upgrade at the Northern STP to replace the existing Main Distribution Board, Auto Transfer Switch, Motor Control Centers at the Digester, Centrifuge, Headworks, and Chlorination Buildings. Premium efficiency motors, transient voltage surge suppression equipment (TVSS), improvements in system grounding, and power factor correction capacitors will also be added.	Complete	100%	Work completed as part of the Primary Treatment Upgrade project	2008	$1,900,000	$1,900,000	$1,900,000	N
41	9-42	WW 12-07	Electrical Upgrade – Umatac-Merizo STP	This project is for the electrical upgrade at the Umatac–Merizo STP to replace the aging Motor Control Center, improve system grounding, and add transient voltage surge suppression equipment (TVSS). The major electrical aeration motors with be replaced with premium efficiency type to save energy. Included is a detailed engineering assessment and design plan preparation.	Ongoing	0%	Scope as identified is included in the Design Build Project for Umatac-Merizo WWTP. Project is underway with construction completion by 12/31/ 2018.	2009	$300,000	$300,000	$0	N
42	9-43	EE 09-01	Wastewater Pumping Station Electrical Upgrade	This project is to upgrade and standardize the electrical control system at the wastewater pumping stations as recommended in the GWA WRMP Report. An initial assessment using a standard checklist will be conducted. Project scope will include significant electrical modifications.	Ongoing	5%	GWA wastewater collection initiated several operations CIP projects, however it is difficult to correlate the work completed to the scope identified in the WRMP needs to be completed.	2007	$1,000,000	$1,000,000	$50,000	Y
43	9-44	EE 09-06	GWA SCADA System - Phase 1	Phase 1 of this project includes reconnecting the existing Motorola SCADA System at the 21 Critical Water Wells and 10 Critical Wastewater Pumping Stations along with the Critical Chlorination System Wells, which can be quickly activated and updated utilizing, in many cases, equipment already in place. The existing Government of Guam Public Safety radio system would be incorporated to convey SCADA data and status information to a GWA Central Dispatch Center where digital text messaging would be directed to key personnel.	Ongoing	25%	13 of 21 Critical wells & 3 of the 10 Critical WW Pump Stations to be reconnected under current project. The intent of the SCADA work as described in WRMP is still applicable however the approach to providing SCADA to GWA facilities will be to follow the SCADA Master Plan. An Important note to make is that other facilities throughout the water and wastewater systems are being improved to make the facilities "SCADA ready".	2007	$250,000	$250,000	$62,500	Y
44	9-45	EE 09-07	GWA SCADA System - Phase 2	In Phase 1 of this project, the critical water and wastewater pumping stations are monitored by activating and updating the existing Motorola SCADA system. In this phase of the project, the balance of the pumping stations and the treatment facilities are to be updated and incorporated into the GWA SCADA System. The treatment facility alarms would be identified and activated to a digital telephone text messaging unit to call key operations personnel related to that specific area.	Not Started	0%	Once Phase I work is complete GWA will move on to Phase II work as intended in the WRMP scope and defined in the SCADA Master Plan.	2008	$1,100,000	$1,100,000	$0	Y
45	9-46	EE 09-08	GWA SCADA System - Phase 3	In Phase 3 of this Project, improvements in real time data acquisition for status monitoring and process control is expanded at the treatment facilities through the incorporation of Programmable Logic Controllers (PLCs). The data is conveyed to the GWA Central as well as identified engineering and operations personnel for analysis and process optimization through the use of Virtual Private Networks (VPNs) or other available secured technology. Further improvements and updating of the pumping station SCADA monitoring would be expanded using digital communications (the GovGuam system is scheduled to be updated during this period) and the radio units would require replacement.	Not Started	0%	Once Phase II work is complete GWA will move on to Phase III work as intended in the WRMP scope and defined in the SCADA Master Plan.	2009	$2,500,000	$2,500,000	$0	Y
46	9-47	EE 09-09	GWA SCADA System - Phase 4	In this Phase 4 of the project, accounting information such as equipment and part costs along with the condition data such as equipment operating time and preventive/predictive maintenance programs are to be	Ongoing	5%	The scope of work as identified in the WRMP relative to the asset management program has started with the creation of the Asset Manage Section in 2016. The reference of	2010	$850,000	$850,000	$42,500	Y

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-2. 2006 WRMP Wastewater and Electrical Systems CIP Project Status												
Number	2006 WRMP Volume 3 Table	Current CIP Project Number	2006 WRMP Project Name	2006 WRMP Project Description	Status	Estimated Percent Complete	Comments	Planned Project Schedule	Planned Total Cost ($)[a]	Projected Cost to 2016 ($)[b]	Approximate Funds Spent to Date	Carry Over to 2016 MP (Y/N)
				incorporated into an asset management program. This portion is for the SCADA system role in being incorporated into the overall asset management program and for the updating of the SCADA equipment and hardware and software.			"accounting information" relative to the asset management program needs to be further clarified.					
GIS Projects												
47	9-48		GIS	Identify areas where water distribution and wastewater collection system assets are not represented in the GIS. Collect data needed to properly document the assets location using GPS, physical attributes (i.e. invert of manhole, pipe diameter, pipe material, etc.)	Ongoing	50%	Project is ongoing with updated data being provided to the GIS group from leak detection, CCTV, and other sources.	2007-2011	$800,000	$800,000	$400,000	Y
Wastewater and Electrical Total									$344,078,000	$168,968,000	$106,166,411	

a. Costs are listed as reported in the 2006 WRMP.

b. Costs are listed as reported in the 2006 WRMP through 2016. Projects scheduled after 2016 are not included in the total.

c. Proposed to be Funded by Sewer Hook-up Revolving Fund.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

BPS and Tank Projects

Table C-3 summarizes the booster pump station (BPS) and tank projects for the following 2006 tables:

- Table 9-13, Water BPS 2005 Improvements
- Table 9-14, Water System Reservoirs 2005 Improvements
- Table 9-19, Water BPS 2025 Improvements
- Table 9-20, Water System Reservoirs 2025 Improvements

Table C-3. Status of 2006 WRMP Water BPS and Tank Projects

Table	Project	Area	Description	2016 WRMP Comment
9-13	B1	Agat	Provide BPS along Route 2 to boost pressure from Agat/Umatac Reservoir to Agat Elevated Tank. Capacity of Lasafua Reservoir is inadequate to supply its service area.	Ignore, Agat Elevated Tank was not constructed. Existing WBP 1 pumps into Lasafua zone
9-13	B2	Talofofo	Provide BPS along Route 4A to boost pressure from Windward Hills #2 Reservoir to Talofofo. New 12-inch transmission line required as well.	This small BPS could be considered in the future if customers complain about pressure problems
9-14	R1	Agat	Provide 0.1 MG elevated tank to replace existing Lasafua Reservoir. Capacity of Lasafua Reservoir is inadequate to supply its service area.	Ignore, decision was made to abandon reservoir, area is served directly by BPS
9-14	R2	Talofofo	Provide 0.1 MG elevated tank. Tank elevation needs to be set high enough to service homes in the 300 to 382-foot elevation.	Ignore, elevated storage is not preferred by GWA, especially for such a small service area.
9-14	R3	Mataguac	Provide 0.1 MG elevated tank downstream from the Mataguac BPS. BPS currently discharges directly into the distribution system.	Ignore, land at correct elevation is not available, elevated storage is not preferred by GWA, but area can be served by Santa Rosa tank
9-14	R4	Barrigada	Provide additional 2.0 MG storage near to Barrigada #3. Evaluate cost effectiveness of using only a partially full Barrigada #2 (due to overflow elevation at 497.8 feet) compared to constructing a new tank.	Completed
9-19	1	Kaiser	Provide BPS at Kaiser Reservoir to boost water to proposed Yigo CIP Reservoir on Route 15. Yigo transmission mains are inadequate to fill proposed CIP reservoir, and Kaiser Reservoir has sufficient capacity.	Ignore, WRMPU proposes a BPS further north to create a Route 15 zone, so this BPS is not required
9-19	2	Barrigada	Provide BPS at Barrigada Reservoirs to boost water to proposed Yigo CIP Reservoir on Route 15. Yigo transmission mains are inadequate to fill proposed CIP reservoir, and Barrigada Reservoirs have sufficient capacity.	Ignore, WRMPU proposes a BPS further north to create a Route 15 zone, so this BPS is not required
9-20	1	Yigo	Provide 0.2 MG elevated tank near Flores Cadena and Chalan Koda. Existing Yigo Reservoirs are too far from this area to provide sufficient pressure or supply.	Ignore, no plans to build Yigo storage in this location because elevated storage is not preferred by GWA
9-20	2	Yigo	Provide 0.3 MG elevated tank up Wusstig Rd. near Chalan Sabana Pale. Existing Yigo Reservoirs are too far from this area to provide sufficient pressure or supply.	Ignore, no plans to build Yigo storage in this location because elevated storage is not preferred by GWA
9-20	3	Yigo	Provide 0.2 MG elevated tank along Route 15 northeast of Route 26. Existing Yigo Reservoirs are too far from this area to provide sufficient pressure or supply.	Ignore, no plans to build Yigo storage in this location because elevated storage is not preferred by GWA

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-3. Status of 2006 WRMP Water BPS and Tank Projects				
Table	Project	Area	Description	2016 WRMP Comment
9-20	4	Astumbo	Provide additional 2.0 MG storage near Flores Cadena and Chalan Koda. Existing Astumbo Reservoirs do not have sufficient capacity, especially after incorporating the 2005 recommended pressure zone boundary changes to serve former Kaiser area.	Ignore, no plans to build Astumbo storage in another location, an additional 2 MG is currently planned at Astumbo
9-20	5	Chaot	Provide additional 2.0 MG storage at existing Chaot Reservoir site. Existing Chaot Reservoir lacks sufficient capacity, and existing Mangilao Reservoirs are too far to provide adequate supply and pressure in this area.	Modified, current plan if for total of 1 MG at Chaot Reservoir

Raw Water Transmission Projects

Table C-4 summarizes the raw water transmission projects for the following 2006 table:

- Table 9-15, Northern System Raw Water Transmission Lines

Table C-4. Status of 2006 WRMP Water Transmission Piping Projects				
Table	Project	Well Series	Description	2016 WRMP Comment
9-15	1	A-23, A-25, A-31, and A-32	Zone 236 Transmission Line: serving the Agana Heights Reservoir along Route 4 and Route 7. (Figure 8-4) Approx. 7,400'. This transmission line is part of the Sinajana Transmission Line project that has been designed and is being prepared for bid.	Completed
9-15	2	A-01, A-03, A-05, A-06, A-12, A-29, and A-30	Zone 381 Transmission Line: serving the Chaot Reservoir along Route 4 and Dero Dr. (Figure 8-4) Approx. 16,450'. This transmission line is part of the Sinajana Transmission Line project that has been designed and is being prepared for bid. Although not included at this time, Wells A-29 and A-30 should be connected to this transmission line in the future. The two wells are assumed to be connected for the "lengths" identified to the left. Also, the designed pipe diameters need to be revised to those recommended herein, since future demands and CIP improvements will require more conveyance capacity.	Completed
9-15	3	D-01 thru D-07, D-09 thru D-11, D-14 thru D-18, EX-05, GHURA-501, H-01, M-12, M-14, M-18, and Y-12	Zone 408 Transmission Line: serving the Kaiser Reservoir along Santa Monica Ave., Route 1, and Route 28. (Figure 8-3) Approx. 47,200'. Wells D-7, D-4, and D-17, have a history of fecal coliform hits, though only D-4 showed their presence from 2003 through 2005. This is the second highest concentration of wells with fecal coliform hits, following the A-series. Also, Wells H-01, M-14, and M-18 are a considerable distance from the Kaiser Reservoir and should be evaluated in the future for their feasibility as part of this transmission main.	Not required under current plan. These projects were recommended to pump wells along transmission lines to storage tanks and centralized treatment locations. The projects were recommended to improve water quality but not for capacity reasons. Due to the
9-15	4	D-08, D-12, D-13, D-19 thru D-22, D-24 thru D-28, F-05, F-06, F-09, F-12, F-13, F-15 thru F-20	Zone 570 Transmission Line: serving the Ysengsong Reservoirs along Route 3, Swamp Rd., Route 28, and Chalan Isang. (Figure 8-3) Approx. 51,500'. D-13, D-19, D-21, D-22, and F-13 have a history of fecal coliform hits.	

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-4. Status of 2006 WRMP Water Transmission Piping Projects				
Table	Project	Well Series	Description	2016 WRMP Comment
9-15	5	AG-01, AG-02A, F-01 thru F-04, F-07, F-08, F-10, F-11, HGC-2, Y-01 thru Y-07, Y-09, Y-10, Y-14, and Y-16 thru Y-23	Zone 658 Transmission Line: serving the Yigo Reservoirs along Route 3, Route 9, and Route 1. (Figure 8-3) Approx. 108,400'. F-02 and F-10 have a history of fecal coliform hits. The Yigo Pressure Zone is the largest zone that will require the highest amount of pipeline capital improvement expenditure.	large cost of implementing these projects and the additional infrastructure constructed for these projects that would need to be maintained, they are not recommended for this WRMPU.
9-15	6	A-02, A-04, A-07, A-08, A-09, A-10, A-13, A-14, A-15, A-17, A-18, A-19, A-21, A-26, and A-28	Zone 381 Transmission Line: serving the Mangilao Reservoirs along Route 15, Route 10, and Chapel Rd. (Figure 8-4) Approx. 51,550'. Although Wells A-15, A-19, and A-26 are included in this transmission line, they are located a considerable distance from the Mangilao Reservoirs. They should be evaluated in the future for their feasibility as part of this transmission line.	
9-15	7	EX-11, M-01 thru M-09, M-15, M-21, and M-23	Zone 481Transmission Line: serving the Barrigada Reservoirs along Route 26, S-3, and Lemon China Rd. (Figure 8-4) Approx. 28,800'. M-21 is located a considerable distance from the Barrigada Reservoirs. It should be evaluated in the future for its feasibility as part of this transmission line.	
9-15	8	M-17A, M-20A, and M-17B	Zone 670 Transmission Line: serving the Hyundai Reservoir along Juan C. Fejeran Rd. (Figure 8-4) Approx. 5,600'.	
9-15	9	Y-15	Zone 724 Transmission Line: serving the Santa Rosa Reservoir along Route 15. (Figure 8-3) Approx. 6,000'.	

Distribution Piping Projects

Table C-5 summarizes the distribution piping projects for the following 2006 tables:

- Table 9-9, Southern System Water Distribution System 2005 Improvements
- Table 9-10, Central System Water Distribution System 2005 Improvements
- Table 9-11, Northern System Water Distribution System 2005 Improvements
- Table 9-17, Southern System Water Distribution System 2025 Improvements
- Table 9-18, Northern System Water Distribution System 2025 Improvements

Table C-5. Status of 2006 WRMP Water Distribution Piping Projects					
Table	Project	Area	Description	Length (feet)	2016 WRMP Comment
9-9	S1, S2, S4, S5, S8-S12	Inarajan, Malojloj, Malojloj Elevated, Merizo, Umatac	Improve available fire flow in the area of each project	Varies	Ignore, not analyzing fire flow
9-9	S3	Malojloj Elevated	Connect the 6-inch and 8-inch pipes with a new 8-inch pipe at the intersection of Malojloj Well and Route 4. Need to verify the location of these two pipes.	50	Ignore, does not appear to be necessary now
9-9	S6	Malojloj	Connect the 8-inch and 12-inch pipes with a new 8-inch pipe at the intersection of Acfalle and Route 4. Need to verify the location of these two pipes.	50	Ignore, no piping on Acfalle, piping was probably incorrect

Brown AND Caldwell

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-5. Status of 2006 WRMP Water Distribution Piping Projects					
Table	Project	Area	Description	Length (feet)	2016 WRMP Comment
9-9	S7	Inarajan	Install 8-inch waterline to complete loop of 6-inch waterline at the ends of Chagamin St. and Y Peca Lane. Need to verify if connection between dead-end leg lines is feasible, or if the waterline along Chagamin St. should be extended to Ad'Man Dr. and connected back to the 12-inch main on Route 4.	500	Ignore, old model piping was incorrect
9-10	C1, C3-C6	Agat, Santa Rita, Talofofo	Improve available fire flow in the area of each project	Varies	Ignore, not analyzing fire flow
9-10	C2	Talofofo	Increase 8-inch waterline to 12 inches along Route 4A from San Miguel St. southward to Manual P Mantanona Lane. Evaluate if an elevated storage tank w/ overflow @ 500' can be placed in this area with a ground elevation of about 382 feet.	3,800	Ignore, not needed since not adding elevated storage
9-11	N1 through N15	Mataguac, Santa Rosa, Yigo, Yigo Elevated	Improve available fire flow in the area of each project	Varies	Ignore, not analyzing fire flow
9-11	N16	Yigo Zone	Increase section of 8-inch waterline to 12 inches along Highway 15 between 12-inch lines at Road B. Wendy and Gayinero Dr. Reduce max-day velocities that exceed six fps and improve fire flows	3600	Ignore, no longer a problem since closed valve on Route 15, so little flow on this line
9-11	N17 through N43	Astumbo, Hyundai, Kaiser, Mangilao/ Chaot, Piti/ Agana, Pulantat, Tumon, Yigo	Improve available fire flow in the area of each project	Varies	Ignore, not analyzing fire flow
9-17	1, 2, 3	Malojloj	Improve available fire flow in the area of each project	Varies	Ignore, not analyzing fire flow
9-18	1	Mangilao/ Chaot	Increase Chaot Reservoir 12-inch inlet/outlet pipe to 24-inch down Dero Rd. to Route 4, then north up Route 4 to Chalan Canton Tutujan, and west to Senator Gibson Ct. Reduce velocity and improve pressure in this area.	13,500	Ignore, a second pipeline has since been constructed to the Chaot Reservoir
9-18	2	Kaiser	Install 24-inch distribution transmission main from Kaiser Reservoir and west along Route 1 to Chalan Liguan. Increase conveyance capacity and Improve pressure in this area	7,480	Ignore, 24-inch not required on Route 1 per current plan
9-18	3	Kaiser	Install 16-inch transmission line from Kaiser Reservoir to Barrigada Reservoirs via Route 1 and Route 26 as part of a booster line to fill proposed Yigo CIP Reservoir. Supply for proposed Yigo Reservoir on Route 15.	8,900	Ignore, not adding reservoir
9-18	4	Barrigada	Install 12-inch transmission line from Barrigada Reservoirs to Route 26 as part of a booster line to fill proposed Yigo CIP Reservoir. Supply for proposed Yigo Reservoir on Route 15.	1,100	Ignore, not adding reservoir

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-5. Status of 2006 WRMP Water Distribution Piping Projects					
Table	Project	Area	Description	Length (feet)	2016 WRMP Comment
9-18	5	Barrigada	Install 16-inch transmission line from Chalan Villagomez, southward on Route 26, and northeast on Route 15 as part of a booster line to fill proposed Yigo CIP Reservoir. Supply for proposed Yigo Reservoir on Route 15.	20,600	Ignore, not adding reservoir
9-18	6	Yigo	Increase existing 12-inch distribution main to 16-inch on Route 15, northward from Route 26 to the proposed Yigo CIP Reservoir. Increase conveyance capacity and improve pressure in the Adacao Rd. area	12,600	Ignore, not adding reservoir
9-18	7	Yigo	Install 24-inch outlet pipe for proposed Yigo CIP Reservoir and connect to distribution main on Route 15. Increase supply and conveyance capacity and improve pressure in Adacao Rd. area	700	Ignore, not adding reservoir
9-18	8	Yigo	Increase existing 8-inch distribution main to 12-inch on Adacao Rd. and Route 26. Increase conveyance capacity and improve pressure in the Adacao Rd. area	4,800	Ignore, the proposed Route 15 zone will increase pressures in this area
9-18	9	Yigo	Increase existing 2-inch distribution main to 8 inches, joining Wusstig Rd. and Chalan Islas Marianas. Improve loop capacity to increase pressure and lower velocity in this area	3,400	Ignore, pipe is 6-inch in latest GIS
9-18	10	Yigo	Install parallel 16-inch distribution main on Wusstig Rd., from Route 1 to proposed Yigo CIP Reservoir. Increase supply and improve pressure in this area	10,600	Ignore, not adding reservoir
9-18	11	Yigo	Install 12-inch distribution main that connects existing parallel mains on Route 1 at Chalan La Chanch. Improve loop capacity and conveyance in this area	100	Ignore, changed plan here for new Santa Rosa zone alignment
9-18	12	Yigo	Install 16-inch parallel main from Yigo Reservoirs, along Route 1, and west through Route 9 to Chalan Santa Bernadita. Part of the proposed pressure zone boundary adjustment that transfers some of the existing area served by the 658 pressure zone into the higher 724 pressure zone.	12,500	Ignore, pressure zone plan used existing piping to create new zones
9-18	13	Yigo	Install 16-inch outlet pipe from proposed Yigo CIP Reservoir to proposed 2005 CIP main on road S-11. Part of the proposed pressure zone boundary adjustment that transfers some of the existing area served by the 570 pressure zone into the higher 658 pressure zone.	1,600	Ignore, not adding reservoir
9-18	14	Astumbo	Increase inlet/outlet pipe for existing Astumbo Reservoirs to 24-inch. Increase conveyance capacity, reduce velocity, and improve pressures in this area.	6,100	Ignore, no longer needed per model
9-18	15	Astumbo	Install 24-inch outlet pipe for proposed Astumbo CIP Reservoir, westward from Chalan Koda to Chalan Ibang. Increase supply in this area.	6,400	Ignore, not adding reservoir
9-18	16	Astumbo	Increase existing 12-inch distribution main on Ysengsong Rd. to 24 inches, northward from Chalan Lahe to Chalan Koda. Increase conveyance capacity and improve pressure in this area.	7,200	Ignore, doing variation of this for updated plan
9-18	17	Astumbo	Increase existing 12-inch distribution main on Ysengsong Rd. to 24 inches, from Chalan Ibang to Chalan Hachon. Increase conveyance capacity and improve pressure in this area.	2,050	Ignore, doing variation of this for updated plan
9-18	18	Astumbo	Increase existing 12-inch distribution main on Ysengsong Rd. to 16 inches, from Chalan Hachon to Route 3. Increase conveyance capacity and improve pressure in this area.	2,900	Ignore, doing variation of this for updated plan

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table C-5. Status of 2006 WRMP Water Distribution Piping Projects					
Table	Project	Area	Description	Length (feet)	2016 WRMP Comment
9-18	19	Astumbo	Increase existing distribution mains to 10 inches for area bordered by Ysengsong Rd. to the north, Kamute and Chalan A'Abang to the south, Chalan Hachon to the east, and Chalan Fago and Nika to the west. Increase conveyance capacity and improve pressure in this area.	31,000	Ignore, no longer needed per model

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Appendix D
Cost Estimate Information

This appendix contains information used to develop cost estimates for recommended improvement projects in Volumes 1, 2, and 3 for the following facilities:

- Water
  - Piping
  - Storage tanks
  - BPSs
  - PRVs
  - Production wells
  - Hydrants
- Wastewater
  - Gravity piping and manholes
  - Force main piping
  - Lift stations

Cost estimates for these facilities were based on unit costs as discussed in this appendix. Costs for projects that are not easily broken down into unit costs (such as WWTP upgrades) were based on the best available information.

General Notes

The following notes apply to the cost estimates.

AACE International Estimate Classification

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, the estimates are Class 5 estimates. A Class 5 estimate is defined as a Conceptual Level or Project Viability Estimate. Typically, engineering is from 0 to 2 percent complete. Class 5 estimates are used to prepare planning level cost scopes or evaluation of alternative schemes, long range capital outlay planning and can also form the base work for the Class 4 Planning Level or Design Technical Feasibility Estimate.

Expected accuracy for Class 5 estimates typically ranges from -50 to +100 percent, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimating Methodology

The estimates were prepared using quantity take-offs, vendor quotes, and equipment pricing furnished either by the project team or by the estimator. The estimate includes direct labor costs and anticipated productivity adjustments to labor and equipment.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and the Rental Rate Blue Book for Construction Equipment (Blue Book).

When noted, some estimates were prepared using BC's estimating system, which consists of a Windows-based commercial estimating software engine using BC's material and labor database, historical project data, the latest vendor and material cost information, and other costs specific to the project locale.

General Estimating Assumptions

The following general assumptions were used in the development of the cost estimates:

1. The cost estimates are based on the unit costs listed in this appendix from comparable projects and do not account for the potential complexities of individual projects, such as an unusually large number of utility conflicts.
2. Bidders will develop estimates with a competitive approach to material pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions, or any other unplanned costs.
3. Estimated costs are based on a minimum of four bidders. Actual bid prices may increase for fewer bidders or decrease for a greater number of bidders.
4. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
5. Contractor has complete access for lay-down areas and mobile equipment.
6. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.

Estimating Exclusions

The following estimating exclusions were assumed in the development of the cost estimates:

1. Hazardous materials remediation and/or disposal.
2. Permits beyond those normally needed for the type of project and project conditions.
3. Easement acquisition and restitution to existing landowners for use of easements (i.e., farmed fields).

Cost Estimates

Cost estimates were generated for each facility. The professional service markups listed in Table D-1 were then applied to the cost estimates for each project.

Table D-1. Professional Services Markups

Item	Rate
Design	10%
Services during construction	5%
Construction management	17%
Total	*32%*

Use of contents on this sheet is subject to the limitations specified at the end of this document.

The following sections describe the methodology for calculating cost estimates.

Pipeline Costs

Pipeline costs were estimated using the three steps summarized below.

1. Unit Costs

Pipeline costs were initially estimated using BC's cost estimating system for average U.S. mainland costs. The following assumptions were made in calculating the pipeline costs:

- Water Piping
  - Pipelines will be C900/C905 PVC with industry standard specifications and thicknesses.
  - Existing pipes will be abandoned in place and filled with grout.
  - Costs include an air relief valve and vault every 1,500 linear feet and a drain valve and vault every 2,500 linear feet.
- Wastewater Gravity Piping
  - Pipelines will be PVC with new manholes every 300 feet.
  - Construction includes bypass pumping and dewatering.
  - Laterals will be constructed every 50 feet on pipes up to 15 inches.
  - Existing piping and manholes will be demolished and new pipes will be put into the same trench.
- General
  - Buried piping will require demolition and repair of existing asphalt pavement one foot beyond the trench limits.
  - Unit costs include traffic control and trenching.

2. Markups

The unit costs were marked up with contractor markups based on BC's experience with other utilities. The markups are listed in Table D-2.

Table D-2. Pipeline Unit Cost Markups

Category	Item	Rate (Percent)
Net Cost Markups	Labor (employer payroll burden)	15
	Material	10
	Subcontractor	10
	Construction equipment	10
	Material shipping and handling	10
Gross Cost Markups	Contractor general conditions	10
	Undesigned/undeveloped detail construction contingency	30
	Bonds and insurance	3.5

3. Guam Location Markup

The marked up costs were compared to bid tabulations from recent GWA water and wastewater projects. When the water pipeline costs were compared, the Guam bids were approximately 40% higher than US mainland costs. The wastewater pipeline costs were approximately 100% higher than

Use of contents on this sheet is subject to the limitations specified at the end of this document.

US mainland costs. Therefore, Guam location markups were applied to increase the costs to match the bid tabulations. The markups included 40% for water pipelines and 100% for wastewater pipelines.

Final Pipeline Costs

Table D-3 lists the marked up pipeline costs. Total pipeline costs include the costs in Table D-3 plus the markups in Table D-1.

Table D-3. Pipeline Unit Costs

Diameter (inches)	Water		Wastewater Gravity		Wastewater Force Main	
	New	Rehab	New	Rehab	New	Rehab
6	$337	$142	$616	$210	$482	$142
8	$360	$148	$650	$273	$515	$148
10	$385	$150	$703	$368	$550	$150
12	$412	$160	$735	$468	$589	$160
14	$414	$188	-	-	$591	$188
15	-	-	$796	$638	-	-
16	$441	$208	-	-	$630	$208
18	$472	$240	$865	$764	$674	$240
20	$523	$300	-	-	-	$300
21	-	-	$1,031	$874	-	-
24	$574	$326	$1,145	$1,000	$820	$326
30	-	-	$1,436	$1,287	-	-
36	-	-	$1,727	-	-	-
42	-	-	$2,058	-	-	-
48	-	-	$2,403	-	-	-

Water Storage Tank Costs

Table D-4 lists new water storage tank costs for pre-stressed concrete tanks. The costs were generated from recent GWA bid tabulations for the construction of new concrete tanks plus a 25% contingency. Total tank costs include the costs in Table D-4 plus the markups in Table D-1.

Table D-4. New Water Storage Tank Costs

Volume (gallons)	Cost per Gallon	Total Cost
250,000	$11.13	$2,783,000
500,000	$9.04	$4,520,000
1,000,000	$6.56	$6,560,000
2,000,000	$3.62	$7,240,000
3,000,000	$3.25	$9,750,000

Other costs include $200,000 to demolish an existing tank and $2.2M for temporary storage.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Water BPS Costs

Table D-5 lists new water BPS costs. The costs were generated from recent GWA bid tabulations for the construction of new BPSs. Total BPS costs include the costs in Table D-5 plus the markups in Table D-1.

Table D-5. New BPS Costs	
Capacity (gpm)	Cost per Gallons per Minute
<= 1,000	$600
1,001 to 2,000	$480
2,001 to 4,000	$430
4,001 to 8,000	$360
> 8,000	$330

Water PRV Costs

Table D-6 lists new water PRV costs. The costs were generated from recent GWA bid tabulations for the construction of new PRVs. Total PRV costs include the costs in Table D-6 plus the markups in Table D-1.

Table D-6. New PRV Cost	
Item	Cost
New PRV	$247,000

Water Production Well Costs

Table D-7 lists well costs. The costs were generated from recent GWA bid tabulations for the construction of new wells. Total well costs include the costs in Table D-7 plus the markups in Table D-1.

Table D-7. Well Costs	
Item	Cost
New Well	$1,980,000
Well Rehabilitation	$1,100,000
Well Repair Costs	$121,000

Wastewater Lift Station Costs

Costs for the rehabilitation of a lift station will vary greatly depending on the issues at the lift station. Costs were generated CDM Smith as an engineer's estimate of probably construction costs for the rehabilitation of 10 lift stations. Table D-8 lists the average rehabilitation cost for the 10 lift stations. Total lift station costs include the costs in Table D-8 plus the markups in Table D-1.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table D-8. Lift Station Costs	
Item	Cost
Lift Station Rehabilitation	$412,600

Water Hydrant Costs

Estimates for costs to replace and repair a typical fire hydrant were obtained for Mueller fire hydrants from a predominate fire hydrant supplier in GWA's inventory, Jones Water Products. The estimates do not account for any lost water from testing a hydrant when it is placed into service. The costs listed below for hydrants already include markups, so the markups listed in Table D-1 were not applied to these costs.

Labor costs for repair and replacement were taken from a mainland average and increased by 100%. It is assumed that GWA will perform the repair or replacement for half of the hydrants at no additional capital cost. An average labor cost was calculated for repair and replacement by dividing the cost for a contractor by two. These average labor costs were used in the tables below.

Repair Costs

Table D-9 lists the costs for hydrant repair. The repair costs are based on a total replacement of all the wearable parts of a fire hydrant for wet and dry barrel hydrants plus labor. Replacement parts include the fire hydrant, valves, and other components required to install a complete fire hydrant assembly from the isolation valve to the hydrant. It was also assumed, based on the age of GWA's hydrants, that 25 percent of the fire hydrant isolation valves will need to be replaced.

Table D-9. Hydrant Repair Costs			
Item	Cost per Hydrant		
	Dry Barrel	Wet Barrel	Average
Parts	$1,882	$886	
Labor per hydrant (covers cost of equipment and excavation)	$950	$950	
Isolation valve 6-inch gate valve (assuming 25% need replacement = 25% x $1,150)	$288	$288	
Miscellaneous costs (concrete, sidewalk, paint, marker and curb replacement)	$800	$800	
Total	*$3,920*	*$2,924*	*$3,422*

Replacement Costs

Table D-10 lists the estimated costs to replace or construct a new fire hydrant.

Table D-10. New Hydrant Costs	
Item	Cost
Fire hydrant (commercial grade hydrant, including shipping as supplied by Mueller)	$1,700
Labor	$2,000
6-Inch Isolation valve	$1,150
Administrative and miscellaneous Costs	$500
Total Estimated Cost	*$5,350*

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Appendix E

Strategic Financial Planning Model

Table E-1 lists the sheets in the spreadsheet used for the SFP model. In addition, the SFP model has been populated with various tables and graphics to enable presentation of financial planning scenarios and associated metrics. Three of the sheets listed in Table E-1 are included in this appendix as Tables E-2 through E-4.

Table E-1. Sheets in SFP Model Spreadsheet

Sheet Name	Description
Assumptions (Table E-2)	Major system financing assumptions, CIP escalation factors, fund balances, and financial policy / performance targets
Revenues at Existing Rates	Input of base service revenues (without rate increases) and projections of other operating and non-operating revenues
Rate Increase	Projections of revenues resulting from rate increases (net of price elasticity adjustments). Also includes calculations of residential and non-residential rates increases (given system-wide rates determined for the financial plan) that would be required to moderate residential rate subsidization by non-residential users over user input periods.
O&M Budget Structure	Identification of budgetary cost centers, line items and escalation factors used for O&M expense projections
O&M Forecast	Application of O&M escalation factors to base year budgets to forecast O&M expenses over the reporting period
CIP Expend	Summary of planned CIP by project and year estimated in default year costs and escalated by factors input in assumptions
MP CIP	Schedule of capital project costs, in current year dollars, identified in this WRMP Update
Ex Debt	Schedules of existing debt service requirements for revenue bonds and Bank of Guam loan payments
New Debt	Projections of debt service requirements on new senior lien or subordinate debt issues
Fin Plan (Table E-3)	Capital financing plan and required system-wide water and wastewater rate increase determination based on key financial performance metrics – including calculations of debt service coverage ratios and minimum fund balance targets. This spreadsheet also provides alternative debt service coverage calculations as well as projections of residential bills as a percent of median and lowest quintile income.
System Fund (Table E-4)	Projected sources and uses of funds, on a cash basis, for the system operating, debt service reserve, and rate stabilization funds

Use of contents on this sheet is subject to the limitations specified at the end of this document.

This page is intentionally left blank.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table E-2. SFP Model Assumptions

Scenario	Estimation Year	Capital Spend-Down					
			Potable Water	Wastewater	Miscellaneous	Other-1	Other-2
General Assumptions							
Budget Year		2018		Price Elasticity of Demand %			-0.50%
Default CIP Cost Estimation Year		2017		Interest Earned			3.00%
O&M Budget Reduction Factor		0.00%		Discount Rate			5.00%
Beginning Balances							
Operation and Maintenance Fund		$ 5,680,349		Minimum Reserve			25.00%
Unreserved Fund Balance				Reserve for subsequent year debt service			50.00%
Reserved for Debt Service		$ 11,187,181		Interest Rate on Debt Service Reserves			0.25%
Reserved for Debt Service Payments				Interest Rates on DSR input for individual years @ FundSum Row 52			
		$ 16,867,530		Rate Stabilization Fund - Beg Balance			$0.0
MHI / CIP Escalation		FY 2018 - 2022	FY 2023 - 2027	FY 2028 - 2032	FY 2033 - 2037	FY 2038 - 2042	FY 2043 - 2047
Prior Yr MHI / Escalation Factors	$42,288	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
Potable Water		3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Wastewater		3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Miscellaneous		3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Financing Assumptions		**FY 2018 - 2022**	**FY 2023 - 2027**	**FY 2028 - 2032**	**FY 2033 - 2037**	**FY 2038 - 2042**	**FY 2043 - 2047**
Revenue Bonds							
Issuance Costs		1.20%	1.20%	1.20%	1.20%	1.20%	1.20%
Bond Surety		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Interest Rate		5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Bond Term (years)		30	30	30	30	30	30
Bond Reserve		6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
Yrs of Capitalized Interest (1,2 or zero)		2	2	2	2	2	0
Yrs of Deferred Principal (1,2 or zero)		2	2	2	2	2	0
SRF Loans							
SRF Cost of Issuance #1		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SRF Cost of Issuance #2		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Interest Rate		2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Term (years)		20	20	20	20	20	20
Annual Loan Fee		0.25%	1.20%	1.20%	1.20%	1.20%	1.20%
Other							
Other (GO, Taxable) Bonds							
Cost of Issuance		1.50%	1.50%	1.50%	1.50%	1.50%	1.50%
Bond Surety / Reserve		1.80%	1.80%	1.80%	1.80%	1.80%	1.80%
Interest Rate		5.80%	5.80%	5.80%	5.80%	5.80%	5.80%
Term (years)		30	30	30	30	30	30
Other		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Debt Service Coverage Targets							
Sr. Lien Coverage (w/o SDC and Legislative Charges)	1.75	All Revenue Bonds (w/o SDC and Legislative Charges)	1.75	Revenue Bonds w/SDC and Leg Charges	1.50	PUC Calc Est. -Incl DS Res.	1.75

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table E-3. Financing Plan

	TOTAL	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034	FY 2035	FY 2036	FY 2037
Beginning "Balance"		$0	$ 20,190	$ 3,990,878	$ 56,634,294	$ 3,673,376	$ 16,028,191	$ 50,330,717	$ 30,628,831	$ 287,646	$ 72,132,476	$ 30,924,915	$ 9,859,077	$ 83,971,442	$ 52,257,295	$ 1,823,091	$ 45,862,612	$ 16,947,318	$ 2,188,854	$ 30,214,223	$ 24,776,552
Override Model CIP Cash Flow																					
Water System		$16,504,720	$37,882,617	$34,415,596	$34,780,408	$21,511,850	$33,440,420	$28,154,559	$25,138,622	$26,282,946	$23,729,910	$20,704,376	$36,594,991	$47,080,050	$57,776,522	$27,913,331	$25,444,724	$23,651,768	$36,360,995	$22,424,448	$28,638,261
Wastewater System		$1,327,670	$13,956,140	$17,333,928	$32,930,421	$29,042,629	$23,707,155	$17,705,407	$34,896,441	$22,431,965	$42,757,417	$35,971,266	$30,850,420	$21,069,894	$31,823,126	$32,116,818	$43,244,502	$35,046,789	$40,688,150	$26,706,067	$45,775,276
SCADA/Miscellaneous Projects		$1,147,420	$4,190,555	$3,607,060	$8,250,089	$7,090,706	$6,549,899	$6,841,920	$6,806,122	$6,440,259	$12,720,234	$7,390,196	$6,442,224	$6,564,203	$6,834,556	$8,930,330	$8,226,068	$4,059,907	$4,925,486	$4,307,156	$7,505,006
Capital Improvement Expenditures (Pending Financing)	**$ 645,640,923**	**$18,979,810**	**$56,029,312**	**$55,356,584**	**$75,960,918**	**$57,645,185**	**$63,697,474**	**$52,701,886**	**$66,841,185**	**$55,155,170**	**$79,207,561**	**$64,065,838**	**$73,887,635**	**$74,714,147**	**$96,434,204**	**$68,960,479**	**$76,915,294**	**$62,758,464**	**$81,974,631**	**$53,437,671**	**$81,918,543**
Current Project Totals (with Funding Allocated)	$69,422,340	$52,118,000	$17,304,340	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
DoD/OEA Funded Projects	$182,802,226	$29,870,000	$54,211,990	$55,838,350	$42,881,886	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
SRF Funded Projects	$44,018,579	$20,939,900	$18,213,531	$3,278,181	$1,586,967	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL - CIP EXPENDITURES	**$1,612,885,136**	**$121,907,710**	**$145,759,173**	**$114,473,115**	**$120,429,771**	**$57,645,185**	**$63,697,474**	**$52,701,886**	**$66,841,185**	**$55,155,170**	**$79,207,561**	**$64,065,838**	**$73,887,635**	**$74,714,147**	**$96,434,204**	**$68,960,479**	**$76,915,294**	**$62,758,464**	**$81,974,631**	**$53,437,671**	**$81,918,543**
Revenue Bonds	**$585,000,000**		**$60,000,000**	**$95,000,000**		**$40,000,000**	**$65,000,000**			**$90,000,000**			**$105,000,000**			**$70,000,000**			**$60,000,000**		
Federal Grants and SRF Funded Project Grants	**$172,018,579**	**$20,939,900**	**$18,213,531**	**$3,278,181**	**$1,586,967**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**	**$8,000,000**
Revenue Bond Debt Coverage	***1.50***	**1.60**	**1.73**	**1.71**	**1.62**	**1.47**	**1.58**	**1.59**	**1.50**	**1.57**	**1.64**	**1.52**	**1.58**	**1.65**	**1.53**	**1.52**	**1.59**	**1.55**	**1.59**	**1.63**	**1.54**
Meets Target Coverage?		Yes	Yes	Yes	Yes	*NO!*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Debt Coverage - PUC Est (incl. DS Res.)	***1.75***	**1.95**	**2.20**	**2.31**	**2.16**	**1.98**	**2.19**	**2.18**	**2.05**	**2.24**	**2.33**	**2.15**	**2.33**	**2.43**	**2.23**	**2.31**	**2.40**	**2.32**	**2.43**	**2.49**	**2.38**
Meets Target Coverage?		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Cumulative	*8.68%*	*13.57%*	*18.68%*	*24.02%*	*29.60%*	*35.43%*	*39.49%*	*43.67%*	*47.98%*	*52.42%*	*56.99%*	*61.70%*	*66.55%*	*71.55%*	*76.70%*	*82.00%*	*87.46%*	*93.08%*	*98.87%*
Proposed Rate Increases		**4.00%**	**4.50%**	**4.50%**	**4.50%**	**4.50%**	**4.50%**	**4.50%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**	**3.00%**
Operating Fund Balance	*NA*	*$ 5,631,667*	*$28,835,857*	*$40,637,780*	*$42,384,785*	*$42,429,007*	*$44,545,142*	*$48,961,675*	*$48,307,824*	*$50,819,460*	*$56,240,205*	*$53,582,874*	*$55,032,109*	*$60,891,269*	*$60,059,065*	*$62,002,093*	*$63,883,643*	*$65,402,124*	*$68,328,083*	*$75,988,554*	*$69,800,232*
Operating funds available	*NA*	*$ (7,780,648)*	*$ (5,649,106)*	*$ 16,283,140*	*$ 23,768,076*	*$ 22,270,984*	*$ 25,254,895*	*$ 26,540,751*	*$ 28,795,596*	*$ 31,196,541*	*$ 33,451,062*	*$ 35,145,074*	*$ 35,926,173*	*$ 36,970,892*	*$ 38,432,562*	*$ 36,646,398*	*$ 40,024,675*	*$ 40,771,238*	*$ 44,899,401*	*$ 47,380,964*	*$ 50,347,581*
Internally Funded CIP (PAYGO)	**$ 604,500,000**	**$19,000,000**		**$13,000,000**	**$23,000,000**	**$22,000,000**	**$25,000,000**	**$25,000,000**	**$28,500,000**	**$29,000,000**	**$30,000,000**	**$35,000,000**	**$35,000,000**	**$35,000,000**	**$38,000,000**	**$35,000,000**	**$40,000,000**	**$40,000,000**	**$42,000,000**	**$40,000,000**	**$50,000,000**
Rate Stabilization Transfers	**$ (47,000,000)**															**-$5,000,000**	**-$5,000,000**	**-$5,000,000**	**-$7,000,000**	**-$10,000,000**	**-$15,000,000**
Total Funds	**$ 1,361,518,579**	**$39,939,900**	**$78,213,531**	**$111,278,181**	**$24,586,967**	**$70,000,000**	**$98,000,000**	**$33,000,000**	**$36,500,000**	**$127,000,000**	**$38,000,000**	**$43,000,000**	**$148,000,000**	**$43,000,000**	**$46,000,000**	**$113,000,000**	**$48,000,000**	**$48,000,000**	**$110,000,000**	**$48,000,000**	**$58,000,000**
Ending Fund Balances																					
Operating Fund Unreserved Balance		**(26,780,648)**	**(5,649,106)**	**3,283,140**	**768,076**	**270,984**	**254,895**	**1,540,751**	**295,596**	**2,196,541**	**3,451,062**	**145,074**	**926,173**	**1,970,892**	**432,562**	**1,646,398**	**24,675**	**771,238**	**2,899,401**	**7,380,964**	**347,581**
Operating Fund Balance Requirements Met?		*NO!*	*NO!*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Capital Balance		20,190	3,990,878	56,634,294	3,673,376	16,028,191	50,330,717	30,628,831	287,646	72,132,476	30,924,915	9,859,077	83,971,442	52,257,295	1,823,091	45,862,612	16,947,318	2,188,854	30,214,223	24,776,552	858,009
Improvements Requirements Met?		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rate Stabilization Fund Balance		**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$5,075,000**	**$10,302,250**	**$15,686,318**	**$23,261,908**	**$34,109,765**	**$50,358,058**
CUMULATIVE RATE INCREASE		*4.00%*	*8.68%*	*13.57%*	*18.68%*	*24.02%*	*29.60%*	*35.44%*	*39.50%*	*43.68%*	*47.99%*	*52.43%*	*57.01%*	*61.72%*	*66.57%*	*71.57%*	*76.71%*	*82.01%*	*87.47%*	*93.10%*	*98.89%*
Estimate of Available Bonding Capacity Under Planned Rate Increases																					
Max Debt Service Capacity -- Sr. Lien		($2,660,557)	($26,113)	($502,350)	$2,198,651	$5,069,323	$8,160,005	$10,155,912	$12,223,593	$14,435,311	$16,693,423	$19,016,106	$21,509,413	$24,088,814	$23,932,240	$26,731,078	$29,641,883	$31,558,346	$33,097,758	$33,563,615	#REF!
Max Debt Principle		($40,408,489)	($396,606)	($7,629,679)	$33,393,065	$76,992,778	$123,934,000	$154,247,809	$185,651,711	$219,243,239	$253,539,402	$288,816,276	$326,684,565	$365,860,463	$363,482,429	$405,991,120	$450,200,377	$479,307,581	$502,688,137	$509,763,566	#REF!
Coverage Dollars Available		$21,788,872	$23,790,336	$25,769,195	$27,793,379	$29,946,548	$32,261,323	$33,759,018	$35,309,035	$36,964,580	$38,657,304	$40,397,711	$42,267,890	$44,202,671	$44,085,265	$46,180,556	$48,362,516	$49,800,266	$50,951,888	$51,302,906	#REF!
Subtotal																					
Max Debt Service Capacity -- All Revenue Bonds		($2,660,557)	($26,113)	($502,350)	$2,198,651	$5,069,323	$8,160,005	$10,155,912	$12,223,593	$14,435,311	$16,693,423	$19,016,106	$21,509,413	$24,088,814	$23,932,240	$26,731,078	$29,641,883	$31,558,346	$33,097,758	$33,563,615	#REF!
Max Debt Principle		($40,408,489)	($396,606)	($7,629,679)	$33,393,065	$76,992,778	$123,934,000	$154,247,809	$185,651,711	$219,243,239	$253,539,402	$288,816,276	$326,684,565	$365,860,463	$363,482,429	$405,991,120	$450,200,377	$479,307,581	$502,688,137	$509,763,566	#REF!
Coverage Dollars Available		$21,788,872	$23,790,336	$25,769,195	$27,793,379	$29,946,548	$32,261,323	$33,759,018	$35,309,035	$36,964,580	$38,657,304	$40,397,711	$42,267,890	$44,202,671	$44,085,265	$46,180,556	$48,362,516	$49,800,266	$50,951,888	$51,302,906	#REF!
Subtotal																					

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table E-3. Financing Plan

Projected Debt Service Coverage																					
		FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034	FY 2035	FY 2036	FY 2037
Operating Revenues		$ 112,811,897	$ 119,045,750	$ 125,764,142	$ 132,491,100	$ 139,387,087	$ 146,649,332	$ 154,355,960	$ 160,223,816	$ 166,284,963	$ 172,665,770	$ 179,208,843	$ 185,940,978	$ 193,056,172	$ 200,404,660	$ 203,046,358	$ 210,942,030	$ 219,130,164	$ 225,673,418	$ 231,644,173	$ 235,844,025
Non-Operating Revenues (System Facilities Charges & Legislative Surcharges)		$4,056,383	$4,096,947	$4,137,916	$4,179,296	$4,221,089	$4,263,300	$4,305,933	$4,348,992	$4,392,483	$4,436,407	$4,480,771	$4,525,580	$4,570,836	$4,616,544	$4,662,709	$4,709,336	$4,756,429	$4,803,994	$4,852,034	$4,900,554
Total Revenues		$116,868,279	$123,142,696	$129,902,059	$136,670,396	$143,608,175	$150,912,631	$158,661,893	$164,572,808	$170,677,446	$177,102,178	$183,689,615	$190,466,558	$197,627,008	$205,021,204	$207,709,067	$215,651,367	$223,886,594	$230,477,412	$236,496,207	$240,744,579
Operating Expenses		$66,184,663	$68,170,203	$70,215,310	$72,321,767	$74,491,419	$76,726,161	$79,027,946	$81,398,784	$83,840,746	$86,355,968	$88,946,645	$91,615,046	$94,363,498	$97,194,403	$100,110,235	$103,113,544	$106,206,948	$109,393,154	$112,674,949	$116,055,197
Net Revenues Available for Debt Service		$46,627,233	$50,875,547	$55,548,832	$60,169,333	$64,895,668	$69,923,171	$75,328,014	$78,825,032	$82,444,217	$86,309,802	$90,262,198	$94,325,932	$98,692,674	$103,210,257	$102,936,123	$107,828,486	$112,923,216	$116,280,264	$118,969,224	$119,788,828
Net Revenues Available Including Sys Facilities and Leg. Charges		$50,683,616	$54,972,493	$59,686,749	$64,348,629	$69,116,756	$74,186,470	$79,633,947	$83,174,024	$86,836,700	$90,746,210	$94,742,970	$98,851,512	$103,263,510	$107,826,801	$107,598,832	$112,537,823	$117,679,646	$121,084,258	$123,821,258	$124,689,382
Debt Service																					
Sr. Lien Revenue Bonds		31,732,298	31,768,303	34,884,826	39,601,624	47,072,535	47,070,335	50,217,414	55,327,875	55,325,064	55,325,465	62,400,301	62,402,276	62,404,350	70,659,005	70,655,804	70,656,273	76,161,164	76,158,299	76,160,788	80,877,704
Jr. Lien Revenue Bonds		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SRF Loans		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other (GO, Taxable) Bonds		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Debt Service		$ 31,732,298	$ 31,768,303	$ 34,884,826	$ 39,601,624	$ 47,072,535	$ 47,070,335	$ 50,217,414	$ 55,327,875	$ 55,325,064	$ 55,325,465	$ 62,400,301	$ 62,402,276	$ 62,404,350	$ 70,659,005	$ 70,655,804	$ 70,656,273	$ 76,161,164	$ 76,158,299	$ 76,160,788	$ 80,877,704
Debt Service Coverage																					
Sr. Lien Coverage (w/o SDC and Legislative Charges)		**1.47**	**1.60**	**1.59**	**1.52**	**1.38**	**1.49**	**1.50**	**1.42**	**1.49**	**1.56**	**1.45**	**1.51**	**1.58**	**1.46**	**1.46**	**1.53**	**1.48**	**1.53**	**1.56**	**1.48**
All Revenue Bonds (w/o SDC and Legislative Charges)		**1.47**	**1.60**	**1.59**	**1.52**	**1.38**	**1.49**	**1.50**	**1.42**	**1.49**	**1.56**	**1.45**	**1.51**	**1.58**	**1.46**	**1.46**	**1.53**	**1.48**	**1.53**	**1.56**	**1.48**
Revenue Bonds w/SDC and Leg Charges		**1.60**	**1.73**	**1.71**	**1.62**	**1.47**	**1.58**	**1.59**	**1.50**	**1.57**	**1.64**	**1.52**	**1.58**	**1.65**	**1.53**	**1.52**	**1.59**	**1.55**	**1.59**	**1.63**	**1.54**
Revenue Bonds with Leg Charges (and excluding SDCs)		**1.58**	**1.71**	**1.69**	**1.61**	**1.46**	**1.56**	**1.57**	**1.49**	**1.56**	**1.63**	**1.51**	**1.57**	**1.64**	**1.52**	**1.51**	**1.58**	**1.54**	**1.58**	**1.62**	**1.53**
PUC Calc Est. -Incl DS Res.		**1.95**	**2.20**	**2.31**	**2.16**	**1.98**	**2.19**	**2.18**	**2.05**	**2.24**	**2.33**	**2.15**	**2.33**	**2.43**	**2.23**	**2.31**	**2.40**	**2.32**	**2.43**	**2.49**	**2.38**
Projected Bills & Median Household Income																					
		FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034	FY 2035	FY 2036	FY 2037
Typical Residential Bills																					
Wastewater (Flat Fee)		$27.54	$28.78	$30.03	$31.33	$32.69	$34.11	$35.59	$36.62	$37.68	$38.77	$39.89	$41.04	$42.22	$43.44	$44.69	$45.98	$47.31	$48.67	$50.07	$51.51
Water																					
- Base Charge		$21.69	$22.67	$23.65	$24.68	$25.75	$26.87	$28.03	$28.84	$29.67	$30.53	$31.41	$32.32	$33.25	$34.21	$35.20	$36.22	$37.27	$38.35	$39.46	$40.60
- Lifeline Rate		$3.01	$3.15	$3.29	$3.44	$3.59	$3.75	$3.92	$4.04	$4.16	$4.28	$4.41	$4.54	$4.68	$4.82	$4.96	$5.11	$5.26	$5.42	$5.58	$5.75
- Lifeline Volume		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
- Lifeline Charges		$15.05	$15.75	$16.45	$17.20	$17.95	$18.75	$19.60	$20.20	$20.80	$21.40	$22.05	$22.70	$23.40	$24.10	$24.80	$25.55	$26.30	$27.10	$27.90	$28.75
- Non- Lifeline Rate		$10.32	$10.79	$11.26	$11.75	$12.26	$12.79	$13.35	$13.74	$14.14	$14.55	$14.97	$15.41	$15.86	$16.32	$16.79	$17.28	$17.78	$18.30	$18.83	$19.38
- Non- Lifeline Volume		2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
- Non- Lifeline Charges		$25.80	$26.98	$28.15	$29.38	$30.65	$31.98	$33.38	$34.35	$35.35	$36.38	$37.43	$38.53	$39.65	$40.80	$41.98	$43.20	$44.45	$45.75	$47.08	$48.45
Monthly Residential Bill		$90.08	$94.18	$98.28	$102.59	$107.04	$111.71	$116.60	$120.01	$123.50	$127.08	$130.78	$134.59	$138.52	$142.55	$146.67	$150.95	$155.33	$159.87	$164.51	$169.31
Increase over Prior Year			$4.10	$4.10	$4.31	$4.45	$4.67	$4.89	$3.41	$3.49	$3.58	$3.70	$3.81	$3.93	$4.03	$4.12	$4.28	$4.38	$4.54	$4.64	$4.80
Annual Residential Bill		$1,081	$1,130	$1,179	$1,231	$1,284	$1,341	$1,399	$1,440	$1,482	$1,525	$1,569	$1,615	$1,662	$1,711	$1,760	$1,811	$1,864	$1,918	$1,974	$2,032
	Prior Year MHI																				
Median Household Income	$42,288	$43,133	$43,996	$44,876	$45,774	$46,689	$47,623	$48,575	$49,547	$50,538	$51,549	$52,580	$53,632	$54,705	$55,799	$56,915	$58,053	$59,214	$60,398	$61,606	$62,838
Projected Median Household Income		4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
Projected 4% of Median Household Income		$1,725	$1,760	$1,795	$1,831	$1,868	$1,905	$1,943	$1,982	$2,022	$2,062	$2,103	$2,145	$2,188	$2,232	$2,277	$2,322	$2,369	$2,416	$2,464	$2,514
Projected 4% of Median Household Income - Monthly Amount		$144.00	$147.00	$150.00	$153.00	$156.00	$159.00	$162.00	$165.00	$169.00	$172.00	$175.00	$179.00	$182.00	$186.00	$190.00	$194.00	$197.00	$201.00	$205.00	$210.00
Projected 4% of Median Household Income - Annual Amount																					
Residential Bill as a Percentage of MHI		2.51%	2.57%	2.63%	2.69%	2.75%	2.82%	2.88%	2.91%	2.93%	2.96%	2.98%	3.01%	3.04%	3.07%	3.09%	3.12%	3.15%	3.18%	3.20%	3.23%
Difference: MHI Threshold - Annual Residential Bill		$644	$630	$616	$600	$584	$564	$544	$542	$540	$537	$534	$530	$526	$521	$517	$511	$505	$498	$490	$482
Lowest Quintile Household Income	$15,608.02	$15,920	$16,238	$16,563	$16,894	$17,232	$17,577	$17,929	$18,288	$18,654	$19,027	$19,408	$19,796	$20,192	$20,596	$21,008	$21,428	$21,857	$22,294	$22,740	$23,195
	Adjustment Factor																				
Adjusted Residential Bill as a Percentage of Lowest Quintile Income	80.00%	5.43%	5.57%	5.69%	5.83%	5.96%	6.10%	6.24%	6.30%	6.36%	6.41%	6.47%	6.53%	6.58%	6.65%	6.70%	6.76%	6.82%	6.88%	6.94%	7.01%

Brown AND Caldwell

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Table E-4. Fund Summary

Sources and Uses of Funds

Operating Fund

	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034	FY 2035	FY 2036	FY 2037
SOURCES																				
Beginning Cash Balance:	*$5,680,349*	*$5,631,667*	*$28,835,857*	*$40,637,780*	*$42,384,785*	*$42,429,007*	*$44,545,142*	*$48,961,675*	*$48,307,824*	*$50,819,460*	*$56,240,205*	*$53,582,874*	*$55,032,109*	*$60,891,269*	*$60,059,065*	*$62,002,093*	*$63,883,643*	*$65,402,124*	*$68,328,083*	*$75,988,554*
Service Charges	$ 107,657,009	$ 108,664,661	$ 109,681,770	$ 110,708,423	$ 111,744,712	$ 112,790,727	$ 113,846,559	$ 114,912,300	$ 115,988,044	$ 117,073,885	$ 118,169,919	$ 119,276,241	$ 120,392,947	$ 121,520,136	$ 122,657,906	$ 123,806,357	$ 124,965,589	$ 126,135,704	$ 127,316,804	$ 128,508,993
Sales Revenue from Rate Increases	4,306,280	9,183,468	14,360,537	19,853,660	25,679,865	31,857,078	38,404,171	43,143,446	48,094,088	53,264,448	58,663,196	64,299,334	70,182,214	76,321,545	82,727,409	89,410,277	96,381,021	103,650,931	111,231,732	119,135,596
Subtotal Service Charge Revenues	$ 111,963,289	$ 117,848,129	$ 124,042,307	$ 130,562,083	$ 137,424,577	$ 144,647,805	$ 152,250,730	$ 158,055,746	$ 164,082,132	$ 170,338,333	$ 176,833,115	$ 183,575,575	$ 190,575,161	$ 197,841,681	$ 205,385,315	$ 213,216,634	$ 221,346,610	$ 229,786,635	$ 238,548,536	$ 247,644,589
System Facility Charges	553,630	559,166	564,758	570,406	576,110	581,871	587,690	593,567	599,503	605,498	611,553	617,669	623,846	630,084	636,385	642,749	649,176	655,668	662,225	668,847
Legislative Surcharge	3,502,753	3,537,781	3,573,158	3,608,890	3,644,979	3,681,429	3,718,243	3,755,425	3,792,980	3,830,909	3,869,218	3,907,911	3,946,990	3,986,460	4,026,324	4,066,587	4,107,253	4,148,326	4,189,809	4,231,707
Miscellaneous Revenues	691,656	698,573	705,558	712,614	719,740	726,937	734,207	741,549	748,964	756,454	764,019	771,659	779,375	787,169	795,041	802,991	811,021	819,131	827,323	835,596
Rate Stabilization Fund Transfers	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(5,000,000)	(5,000,000)	(5,000,000)	(7,000,000)	(10,000,000)	(15,000,000)
Interest Revenue	156,951	499,049	1,016,277	1,216,403	1,242,769	1,274,589	1,371,024	1,426,521	1,453,867	1,570,983	1,611,710	1,593,744	1,701,636	1,775,810	1,866,002	1,922,405	1,972,533	2,067,651	2,268,315	2,363,840
Total Sources	***$ 122,548,628***	***$ 128,774,363***	***$ 158,737,916***	***$ 177,308,176***	***$ 185,992,961***	***$ 193,341,638***	***$ 203,207,035***	***$ 213,534,483***	***$ 218,985,270***	***$ 227,921,638***	***$ 239,929,820***	***$ 244,049,431***	***$ 252,659,117***	***$ 265,912,473***	***$ 267,768,132***	***$ 277,653,460***	***$ 287,770,236***	***$ 295,879,536***	***$ 304,824,291***	***$ 316,733,133***
USES																				
Utility Costs	$ 21,349,320	$ 21,989,801	$ 22,649,495	$ 23,328,980	$ 24,028,850	$ 24,749,716	$ 25,492,207	$ 26,256,974	$ 27,044,683	$ 27,856,023	$ 28,691,703	$ 29,552,454	$ 30,439,028	$ 31,352,199	$ 32,292,764	$ 33,261,547	$ 34,259,392	$ 35,287,173	$ 36,345,788	$ 37,436,162
Salaries, Wages & Benefits	24,015,371	24,735,832	25,477,907	26,242,244	27,029,511	27,840,396	28,675,608	29,535,876	30,421,952	31,334,610	32,274,648	33,242,888	34,240,175	35,267,381	36,325,403	37,415,165	38,537,620	39,693,748	40,884,561	42,111,098
Administrative and Services	12,866,977	13,252,986	13,650,576	14,060,092	14,481,894	14,916,351	15,363,842	15,824,756	16,299,498	16,788,483	17,292,137	17,810,902	18,345,229	18,895,585	19,462,453	20,046,327	20,647,716	21,267,147	21,905,161	22,562,315
Contractual	4,478,895	4,613,261	4,751,659	4,894,208	5,041,034	5,192,264	5,348,032	5,508,473	5,673,727	5,843,939	6,019,257	6,199,835	6,385,830	6,577,405	6,774,727	6,977,970	7,187,309	7,402,928	7,625,016	7,853,766
Retiree Benefits	3,474,100	3,578,323	3,685,673	3,796,243	3,910,130	4,027,434	4,148,257	4,272,705	4,400,886	4,532,913	4,668,900	4,808,967	4,953,236	5,101,833	5,254,888	5,412,535	5,574,911	5,742,158	5,914,423	6,091,856
Incremental O&M Expense - CD Compliance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Operating Expenses	$ 66,184,663	$ 68,170,203	$ 70,215,310	$ 72,321,767	$ 74,491,419	$ 76,726,161	$ 79,027,946	$ 81,398,784	$ 83,840,746	$ 86,355,968	$ 88,946,645	$ 91,615,046	$ 94,363,498	$ 97,194,403	$ 100,110,235	$ 103,113,544	$ 106,206,948	$ 109,393,154	$ 112,674,949	$ 116,055,197
Transfer to CIP	19,000,000	-	13,000,000	23,000,000	22,000,000	25,000,000	25,000,000	28,500,000	29,000,000	30,000,000	35,000,000	35,000,000	35,000,000	38,000,000	35,000,000	40,000,000	40,000,000	42,000,000	40,000,000	50,000,000
Existing Debt Service	$31,732,298	$31,768,303	$34,884,826	$34,884,588	$34,886,775	$34,884,575	$34,886,963	$34,887,388	$34,884,576	$34,884,976	$34,884,426	$34,886,401	$34,888,476	$34,888,401	$34,885,200	$34,885,669	$34,887,519	$34,884,656	$34,887,144	$34,887,025
New Debt Service	$0	$0	$0	$4,717,036	$12,185,760	$12,185,760	$15,330,451	$20,440,487	$20,440,488	$20,440,489	$27,515,875	$27,515,875	$27,515,874	$35,770,604	$35,770,604	$35,770,604	$41,273,645	$41,273,643	$41,273,644	$45,990,679
Ending Cash Balance	$ 5,631,667	$ 28,835,857	$ 40,637,780	$ 42,384,785	$ 42,429,007	$ 44,545,142	$ 48,961,675	$ 48,307,824	$ 50,819,460	$ 56,240,205	$ 53,582,874	$ 55,032,109	$ 60,891,269	$ 60,059,065	$ 62,002,093	$ 63,883,643	$ 65,402,124	$ 68,328,083	$ 75,988,554	$ 69,800,232
Total Uses	***$ 122,548,628***	***$ 128,774,363***	***$ 158,737,916***	***$ 177,308,176***	***$ 185,992,961***	***$ 193,341,638***	***$ 203,207,035***	***$ 213,534,483***	***$ 218,985,270***	***$ 227,921,638***	***$ 239,929,820***	***$ 244,049,431***	***$ 252,659,117***	***$ 265,912,473***	***$ 267,768,132***	***$ 277,653,460***	***$ 287,770,236***	***$ 295,879,536***	***$ 304,824,291***	***$ 316,733,133***
Net Increase (Decrease)	$ (48,682)	$ 23,204,190	$ 11,801,923	$ 1,747,005	$ 44,221	$ 2,116,135	$ 4,416,533	$ (653,851)	$ 2,511,636	$ 5,420,745	$ (2,657,331)	$ 1,449,236	$ 5,859,160	$ (832,204)	$ 1,943,028	$ 1,881,550	$ 1,518,482	$ 2,925,959	$ 7,660,470	$ (6,188,322)
Balance Summary	$5,631,667	$28,835,857	$40,637,780	$42,384,785	$42,429,007	$44,545,142	$48,961,675	$48,307,824	$50,819,460	$56,240,205	$53,582,874	$55,032,109	$60,891,269	$60,059,065	$62,002,093	$63,883,643	$65,402,124	$68,328,083	$75,988,554	$69,800,232
Unreserved Balance	-$26,780,648	-$5,649,106	$3,283,140	$768,076	$270,984	$254,895	$1,540,751	$295,596	$2,196,541	$3,451,062	$145,074	$926,173	$1,970,892	$432,562	$1,646,398	$24,675	$771,238	$2,899,401	$7,380,964	$347,581
Minimum Reserve Balance	$16,546,166	$17,042,551	$17,553,828	$18,080,442	$18,622,855	$19,181,540	$19,756,987	$20,349,696	$20,960,187	$21,588,992	$22,236,661	$22,903,762	$23,590,875	$24,298,601	$25,027,559	$25,778,386	$26,551,737	$27,348,289	$28,168,737	$29,013,799
Reserved for Debt Service	$15,866,149	$17,442,413	$19,800,812	$23,536,268	$23,535,168	$25,108,707	$27,663,938	$27,662,532	$27,662,733	$31,200,151	$31,201,138	$31,202,175	$35,329,503	$35,327,902	$35,328,137	$38,080,582	$38,079,150	$38,080,394	$40,438,852	$40,438,852
DEBT SERVICE RESERVE FUNDS																				
Beginning balance	**$11,187,181**	$11,215,149	$14,945,300	$20,823,253	$21,239,719	$24,088,513	$28,769,668	$29,632,758	$30,521,741	$36,918,393	$38,025,945	$39,166,724	$46,736,225	$48,138,312	$49,582,462	$55,332,936	$56,992,924	$58,702,711	$64,117,793	$66,041,327
Reserve fund contribution	$0	$3,600,000	$5,700,000	$0	$2,400,000	$3,900,000	$0	$0	$5,400,000	$0	$0	$6,300,000	$0	$0	$4,200,000	$0	$0	$3,600,000	$0	$0
Interest Rate on Debt Service Reserves	0.25%	1.00%	1.00%	2.00%	2.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Interest on reserve funds	$27,968	$130,151	$177,953	$416,465	$448,794	$781,155	$863,090	$888,983	$996,652	$1,107,552	$1,140,778	$1,269,502	$1,402,087	$1,444,149	$1,550,474	$1,659,988	$1,709,788	$1,815,081	$1,923,534	$1,981,240
Ending balance	$11,215,149	$14,945,300	$20,823,253	$21,239,719	$24,088,513	$28,769,668	$29,632,758	$30,521,741	$36,918,393	$38,025,945	$39,166,724	$46,736,225	$48,138,312	$49,582,462	$55,332,936	$56,992,924	$58,702,711	$64,117,793	$66,041,327	$68,022,566
RATE STABILIZATION FUNDS																				
Beginning balance	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$5,075,000	$10,302,250	$15,686,318	$23,261,908	$34,109,765
Rate Stabilization Fund Transfers	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$5,000,000	$5,000,000	$5,000,000	$7,000,000	$10,000,000	$15,000,000
Interest Rate on Debt Service Reserves	0.25%	1.00%	1.00%	2.00%	2.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
Interest on reserve funds	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$75,000	$227,250	$384,068	$575,590	$847,857	$1,248,293
Ending balance	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$5,075,000	$10,302,250	$15,686,318	$23,261,908	$34,109,765	$50,358,058

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Appendix F

Public Outreach Program Documentation

- **Appendix F-1. GWA Ratepayers' Monthly Newsletter, Issue No. 002, May 2018**
- **Appendix F-2. WRMPU Public Outreach Summary**
- **Appendix F-3. Public Outreach Questions and Comments Summary**
- **Appendix F-4. Public Outreach Meetings' Attendance Sheets**

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

GUAM WATERWORKS AUTHORITY

Gasetan Hånom

RATEPAYERS' MONTHLY NEWSLETTER • ISSUE NO. 002 • MAY 2018

GWA Water Resources MASTER PLAN UPDATE

In 2006, the Guam Waterworks Authority (GWA) completed and adopted a Water Resources Master Plan (WRMP) that summarized the condition of GWA's water and wastewater system facilities and outlined improvements needed over the subsequent 20 years to achieve regulatory compliance and improve the reliability of GWA. The 2006 WRMP proposed approximately \$900M in capital improvement projects (CIP) for the 20-year period from 2007 to 2026. \$250M of these CIPs are completed and another \$280M are in progress.

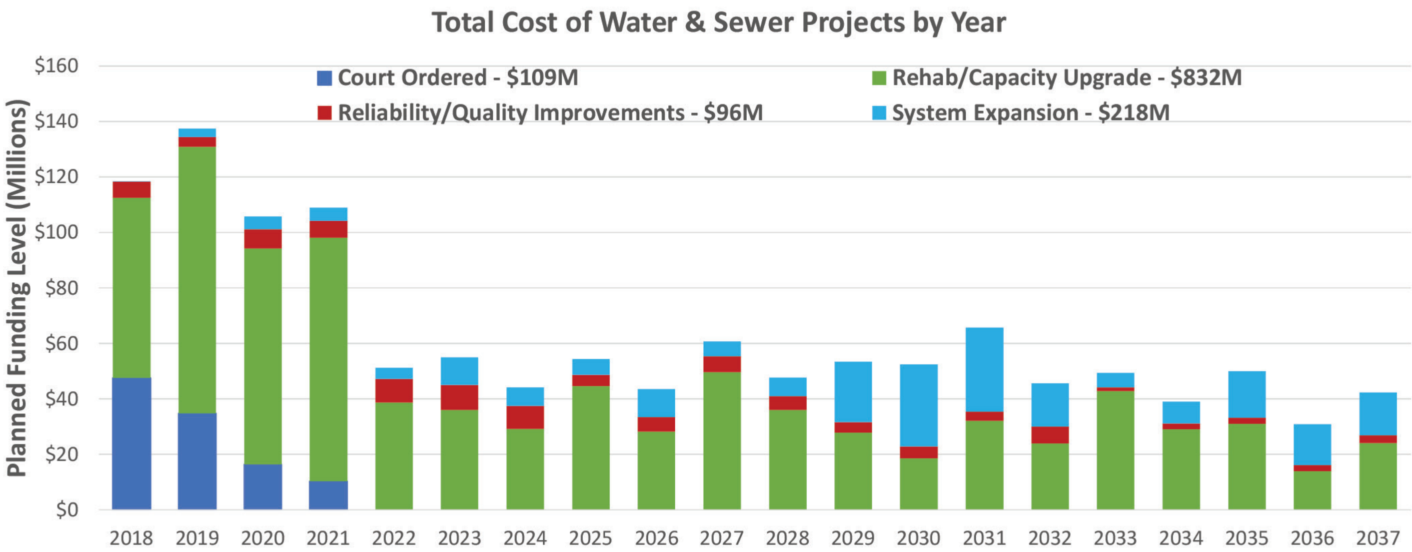
In 2016, GWA began updating the WRMP to:

- Assess progress on implementing the recommendations of the 2006 WRMP.
- Define/update service levels and assess current systems/suitability for future needs.
- Define future needs and plan CIP to meet those needs.

GWA has made significant progress towards the implementation of the 2006 WRMP. However an update is needed to:

- Incorporate new information, changing system conditions, and new regulations.
- Define additional demands for services.
- Re-evaluate the water/wastewater systems capacity for current and projected future conditions.
- Plan for the next 20-year period to provide a reasonable and practicable path for the utility to move forward and meet customer needs.
- Meet the requirement for every U.S. water utility that 2 percent of assets are replaced ever year to keep the systems in good operating condition.
- Assess progress towards meeting the goals established in 2006 and update the list of project needs.
- Re-assess the condition of the water and wastewater systems as they degrade over time.
- Update estimated costs for the required facilities.
- Develop an updated CIP for the next 20-year period (2018-2037) needed to comply with drinking water and wastewater regulations AND ensure continuous reliable services to GWA customers throughout Guam.
- Develop an updated financial plan to enable GWA to fund its CIP without excessive financial burden to our customers.

Agat-SR Wastewater Treatment Plant (Agat)



- Plan WRMP progress reviews for 2-year intervals with a major update completed every five years.

How does the Master Plan impact you?

Maintaining safe drinking water delivery and sanitary wastewater collection, treatment, and disposal has both public health and environmental benefits. Capital improvements are needed to keep our water system safe and reliable, and ensure GWA customers that their tap water is clean and potable. The WRMP Update recommends a plan to provide for the needed improvements to sustain reliable water and sewer services, protect public health and safeguard the environment now and into the future.

To provide the facilities outlined in the WRMP Update, funding will be required over the course of the 20-year planning period. The chart above shows the anticipated annual funding required based on project type for the WRMP Update period (2018-2037). Projects are grouped into four categories: 1) projects to meet current Court Order requirements, 2) projects for refurbishing/upgrading system capacity, 3) projects for improving system reliability or quality, and 4) projects for future system expansion. A total of 150 projects are included in the WRMP Update; 73 for the Water System, 61 for the Wastewater System, and 16 for General Improvements. 26 of these projects are already in progress.

Funding for the Capital Improvements Projects will come from the Environmental Protection Agency (EPA) grants, Office of Economic Adjustment (OEA) grants, bond sales, and user rates. In order to fund the projects described in the WRMP Update, GWA will seek approval to modestly increase user rates (water and sewer) from the CCU and the PUC. GWA anticipates any increases in user rates will slightly out pace inflation and range between 3 and 4.5 percent annually from 2019 to 2037. Any rate increases necessary will be re-evaluated annually with an emphasis on keeping rates as low as possible.

These planned increases are well within EPA's guidelines of water affordability for utility planning and funding purposes. Although the anticipated rate increases are modest, GWA realizes that without some rate structure changes, the increases will negatively impact low income customers. Therefore GWA is currently reviewing programs to specifically address affordability and assistance to those low income customers.

GWA will be conducting public information meetings in Agat, Tamuning and Yigo. Copies of the WRMP can be found at those 3 Village Mayor's office locations as well. Check GWA's webpage for further details as to the specifics of the upcoming village meetings.

Copies of the proposed WRMP are located at GWA Customer Service, Fadian Building Mangilao. Interested persons can also visit www.guamwaterworks.org to download the WRMP and make comments there as well.

EXHIBIT C
Water Resources Master Plan Update
Public Outreach Summary
June 26th to July 27th, 2018

Meeting 1 **June 26th Northern Village Meeting, Yigo Senior Center**

Number of attendees: 35
Questions / Comments: 3
Responses: 3
Summary:
- Status of Gill-Breeze subdivision
- Cost of water connection for new customers
- Change of use for existing customers on septic

Recommended Changes to WRMPU:
- No changes recommended

Meeting 2 **June 27th Southern Village Meeting, Agat Community Center**

Number of attendees: 5
Questions / Comments: 17
Responses: 17
Summary:
- Water supply issues to Talafofo
- Progress towards meeting the Stipulated Order requirements
- Issues with water outages in various areas
- Elimination of septic tanks
- Linking of GWA and DoD systems

Recommended Changes to WRMPU:
- No changes recommended

Meeting 3 **June 28th Guam Hotel and Restaurant Association (GHRA), Outrigger Resort**

Number of attendees: 85
Questions / Comments: 4
Responses: 4
Summary:
- Extent of water loss in GWA system
- Quality of pavement repair work
- Capacity of the Aquifer with respect to new development and military build-up

Recommended Changes to WRMPU:
- No changes recommended

Meeting 4 **June 28th Central Village Meeting, Tamuning Community Center**

Number of attendees: 15
Questions / Comments: 0
Responses: 0
Summary:

- No Questions/Comments received

Recommended Changes to WRMPU:

- No changes recommended

Meeting 5 **July 9th Legislature Meeting, CCU Board Room**

Number of attendees: 5
Questions / Comments: 11
Responses: 8
Summary:

- Plans for elimination of 2” water lines
- Impact of H2 visas on current project delivery
- Funding sources for proposed capital improvement projects
- Status of land issues for ongoing and proposed improvement projects
- Pace of increases in water and sewer bills
- Investigations into the use of bio-gas from GWA facilities

Recommended Changes to WRMPU:

- No changes recommended

Meeting 6 **July 17th Guam EPA, Department of Public Works and Governor’s Chief of Staff, CCU Board Room**

Number of attendees: 5
Questions / Comments: 58
Responses: 46
Summary:

- Septic Tank Elimination Program
- Financial assistance with sewer connection fees
- Discussion on accomplishments with respect to 2006 Master Plan
- Current use and cost of water supplied by the Navy
- Current and planned integration of DoD facilities into the GWA network
- Water system sources and supply pressures
- Population growth and water use

Recommended Changes to WRMPU:

- No changes recommended

Meeting 7 **July 25th Guam Society of Professional Engineers, Westin Resort**

Number of attendees: 32
Questions / Comments: 14
Responses: 12
Summary:

- Potential water shortages and water supply
- Planned methods for CIP project delivery
- Leak detection and leakage reduction
- Current court orders and potential for future court orders
- Water and Sewer Rate comparison
- Upgrade of Hagatna Wastewater Treatment Plant

Recommended Changes to WRMPU:

- No changes recommended

Meeting 8 **July 26th Governor's Office / Cabinet, Adelup**

Number of attendees: ~ 20
Questions / Comments: 19
Responses: 15
Summary:

- Water Supply with respect to Ugum SWTP, water loss and new DoD production wells
- GWA projects and issues with pavement restoration
- Physical and cyber security of GWA facilities and systems
- Funding sources for proposed capital improvement projects
- Planned schedule for upgrade of the HWWTP

Recommended Changes to WRMPU:

- No changes recommended

Meeting 9 **July 27th Mayor's Council, CCU Board Room**

Number of attendees: ~ 17
Questions / Comments: 41
Responses: 21
Summary:

- Water tank construction, scheduling, type of construction (new or refurbishment)
- Change of use for existing customers on septic
- Plans for the upgrade of the HWWTP
- GWA projects and issues with pavement restoration
- Status of the existing Asan Springs water source
- GWA emergency communication SMS system

Recommended Changes to WRMPU:

- No changes recommended

Guam Waterworks Authority
Master Plan Update 2018
Download Summary

April 24, 2018- Tuesday	April 25, 2018 - Wednesday
1 - RE: 2018 Water Resources Master Plan From: manny apuron Email: mpapuron@guamwaterworks.org Company: Phone: 3006833 Date: April 23, 2018 2- RE: 2018 Water Resources Master Plan From: Andrew Foust Email: andrew.foust@mackayshields.com Company: MacKay Phone: 6097508371 Date: April 24, 2018 3- RE: 2018 Water Resources Master Plan From: Kurt Bilz Email: kbilz@brwncald.com Company: Brown and Caldwell Phone: 671 300 4221 Date: April 24, 2018 4- RE: 2018 Water Resources Master Plan From: Steve Limtiaco Email: slimtiaco@guampdn.com Company: Phone: 488-1419 Date: April 24, 2018 5 - RE: 2018 Water Resources Master Plan From: Manami eguchi Email: eg_manami@icloud.com Company: Phone: 3863383 6- RE: 2018 Water Resources Master Plan From: Francis Santos Email: fesantos57@gmail.com Company: Phone: 6714829355	7- RE: 2018 Water Resources Master Plan From: Clint Huntington Email: clintwhii@guam.net Company: private Phone: 671 686 3109 8 - RE: 2018 Water Resources Master Plan From: Chip Brown Email: cbrown@eaest.com Company: EA Engineering, Science, and Technology, Inc., PBC Phone: 671-646-5231 9 - RE: 2018 Water Resources Master Plan From: MICHAEL BORJA Email: MICHAEL.BORJA@LAND.GUAM.GOV Company: DEPARTMENT OF LAND MANAGEMENT, CHAMORRO LAND TRUST COMMISSION Phone: (671) 649-5381

April 26, 2018 - Thursday
10 - RE: 2018 Water Resources Master Plan
From: Shannon Groff
Email: shannon.groff@fitchratings.com
Company: Fitch Ratings
Phone: 415-732-5628

11 - RE: 2018 Water Resources Master Plan
From: Stephen Field
Email: stephen.field@citi.com
Company: Citigroup
Phone: 2068306002

12 - RE: 2018 Water Resources Master Plan
From: Stephen Field
Email: field.a.stephen@gmail.com
Company: Citi
Phone: 206-830-6002

13 - RE: 2018 Water Resources Master Plan
From: John I. Borja
Email: reporter4@glimpsesofguam.com
Company: Marianas Business Journal
Phone: 649-0883 ext. 125

April 27, 2018 - Friday
14 - RE: 2018 Water Resources Master Plan
From: Pete Diaz
Email: pete.diaz@aecom.com
Company: AECOM
Phone: 6174778327

15 - RE: 2018 Water Resources Master Plan
From: Tony Hughes
Email: tony.hughes@barclays.com
Company: Barclays
Phone: 415-274-5355

April 30, 2018 - Monday
16 - RE: 2018 Water Resources Master Plan
From: Tria Paulino
Email: tria.paulino@investguam.com
Company: GEDA
Phone: 671.647.4332

May 1, 2018 - Tuesday
17 - RE: 2018 Water Resources Master Plan
From: Jason Jaskowiak
Email: jjaskowiak@eaest.com
Company: EA Engineering
Phone: 671-929-9354

May 8, 2018 – Tuesday
18 - RE: 2018 Water Resources Master Plan
From: Esther Camacho
Email: esther.camacho@bsp.guam.gov
Company: Bureau of Statistics and Plans
Phone: 6714759680

May 10, 2018 – Thursday
19 - RE: 2018 Water Resources Master Plan
From: April Manibusan
Email: april.manibusan@bsp.guam.gov
Company: Bureau of Statistics and Plans
Phone: 671-475-9680

20 - RE: 2018 Water Resources Master Plan
From: Esther Camacho
Email: esther.camacho@bsp.guam.gov
Company: Bureau of Statistics and Plans
Phone: 6714759680

May 14, 2018 – Monday
21 - RE: 2018 Water Resources Master Plan
From: Nick Manley
Email: nmanley@hdrinc.com
Company: HDR, Inc.
Phone: 671-686-6425

May 15, 2018 – Tuesday
22 - RE: 2018 Water Resources Master Plan
From: Thomas Cruz
Email: thomas@guamwaterworks.org
Company: GWA
Phone: 300-6036

May 23, 2018 – Wednesday
23 - RE: 2018 Water Resources Master Plan
From: JOSEPHINE EVANGELISTA
Email: jevangelista@guamwaterworks.org
Company: GWA
Phone: 300-6037

24 - RE: 2018 Water Resources Master Plan
From: Barbara Cruz
Email: bccruz@guamwaterworks.org
Company: Guam Waterworks Authority
Phone: 300-6039

May 24, 2018 – Thursday
25 - RE: 2018 Water Resources Master Plan
From: Lynden Kobayashi
Email: lynden.kobayashi@wsp.com
Company: WSP USA Inc.
Phone: 646-6872

June 5, 2018 – Tuesday
26 - RE: 2018 Water Resources Master Plan
From: Dr. Joseph David L.G. Shimizu
Email: dlgshimizu@yahoo.com
Company:
Phone: 688-1946

27 - RE: 2018 Water Resources Master Plan
From: Dr. Joseph David L.G. Shimizu
Email: dlgshimizu@yahoo.com
Company:
Phone: 688-1946

June 11, 2018 – Monday
28 - RE: 2018 Water Resources Master Plan
From: jude calvo
Email: judecalvo@guamwaterworks.org
Company:
Phone: 300-6066

June 14, 2018 – Thursday
29 - RE: 2018 Water Resources Master Plan
From: Jeffrey Boblick
Email: jeffrey.boblick@gmail.com
Company:
Phone: 708-655-0103

30 - RE: 2018 Water Resources Master Plan
From: Jennifer Louise Dulla
Email: jenniferdulla@gmail.com
Company:
Phone: (671) 482-5556

June 15, 2018 – Friday
31 - RE: 2018 Water Resources Master Plan
From: Raeann Lefever
Email: rlefever@investguam.com
Company: Guam Economic Development Authority
Phone: 671-472-8931 . Ext. 377

June 18, 2018 – Monday
32 - RE: 2018 Water Resources Master Plan
From: Tricee Limtiaco
Email: tlimtiaco@gpagwa.com
Company: Guam Power Authority
Phone: 6716483222

June 20, 2018 – Wednesday
33 - RE: 2018 Water Resources Master Plan
From: Kevin Bock
Email: kevin.bock@macquarie.com
Company: Macquarie Investment Management
Phone: 215-255-8556

June 22, 2018 – Friday
34 - RE: 2018 Water Resources Master Plan
From: M. Noel DelRosario
Email: ndelrosario@hawaiienergysystems.com
Company: Hawaii Energy Systems
Phone: 6717875309

35 - RE: 2018 Water Resources Master Plan
From: M. Noel DelRosario
Email: ndelrosario@hawaiienergysystems.com
Company: Hawaii Energy Systems
Phone: 6717875309

June 25, 2018 – Monday
36 - RE: 2018 Water Resources Master Plan
From: Mary Jane T. Perez
Email: mjperez504@gmail.com
Company:
Phone: 864-1864

June 28, 2018 – Thursday
37 - RE: 2018 Water Resources Master Plan
From: Senator Tom Ada
Email: tom@senatorada.org
Company: Guam Legislature
Phone: 473-3301

July 4, 2018 – Wednesday
38 - RE: 2018 Water Resources Master Plan
From: Robert Young
Email: robert@economists.com
Company: Economists.com
Phone: 503-274-0689

July 7, 2018 – Saturday
39 - RE: 2018 Water Resources Master Plan
From: Senator Tom Ada
Email: tom@senatorada.org
Company: Guam Legislature
Phone: 473-3301

July 12, 2018 – Thursday
40 - RE: 2018 Water Resources Master Plan
From: Brett Railey
Email: brett@guamwaterworks.org
Company: GWA
Phone: 671-300-6040

July 16, 2018 – Monday
41 - RE: 2018 Water Resources Master Plan
From: jude calvo
Email: judecalvo@guamwaterworks.org
Company: Guam Waterworks Authority
Phone: 300-6066

July 18, 2018 – Wednesday
42 - RE: 2018 Water Resources Master Plan
From: Mark Anthony Ancheta
Email: m.ancheta@smccguam.com
Company: Sumitomo Mitsui Construction Co., Ltd.
Phone: 671-649-7521

July 25, 2018 – Wednesday
43 - RE: 2018 Water Resources Master Plan
From: Walter B. Perry
Email: perry@guam.net
Company: Pernix Guam, LLC.
Phone: (671) 888-0801

44 - RE: 2018 Water Resources Master Plan
From: AJ Layson
Email: andrewl@tg-engr.com
Company: TG Engineers PC
Phone: 6716470808

July 27, 2018 – Friday
45 - RE: 2018 Water Resources Master Plan
From: Mike Walworth
Email: mwalworth@aqua-aerobic.com
Company: Aqua-Aerobic Systems
Phone: 815-218-9045

July 31, 2018 – Tuesday
46 - RE: 2018 Water Resources Master Plan
From: Glen Davies
Email: gdavies@hdcc.com
Company: HDCC Guam, LLC
Phone: 6718980057

47 - RE: 2018 Water Resources Master Plan
From: Ken Rekdahl
Email: kmrekdahl@dcaguam.com
Company: DCA
Phone: 671-477-7991

August 23, 2018 – Thursday
48 -RE: 2018 Water Resources Master Plan
From: Mariano Cruz
Email: marianofcruz@yahoo.com
Company:
Phone: 472-5965

Guam Waterworks Authority
Master Plan Update 2018
Download Summary

Total number of Downloaded copies	48
Comments received via email/Website submittal	0
Recommended Changes to WRMPU:	No changes recommended

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
June 26, 2018 Yigo Village	QUESTION 1. What is the status of the Gill-Breeze Subdivision?	We are trying to get funding though nothing is specific yet; however, the septic/cesspool system reduction program mentioned is one project for all areas with septic tanks.	Volume 3, Sections 4.3, 4.7 and Project MP-WW-Pipe-27.	No
	QUESTION 2. There are existing users in the Mataguac area on a 2" line who say they can't afford to tie into the main because it's expensive; can they at least be given a reduction in price to do so, or should they even be charged?	We will look into your concern. There shouldn't be a cost if there's an existing line & they are existing users.	N/A	No
	QUESTION 3. There is a situation at Mataguac area where	We are expanding on the sewer side to take customers off septic.	Volume 3, Sections	No
June 27, 2018 Agat Village	QUESTION 1. Are you building a tank in Talofofo?	Talofofo will be supplied by the Windward Hills tank. GWA is planning to refurbish the old tank which will be confirmed upon completion of the existing tank inspection.	Volume 2, Project No. MP-PW-Tank-20.	No
	QUESTION 2. Are they putting in a new one and all its equipment for that?	GWA will have additional tanks coming on line. As part of the court order we're refurbishing all the tanks that we currently have and that will be completed in 2021, but in the 20 year planning period we do have a new batch of tanks that will go in, in about another 10 years. The current plan is primarily to replace the steel tanks unless we can refurbish them and still have a useful service life. There are also recurring booster pump station upgrade projects.	Volume 2, Section 6.	No
	QUESTION 3. How much of the stipulated order has been accomplished with the wastewater and the development of the increase in water in the South under the masterplan? I was reading the 2010 but that is the latest one that has identified the increase for southern villages for the water plan.	For the court order, all of the critical wastewater projects, including the one in the south, have been started and are scheduled for completion by next year. For the storage tank and the water system improvements that are required under the court order, GWA has until 2021 and unfortunately we're going to butt up against that deadline to get all those projects completed. We are working as fast as we can. The Master Plan includes several on-going tank projects right now, but there have been some delays, for example the Ugum tank which is part of the court order that we need to add to its capacity, that project has been held up because of the land acquisition that is required for its replacement.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 4. The other issue that I need to bring up is the resort operating over at the Talofofo waterfalls. Because the Ugum water treatment area or even the water that is joined to Ugum river comes from Babulao, how much water is coming from Inarajan water shed? I know Ugum is at the other side of the ridge line that is dividing the Inarajan and Ugum watershed. But is the water from the waterfalls still active in going down to Ugum water source?	There isn't any change in that watershed, so if it was contributing to Ugum watershed before, it is still contributing to Ugum watershed. In terms of other sources that GWA looked at for the south, we have an assessment in the masterplan for several alternate water sources that were identified, although our team weren't able to visit all of them. For example, I don't think our hydro geologist had a chance to visit Faifai springs in Umatac, but that was identified and discussed as an example of alternative water sources in the south. On the Inarajan watershed, we don't have any sources, currently, that we're drawing from. We did have the As Alanzo source in Malojloj, and we had a couple of small producing wells but those are not active this time.	Volume 1, Sections 5.2, 5.3 5.4 and 5.5.	No
	QUESTION 5. Thank you. I thought that the wells are also adding to the supply of water because now, I believe there has been additional water given to Talofofo and I don't know if that is also trickling down to Agat with the development from Ugum.	No. The water from Ugum stops in Umatac. It doesn't go over to Agat. All of the Agat areas are served either by the Santa Rita Spring or Navy Water sources. But GWA is looking at ways to try and loop the southern end and make sure that we have alternate water supplies.	Volume 1, Section 5.3.	No
	QUESTION 6. That is why I'm asking you about a water tank where I live in Talofofo. When there is a little storm, for some reason my water pressure drops and nearly nothing is coming out of the faucet. That is why I am wondering when will you improve that? And be consistent like with the Windward Hills. But on that side of the village, the pressure is good	GWA has a few different projects that may improve that situation. We currently have a project for the upgrade of the Brigade booster pump station which is down at the intersection of Route 4 and Route 17.	Volume 2, Section 6 & 7.	No
	QUESTION 7. But when there is no power in the area of Windward, we're the only ones that have no water. The distant villages have water. That's why I'm asking if we have the tank that can fill-in the line?	We do have a tank project for that area, I can get back to you to see if the capacity is going to increase, or if we are just refurbishing the existing one.	Volume 2, Section 6.	No
	QUESTION 8. Are we still on the gravity side of the tank which is supplied by gravity or by the direct distribution from the pipeline?	GWA is still running a hybrid system. We have some portions that are fed off the pipelines, we have some that are driven by gravity from the tanks, then we have some portions in higher elevations that require the use a booster pump.	Volume 2.	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 9. In low areas, during the peak hour in the evening and early morning you can't have 2 faucets running, 1 outside and 1 inside, because it doesn't have that pressure. We have low pressure during the peak hours. What's the solution?	GWA has a pressure zone realignment program in progress to address low and high pressures in the system. We also have a program to eliminate 2-inch supply lines from the system. Both of these programs should improve the low pressure situation.	Volume 2, Section 8.	No
	QUESTION 10. Is that because Malojloj has always been from the tank and it's never on the distribution line.	Malojloj still has a tank as part of the distribution system, but now GWA has added a booster pump system as well.	Volume 2, Section 8.	No
	QUESTION 11. That water source has been there even pre-war and it shuts down because of the road to the landfill and that limits the streams that goes down. So in case there is a typhoon, we utilized that pipeline that goes to Malojloj well but I found out that it was shut down, is that correct?	GWA doesn't have any plan to resurrect any of those water sources (wells), our primary water source for that area will still be the Ugum water plant. But we do, as I mentioned, have rehabilitation projects planned for Ugum.	Volume 1, Section 5 and Volume 2 Projects MP-PW-SWTP-01 to 04	No
	QUESTION 12. Can we eliminate septic tanks?	GWA has included in the Master Plan a septic tank elimination program, primarily for the northern areas over the aquifer, and we have added it as one of the Level of Service goals that we reduce the number of septic systems in use.	Volume 3, Sections 4.3, 4.7 and Project MP-WW-Pipe-27	No
	QUESTION 13. But not down south?	The program is island wide, and the priority is to focus on areas over the aquifer, but if there are other areas that have been identified that have a high need for septic system elimination, then it will be prioritized and incorporated into that program.	Volume 3, Sections 4.3, 4.7 and Project MP-WW-Pipe-27	No
	QUESTION 14. They recently replaced a pipe in my house and after that all the surrounding houses have water but I don't have water. How can you present this concept of a masterplan with all the gaps in between?	GWA still needs the Master Plan in order to guide our improvement, and we understand that there are gaps in our service until we can make those improvements. We can take the details of your complaint and look at it. We might need more investigation in order for us to figure out the specific conditions of your situation.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 15. You mentioned about the military possibly linking into our system, what exactly is the reason for it? Is it because they lack confidence in GWA, that's why they don't want to be your customer?	No. The Navy told GWA that they would give us a 1-year license to demonstrate that we can operate to military standards. That was a year and a half ago. So GWA has done that successfully, and the Navy renewed the license so I don't think it's a lack of confidence. The Navy currently has their own system, but the Navy is cautious and moves slowly, but has expressed their desire to become a customer of ours in certain areas, like the new marine corps base. It may take years before the Navy turns anything else in their system over for GWA operation.	Volume 1 Section 5.4	No
	QUESTION 16. Is there a timeline for as to when that occurrence may happen?	There is a direct coordination between GWA and the military on a bi-weekly basis on system integration. But no timeline for it overall. They have conducted a study, they sent their consultant out and interviewed us to gather information about our capabilities. That was a study that they ordered but we're not privy to that. The feedback that I've gotten from our counterpart from the military is that it was relatively good.	Volume 1 Section 5.4	No
	QUESTION 17. With all those improvements and the winding down of the stipulated order, what is your forecast for water rates going down?	There are a lot of projects in the master plan and the plan comes with a significant price tag. GWA is subject to a lot of mandates, e.g., clean water act, safe drinking water act, and most of those mandates are unfunded. We do get assistance from the federal government in terms of grants. GWA continually looks into grants and we look into our internal program, to see how we can keep the costs down in running the utility… but it's not enough sometimes. With these mandates, that's what explains the increases in the last 10 years and the 4% rate increase that was approved by the CCU & PUC that's in your water bill today. But for the Master Plan, beginning 2019 through 2037 we're looking at 4 to 4 1/2% rate increases for the 1st 7 years and 3% for the remaining 13 years.	Volume 1 Section 12	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
June 28, 2018 GHRA	QUESTION 1. Water loss has been reported for GWA between 40% and 60%, well above what is considered industry standard at 15%. These losses tax the aquifer, and while GWA is doing a good job on the major CIP projects the everyday smaller leak and road repair jobs are not being done correctly or efficiently. This leads to repeat repairs for the same issue because of the workmanship or improper materials used.	GWA's latest numbers on water loss are around 48%, and we are making efforts to get those numbers down. Leak repair and leak detection are priorities for GWA, addressing non-revenue water is a process, not a project. The master plan has, in addition to the larger CIPs for line replacement where we can achieve economies of scale, programmatic elements for replacement of old 2-inch galvanized pipes, and some of that work will be done in house in smaller areas where it doesn't make sense to issue a CIP. With regard to the road repair, GWA does not do that well, and we recognize that. GWA crews will repair breaks and leaks, and temporarily patch the pavement, but private contractors are being used to make proper and permanent repairs with hot-mix asphalt after initial repairs are made. The scheduling is sometimes problematic, with major throughfares getting priority.	Volume 2, Section 9 and Section 12.1	No
	QUESTION 2. Is the Air Force drilling more water wells?	If you are referring to new wells for the Air Force water system to support the on-base military build-up, I believe that is correct. That is not a part of GWA's master plan.	N/A	No
	QUESTION 3. With regard to Guam's aquifer, does it produce enough water to address the increased population in light of the fact that we also lose a lot of the water we pump up.	Based on the latest study by the Water and Environmental Research Institute (WERI) at UOG, we are currently withdrawing about 40% of the estimated maximum yield of the Northern Guam Lens Aquifer. That usage should decrease as GWA improves its percentage of water loss. As long as Guam does not have a prolonged drought, e.g. more than 2 years, the yield of the aquifer should be more than enough to address current and future demands.	Volume 1, Section 5	No
	QUESTION 4. GWA was addressing long overdue issues in Tumon, and based on frequent discussions with members of the Legislature, was under the impression that the Fujita area issues would be addressed by HOT BONDS, and not GWA bonds.	GWA has plans to address Capital Improvement Projects needed for the Fujita Sewer Pump Station and force main, but if the reference was to the Storm Water drainage issues at the ponding basin near Fujita pump station - those projects are not under GWA's authority or responsibility.	N/A	No
June 28, 2018 Tamuning Village	No Questions or comments received at the Tamuning Meeting			

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
July 9, 2018 Legislature	QUESTION 1. I know that's a lot of work and it's hard to appreciate, but what about the neighborhoods being served by 2" water lines? There has to be a balance, and also need to upgrade distribution lines out there in the community.	The Master Plan is three volumes and Volume 2 covers the water system improvements and line replacement upgrades. GWA will put out Contracts for the larger areas as CIP projects, but there are smaller pockets served by 2" lines that will be upgraded to 6" lines in smaller areas that are not suited for large CIPs. Those areas will be addressed by GWA internally. The Line Replacement Program can utilize the SDC as a funding source. These smaller areas will be prioritized based on objective criteria in accordance with GWA's established program. Chief Engineer Tom Cruz also mentioned that there will be pressure zone realignments since some service area boundaries have changed. The intent of this project is to adjust the pressure zones so that each customer can be served at the right pressures.	Volume 2, Section 8 and Project MP-PW-Pipe-13.	No
	QUESTION 2. Does the timeline for projects and construction take into account the issues with having H2 workers?	In preparing the estimated costs for the recommended projects, we took cost escalation into account using the best available information, however, the recent relief for H2-B visas on projects related to the buildup only apply to the DoD-OEA funded projects.	N/A	No
	QUESTION 3. Is all of that project funding to be paid for by customers or grants?	The financial component of the Master Plan includes a combination of funding, including, for example, maintaining existing SRF grant funding levels and utilizing current OEA grants for the near term work at the Northern District WWTP. However, the majority of funding will be ratepayer derived, and GWA will do our best to look for grant money where we can.	Volume 1, Section 12.	No
	QUESTION 4. You have a number of water storage tanks that still need to be replaced. Will there be a need to authorize Chamorro Land Trust to sell additional land and do you see the need to purchase within the next 5 years?	With regard to land needed for our storage tanks, there are some private parties, other government agencies and some federal agencies we are working with on property issues. Several of these needed lots will be required before 2020.	Volume 2, Section 6.	No
	QUESTION 5. Since the old Agat WWTP has been taken off line. What are you going to do with that property?	GWA will be keeping the property, because we have to keep the existing pump station located on the property - it is still a vital part of the collection system.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 6. Senator Esteves thanked GWA for the presentation and said the progress GWA has made is great and that 3% per annum over the planning period sounds reasonable. But, you need to understand that GPA and GWA increases are a huge factor in the "overall" picture and it severely impacts the government's ability to keep up with their costs. Maybe working off the mandate GWA should consider maybe a 9-12% increase over a 3 year period, instead of 3% every year.	GWA has engaged a financial consultant specializing in municipal utility financial planning, and he was pressed during the development of the plan to evaluate various funding alternative scenarios. The resulting plan incorporates a strategy to minimize the financial burden and build necessary rate structure to achieve the required level of CIP spending. From 2005 to date GWA has been working off of multiple five-year rate plans. The Master Plan CIP projects will be rolled into the next 5-year rate plan.	Volume 1, Section 12.	No
	COMMENT 1. Senator Esteves stated that it might be better if they get changed now, people don't understand capital overlay.			
	QUESTION 7. Have there been any reports or have we started looking at investing in bio-gas for WW output? Methane output can provide power to network.	GWA has evaluated generating power from methane produced as part of the wastewater treatment process at the NDWWTP. However, based on the characteristics of Guam's "weaker" wastewater that does not easily support the process capturing methane gas as compared to other jurisdictions with more diverse wastewater flows (e.g., more industrial wastewater, more food wastes, etc.), such a process is not financially viable.	Volume 3, Section 8.	No
	QUESTION 8. With regard to upgrading to secondary treatment for wastewater, by what percentage has it increased your costs?	We don't have that information at this time. In terms of capital costs, NDWWTP is a $130 million project and HWWTP is a $200 million project to get it to secondary treatment. There will be impacts to operational costs, but those have yet to be fully determined.	Volume 3, Section 8.	No
	COMMENT 2. Senator Esteves added that customers are going to want to see the best service, like fixing broken water lines. He also stated that having good infrastructure is the key to economic growth.			

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
July 17, 2018 GEPA and DPW	QUESTION 1. With regard to the difference between the number of GWA water customers and GWA sewer customers, for those areas where customers are not on the sewer system, is a sewer connection not possible for 100% of those areas?	No - there are areas where GWA has sewer infrastructure in place but it may have been installed after some homes were built, and so if the sewer is within 200-feet the law requires the homeowner to connect. GWA has established a sewer connection revolving fund to address this condition. The program has not been well-used as the funding is limited. GWA has been working with GEPA to improve the program by focusing on areas of concern (e.g., those septic systems closest to production wells), conducting field assessments to determine what accounts in our data base are correctly not on the sewer system. GWA is also trying to augment available funding using system development charge funds to make the revolving fund program more effective.	Volume 1, Section 3.4, and Volume 3, Section 10	No
	QUESTION 2. GEPA helped to develop a revolving fund so that we can help people pay to get on the sewer system, but the fund was established before GWA raised rates for connection and that resulted in actual connection costs exceeding what was anticipated for the program and the funding needs per participant. So the money that we initially helped to put together for them is not enough.	Correct - GWA has developed standard details and schematics to assist potential participants to define and estimate what the cost of connection is going to be. If GWA is able to increase the amount in the revolving fund, and raise the amount that participants will be able to borrow from the revolving fund, it would help us get to our goal of reducing the number of septic systems over the aquifer.	N/A	No
	QUESTION 3. With regard to projects from the 2006 Water Resource Master Plan, can you give us an example of the 15% that were determined to be not needed?	One example of the projects that are not needed are water projects that were intended specifically to address fire flow issues, but did not address other key service issues, such as service pressure. In approaching these projects, the thought was, GWA can't just replace pipes for the narrow reason of meeting the fire code, but should work to achieve a more long term program of improvement with broader benefits to system performance.	Volume 1, Section 2	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 4. This master plan is for a planning period of 20 years, so typically you've got to go to the legislature to approve, right?	GWA does not require legislative approval for this 20-year plan as a long-term planning document. However, in implementing the plan, GWA will use this as our guideline to develop a Capital Improvement Program for projects needed over the next 5 years , and the 5-year rate plan needed to support the CIP. If that rate plan calls for borrowing to execute the CIP, then GWA will have to get legislative approval for the needed borrowing.	N/A	No
	QUESTION 5. With regard to the capital funding required over the next 20-years, as a comparison, what portion of the CIP resulting from the 2006 plan was funded by grants like the State Revolving Fund from USEPA?	Since 2006, GWA has received about $ 50 Million in SRF funding, with the majority of that funding being received/spent within the last 3 years.	Volume 1, Section 12	No
	QUESTION 6. For your future funding needs, will there be any more funding from the USEPA?	GWA has consulted with US EPA about potential grant funding, and have taken that into account in our funding projections, maintaining the same level of grant funding for the planning period.	Volume 1, Section 12	No
	QUESTION 7. Are the assumptions regarding USEPA funding realistic?	GWA believes it has used the best available information and that the information provided by US EPA on this subject is realistic.	N/A	No
	COMMENT 1. The Governor's office is very happy to be working with Region 9 and with USEPA as a whole because they have good leadership.			
	QUESTION 8. With regard to GWA's reliance on Navy water, are they not providing GWA a discount?	GWA receives no discount for the purchase of water from the Navy. Generally, it costs GWA 3 to 4 times more than if we produce it. This has an adverse affect in terms of cost-recovery for some rate classes over others, for example, residential versus commercial or government rates.	Volume 1, Section 5	No
	QUESTION 9. Have you challenged their rate?	GWA has asked our Guam-based counterparts many times for their cost-of-service study and and has been advised that the unit that provides the cost for them is in another location and the cost-of-service study is not done here. However, they operate on a short-term cost recovery model, and are apparently not allowed to use long-term financing for capital cost recovery.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 10. With regard to limitations on water available from the Navy (Fena SWTP), is it not that by law Guam water resources are for GWA to handle?	The issue of water rights or Fena resource ownership is outside the scope of the Master Plan. As a matter of policy, the approach GWA governance has espoused is that GWA should operate an integrated system, and GWA is encouraged to improve so as to be able to eventually the water system for both Navy and civilian customers.	Volume 1, Section 5.4	No
	QUESTION 11. Under the law, water is for the people, for GWA, so why should we pay? Why are they charging us? It should be GWA charging them, right?	That is correct - for the facilities we operate there is no cost for the water. As an example, for the Tumon Maui Well - it is a Navy facility that GWA operates, but there is no cost associated with the water extracted. However, for the facilities that they operate, the costs charged to GWA are the costs of their processing and treating the water - not for the water itself.	N/A	No
	COMMENT 2. Maybe it is a little difficult. But I just think that if it is your water, then you charge them for them to take the water out. It may not be that simple. But the law says, the water is yours and for them to use it then you can charge them.			
	QUESTION 12. Is there a lease for Tumon Maui? How much does it cost?	There is a license for the Navy's Tumon Maui Well. The cost is about $4,000 a year.	N/A	No
	QUESTION 13. What is its capacity? And how much do we use?	GWA averages about 1.2 million gallons per day produced from the well. As part of this initiative, GWA provided the connection for the new Marine Cantonment, and eventually, GWA will provide water service to the base and charge them as a customer using the appropriate tarriff.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 14. With the responsible management of our water resources or production wells, do we fund this? How is WERI tied into this?	The legislature approved a certain amount of funding every year for WERI. Through the ONE GUAM WORKING GROUP with the Navy they have come into a tentative agreement for monitoring the wells that are currently in place. For those wells that are inside the military base, the Navy has agreed to maintain them, and for wells that are off the base GWA has agreed to maintain them. GWA is working to resolve ownership or access rights to the off-base sites. In addition, the DoD grant we received for the military build-up includes the funding to add monitoring wells to sub-basin within the aquifer for which we have no data. So those are new wells that are going primarily on DOD property. So it is our project, we received the grant funding and we're doing all the work to put the new wells in so WERI/USGS will have better opportunity to monitor the aquifer. But those wells should be maintained by the Navy because they are on federal property. With regard to long-term monitoring, USGS/WERI are putting the price together for what it is going take to sustain the monitoring program. We're talking with DoD about the cost split now, based on the number of wells and where they are situated. I think, it's a 60-40% split, with 60% of the cost paid by DOD and we pick-up the 40%.	N/A	No
	QUESTION 15. How many customers are serviced by the navy water?	Customers in service areas in Agat, Santa Rita, a portion of Nimitz Hill, Angoco area of Asan/Maina, and outside of Naval Magazine.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 16. With that Septic Tank Elimination Program, what are you guys doing on that, and can you make sure that GEPA are included. When we approve building plans, sometime we have to do a waiver because it is so far from the sewer line and unfortunately some of this, they say we're not even be able to get our own line. Some of these people live near the rivers or swamps and you guys have no sewer lines so we have to sign waiver for those things. I hate doing it but I have to.	In addition to CIPs, which is the primary focus of the masterplan, we've also incorporated some programmatic improvement, to establishing regular funding for programs so that we can keep certain initiatives going. This includes includes replacing the old, 2-inch galvanized water lines, for example, and extending sewer lines. The Master Plan includes a line item program for this and a goal to eliminate a certain number of septic system every year. Whether we do it as part of a CIP project or whether we do it using our in-house resources, we haven't gotten to that part yet. We recently initiated a similar program with waterline replacement which allows us to do both; we started out with our big CIP projects where you get the most "bang for your buck" in big neighborhoods. And we have isolated pockets in the villages that have low pressures and we need the lines to be upgraded. It is just not a big enough area to make it worth it as a large CIP, so we will use in-house resources and we've stablished the program now to prioritize areas based on objective criteria relating to cost-vs-benefit. The criteria have been set-up so we can objectively rank all these different areas to determine which areas to address in what order. We're going to set-up a similar system for sewer line expansion.	Volume 1, Section 3.4, Volume 3, Section 4.3	No
	QUESTION 17. When are you going to set-up the performance metrics/criteria for this program?	We've already set-up the performance metrics. And we already have a list of prioritized projects, including areas affected by upcoming DPW projects which we've worked out with you. For example, we checked with you on the DPW road pavement projects, which areas would overlap, and we prioritized one area in Ipan where we have old 2-inch galvanized lines and low service pressures.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 18. When you do this and you try to determine what should be your priority, GEPA doesn't want to run what you do but we would definitely want to provide some input. I am just hoping that part of your process includes, you guys talking to our engineers. You guys are doing more field work than GEPA, I admit that, but we can still provide some input.	Yes. This is also tied to the existing sewer revolving fund program - as I mentioned , we coordinated with GEPA which areas we should focus on first. We will do the same thing when we get to the prioritization for this Septic Tank Elimination proram.	Volume 1, Section 3.4, Volume 3, Section 4.3	No
	QUESTION 19. I have a question about sewage spills, I think we're receiving more and more spill reports and that there are still problematic wells which may have E. Colli hits, so what are you doing to resolve this issue?	GWA is engaged with the US EPA on our Sanitary Sewer Overflow (SSO) reduction program and they are focusing on the collection system capacity and pump station issues. They have information from GEPA about production wells you are concerned about, and have come back to GWA and said, "what are you doing about this?" GWA has (1) compiled a list of all these pump stations, (2) provided the list of all the pipe capacity projects that we have as part of the Master Plan, and we're going over it with US EPA. We had several meetings with US EPA already and GWA will now provide a revised prioritized list and will determine how the funding identified in our Master Plan will be used to address these issues based on the established priorities. You will also see some programmatic improvements. We've identified some specific pump station projects and some specific collections projects in the CIP list but there will always be a need to upgrade pump stations and so we have regular funding proposed in here as programmatic improvements. We always want to make sure we have enough money to do the upgrade and improvements needed at these pump stations.	Volume 3, Section 6, Volume 3, Section 11.3	No
	QUESTION 20. With regard to the CIP, have the DoD grant projects been included here?	Yes. The $278 million identified as current/on-going CIP includes those DoD grant-funded projects.	Volume 1, Section 11, Table 11-7	No

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 21. Has the new requirement for Construction General Permit (CGP) delayed your project in Agat, the wastewater treatment plant? I'm talking about the new requirement for endangered species that took effect in 2017.	In reference to the endangered snails, GWA did plan for it in the design and construction of the new plant in Agat. The contractor, early on, didn't delay us, but he over cleared for some additional parking and intruded into the buffer zone and ended-up impacting a few snails. But it was more for the Baza Gardens project, and Umatac-Merizo. Apparently, when they submitted contract for Umatac-Merizo for the NOI for the general construction permit for the NPDES, there was a formal consult at the headquarters' level between EPA and US Fish & Wildlife for the nation-wide permit, where they agreed that any issues will be handled by EPA. So USF&W gave-up its authority to stop projects, it is only when EPA says there are issues, then USF&W could come in. No one told the field offices, so Hawaii office of USF&W was heavy-handed with us on Baza, Umatac-Merizo and it caused us delays, it's not just time but also money that was involved. So we complained to US EPA about that.	N/A	No
	QUESTION 22. Is this *(referring to the pictures on the slide)* design for this tank 500,000 gallons, right? Is it standard? I see a bigger one in Yigo? And how many customers does it serves?	There are different sizes. The new Yigo reinforced concrete tank is 2 million gallons. The Chaot tank is 500,000 gallons and serves Chalan Pago through Sinajana.	N/A	No
	QUESTION 23. Are all customers downhill? And what supplies the tank, is it a well?	For this one yes, but it it's the same level as the Agana Heights tank. And at Agana Heights, we have a booster pump because we have some higher elevations served by that tank. Well water from several A-series wells from Sinajana, Afame towards Chalan Pago supply this tank.	N/A	No
	QUESTION 24. Let's say, a tank is full of water, how much water does it supply? How many days can it supply water?	Without water coming-in, we'll probably drain it within a day.	N/A	No
	QUESTION 25. For Guam wide, how many gallons do you serve every year?	Approximately we sell about 6 billion gallons every year. The point here is we billed for 6 billion gallons a year and we needed to produce money for 12 to 13 billion gallons a year. That shows that our non-revenue water is high. Part of that is leaks so that's part of programmatic improvements that we are trying to tackle.	Volume 1, Section 5	No
	QUESTION 26. Does that include the navy?	All GWA consumption.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 27. For the tanks built, are the contractors the same for all?	No. Same tank manufacturer and process, but different local contractors.	N/A	No
	QUESTION 28. These projects in our handouts are not on-going, right?	There are 15% of those projects that we haven't gone through from 2006, those have been rolled into this update. So it includes some of the projects from the previous masterplan and we're continuing in the CIP list of this new Master Plan. So in this masterplan, there are a few on-going projects but for most part they are proposed projects.	Volume 1, Section 11, Table 11-7	No
	QUESTION 29. So there are no on-going project or previously listed projects in here?	There are a few on-going projects but for the most part they are proposed projects.	Volume 1, Section 11, Table 11-7	No
	QUESTION 30. For the existing old metal tanks, will there be a 100% replacement of it with a concrete tank?	Those metal tanks that we inspect and find we still have a useful service life, will end up being repaired. After that repair they may be good for a period of 10-15 years, then we'll replace them.	Volume 2, Section 6	No
	QUESTION 31. But it's not likely that where there is a tank, would no longer be a tank?	No, either it will be repaired or replaced.	N/A	No
	QUESTION 32. I have one question about one well specifically in Dededo that was found to be contaminated with chlordane and has been out of order for 3 years now. The concern is if you will not pump the water and treat the contaminant, then eventually the contaminants will spread-out in the aquifer, so what is the plan? For 3 years it hasn't be touched.	GWA may not have included it in the Master Plan as a specific project. But if we need to get the well back online then it would be part of the Well Rehabilitation program item as listed in the CIP and Master Plan.	Volume 2, Section 5.4; Volume 2, Section 12.4	No
	COMMENT 3. For the purpose of not to spread-out I think it will be better to repair it.	But in that case if we allocated $5.8 million to rehab maybe 3 to 4 wells but this one will need to have a treatment system that we need to put in for that 1 year that we have that bid package out, we'll probably get maybe only 2 wells. The program, if it gets approved and adopted allows us the funding mechanism to handle projects like that.		

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 33. One more thing before we move-on, on the asbestos pipe replacement on the current removal or potential removal, as an example - DPW is asking from us a waiver for handling off-island disposal, what are you going to do with that?	GWA has had to pay for removal on previous projects. If we're looking at a long-term plan and we've got a regular funding to take care of those old pipes because it is a problem to us, we are losing water, for the disposal of old pipes we remove out of the ground, my suggestion is move forward with establishing a new cell at the landfill that can handle it to avoid excessive off-island disposal costs.	N/A	No
	COMMENT 4. GEPA is working on it. The landfill operation is supposed to be turned-over to Guam Solid Waste Authority, and that's when SWMA can do it. The receiver is telling the Judge "we don't want it (asbestos)." We're pushing. In fact even for the development of cell 3 we are trying to push shredded tires as aggregate, we have a tire problem here and that will help us alleviate it. The receiver is the one not wanting to do it. I don't know if it's their idea or plan. We are trying to force Guam Solid Waste Authority to speak up and hopefully the judge will listen. We're on the side of rectifying Guam's problem and we're not making money for ourselves.			
	COMMENT 5. What we've done in the past and I think for 1 project is that we allowed pipe bursting, but the only thing that we require, and we also have the new technology to make sure, is that it is in your data base that if anybody digs, that's the first flag that comes up. If you've got damaged, friable asbestos because you've done bursting, that's one of the things that you need to have. I know GWA has that GIS item in their slides. I'm not sure how DPW is at this point but GWA's GIS is pretty effective and a lot of this is paid for also by USEPA assistance. So I need to have those assurances as well for pipe bursting.			

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 34. With regard to the Cross-Island Piping project in 2021, on road restoration, is it included in your budget?	Yes, road restoration is included for the lane that is disturbed. I'm not sure we're including the DoD enhanced "beefed up" restoration because our numbers were done before that advice has come out, and we have not received the information on what the enhanced restoration is.	Volume 2, Section 8	No
	COMMENT 6. Well I need your help. Remember I called you? There were a couple of hot patches that we did near route 1 around the Liberation Day parade last year - The patching that you do in very short and very professionally nice work was in front of Bank of Guam. You guys only had 20 hours working on that water main break, but when you left it was like nothing ever happened.	GWA has been put under a lot of pressure by DPW on this issue. That is part of why we have our regular meetings, to let you know what our plans are. In terms of operations for us, we are trying to put out an IQ contract to get a paving contractor on board because we know we aren't good at it and we put it out three times but we've got no responses.		
	COMMENT 7. Regarding your existing project for your storage tanks design, right now, we have submitted our comments for the storage tank but our concern there is, on your Windward Hills pump, you are trying to design that pump to reach at the overflow of Sinifa, requiring 100 PSI or more. GEPA suggests that you just have to use a line booster at the highest point before Sinifa so that you don't have to be designing the pumps at your Windward Hill pump station with such a high pressure, which I believe is causing some of these pipes probably to break because the pressure is too high. Our concern right now is the design for the storage tank, we're recommending you to have a line booster rather than designing the head to reach an overflow in Sinifa.	To clarify, you want us to add another pump station *(Windward Hill)* to the design? We can discuss that, as there will be additional design cost for that. Then there is land acquisition. We will need a land for the additional line booster. But we can discuss it.		
	COMMENT 8. With this update you're giving GEPA the dates for design but can you give us design and date as to when you're planning to submit for permits? These are big projects? The Governor said that we would tell DoD about big projects that are non-DoD so that your project will get priority over DoD. But we need to tell them, "DoD, this plan/time has been set." So it would be better if you give us, like a start date. That will really help us and our team.			

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 35. Regarding wastewater projects, are there any improvements taking place in Machanao pump station in the next few years? In the last typhoon, that's the only pump station we inspected that had sewage overflowing.	Same plan I described to you earlier where we've got pump station and sewer capacity improvement projects. We have the proposed 3 tier prioritization that we're working on with EPA and we're doing the funding estimate for that right now. So we're figuring out how we're going to merge these items to address those types of issues.	Volume 3, Section 6, Volume 3, Section 11.3	No
	QUESTION 36. In 2006 masterplan, we went for about a 100% increase in rate, right?	Yes, for the last 10 years, over 100% of rate increases have been implemented.	N/A	No
	QUESTION 37. Do you assume the same number of customers?	There is growth included, it's less than 1% per year.	Volume 1, Section 12	No
	QUESTION 38. This prediction includes even the military population growth?	Yes. We did our own estimate because there are a lot of independent estimates. So we incorporated what DoD says about their impact, Tourism 2020 impacts, and similar information from other sources to determine how they are going to impact the population for our Master Plan over the planning period.	Volume 1, Section 4	No
	QUESTION 39. What do our water rates look like versus the average water rates nationwide?	In terms of similar water systems in other island communities, we are right in the middle. The needs that we face are not different from the needs of any other public water system in the states, so everybody's rate is going to end up increasing. All money that we've spent up to this point has been used to pay to get us to be a decent utility. All we're trying to do is maintain that. We're not shooting for world class. We might have been, at one point, but what I'm showing to you now is a more realistic plan.	N/A	No

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
July 18, 2018 GCA	QUESTION 1. You talked about the septic sewer conversion, is that going to be by village? And is there a cost to people or to whoever owned that property to be converted?	Yes, it will have a cost to the homeowners. Our job is to expand the collection system into the areas that don't currently have it. We have established a sewer connection revolving fund in cooperation with Guam EPA and USEPA, that was our first step. I think that fund was established before the system development charge was put into place. So it was seed funding that was provided by the EPA. It isn't really enough to make it an effective tool for homeowners, what I'm asking for is that some of that SDC money that we have in our account and use it to augment what is available in that revolving fund to allow more customers to apply and receive assistance in connecting to our system once we have it extended into a village. But in terms of water it's going to be village by village. We are developing a system right now to prioritize areas and we're doing that in conjunction with Guam EPA because they have their own idea about where we need to extend in order to minimize the impact on rivers and streams and wells. That's the decision we made in consultation, but we don't have the specific areas worked out yet. We have the funding that we've been asking for for the plan and we do have the outright program to prioritize those areas, so we have to come-up with criteria to rank each area, possibly each village, by using those criteria to come with objective determination of who goes first.	Volume 3, Sections 4.3, 4.7 and Project MP-WW-Pipe-27	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 2. Are the water and sewer projects coordinated with the highway masterplan, as well as the secondary road renovation plan?	I just finished giving a presentation to the DPW Director and Chief of Staff of the Governor's Office yesterday, I have another presentation with them (they haven't advise us of the time yet, but they have been provided the link to download the document and they are reviewing it with their staff right now), we're doing our best to coordinate that. In addition, I have regular monthly meetings with the Director of DPW and the Guam Public Administrator and both ganged up on me and told me I am doing well, that includes preparing stuff like that. So we have been in regular coordination for the last year.	N/A	No
	QUESTION 3. Thank you for your presentation. I have a question on the maps. Do you have in your website something similar to real estate, where it shows property lines or markers where your size (water pumps run into secondary roads or main roads) whether it is 6-inch, 4-inch or 2-inch?	We don't have that available for public consumption on the website. We have a GIS system which has the roads and the parcels as we get that information from third parties, our own water lines and wastewater lines and pump stations, etc. We have all that in our GIS. Access to that for example, design, is coordinated through the engineering department.	Volume 1, Section 8.	No
	COMMENT 1. If I may request that it may be made available. That way, before any money is spent by the consumer or contractor or developer that we have an idea of what to expect from distances, e.g. how far 6-inch line is, how far away the 2-inch and 4-inch line. Just to get an idea of what this could possibly be.			
	QUESTION 4. So if we aren't on the sewer line, but you guys are going to install will you also be allowing for the use of that subject house that is on the septic tank to be installed with a new infrastructure for the new sewer line in the areas that don't have a good line at this time?	Yes, we will procure for that.	Volume 3, Sections 4.3, 4.7 and Project MP-WW-Pipe-27	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
July 25, 2018 GSPE	QUESTION 1. There is talk about a water shortage on Guam in the future and we have 120 wells now. How many many more wells can we have?	MCB noted that Dr. Jenson who is in attendance is an expert on the Aquifer, but we believe we are at around 40% of the ultimate yield of the aquifer. We also have a high number of leaks in the system we are working to address, so if we can reduce leakage, we can increase our supply without increasing withdrawal from the aquifer. There is a current emphasis on that, an emphasis in the master plan and one of our Levels of Service goals.	Volume 1, Section 5.	No
	COMMENT 1. Dr. Jenson noted that there is more capacity in the aquifer. There is also some question as to what we are actually producing, because I understand that with possible meter inaccuracies, we could be reporting that we are actually withdrawing more than we are. That means we are potentially better off than we think we are, but even that is only 14% of annual recharge. As a rule of thumb, you are stressing the limits of what you can economically extract from an aquifer when you get to about 40% of the recharge so we have a lot more capacity, we just have to do it carefully and do it right.			
	QUESTION 2. What contract mechanism will be used for most of the projects proposed in the plan. Will they be Design-Bid, Design-Bid-Build or other.	There will be more details on that when we put the 5-year CIP plan together, but the master plan doesn't make any attempt to specify what the delivery mechanism will be, but you can tell from our experience that we use a combination of both methods.	Volume 1, Section 11.	No
	QUESTION 3. What projections do you have for increases in the customer base and what projections are you looking at for population increase over the next 20 years?	We used information from a lot of different sources, organic growth unrelated to the build-up, growth related to the build-up, visitor population, etc. We also coordinated with GVB and GEDA on what their projections were. We also looked at what development projects were planned and all that was wrapped up into our population projections. There is a detailed analysis included in the Master Plan Volume 1.	Volume 1, Section 4.	No

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 4. What projections do you incorporate for increased efficiency for modern methodologies and things of that sort that might help you find a lot more leaks.	The projections do not include the results of the efficiencies, but they include costs to improve the efficiencies. So from that perspective, the projects are conservative.	Volume 2, Section 9.	No
	QUESTION 5. What I don't see is any future court orders. Do you foresee any new court orders or changes at EPA that would cause them to throw more requirements at us? Because I know that regulations are changing for water quality and other things.	Let me answer that in a couple of ways. First we are making our best efforts to try and move from being forced into compliance to becoming voluntarily compliant. We believe that what we have put forth in the master plan projects will get us there in a reasonable fashion that our rate payers can afford. Rate payer affordability is kind of on EPA's mind but not really, we can say it's too expensive, but they don't really care. They are looking for compliance. I have also asked if they are planning any action for us and they would neither confirm nor deny. But it is possible that there will be another compliance action, but all we can do is our best to try and prove that we don't need it and be proactive about it. US EPA has a copy of the Master Plan and we went to San Francisco to present it but whether or not they believe it has yet to be determined. So will there be some changes, possibly, but the Master Plan will not change because this is our plan for how we want to run the utility. So if you look at our performance, as noted in the Master Plan relative to 2006 we have completed 30% of the projects and have 40% ongoing. So we are working towards the plan. So I think that's a reasonable argument to make to EPA that we will follow this Master Plan Update. But whether they believe it is another matter. We currently do not have any future enforcement action in the plan, and do not plan to add them if they do happen. Any changes required due to future action would be reflected in our 5-year CIP plan. So it could change our rate projections at some point in the future but at this point we do not know so this is our best approach.	Volume 1.	No
	QUESTION 6. Since you have an aggressive program to reduce leaks, if you reach your goals will that reduce your cost of power? Can you estimate what that might be?	Absolutely. I do not know the amount, but we do have someone in the office that keeps track of that so we have that information, but I do not have it with me right now.	Volume 2, Section 9.	No

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 7. $1.26 billion is a big number. I'm curious how that lines up with other master plans on Guam with similar jurisdictions?	I do not know how this compares to other Plans. Kurt Bilz added that the 2006 Master Plan proposed $900 million in CIP so if we consider inflation, the costs expected in 2006 are similar to the costs proposed in this update. A big component of that was to address GWUDI which became one of the unnecessary projects, but the original program was around $900 million.	Volume 1, Section 12.	No
	QUESTION 8. Does the planning of the projects tie into the One Guam initiative and what the Navy is doing. Are these part and parcel to what the Navy is doing?	There aren't any specific projects that are specifically tied to the One Guam initiative. But there is a Level of Service goal for us internally to continue to advance the agreements that we have under the One Guam initiative. We can't include anything in here because we are only half of the equation. They have to agree to it as well. We are not to that point yet with the Navy, but that's something that we will be working towards in the future. We are already talking about joint modeling for the water system. They have a model and we have a model and coincidentally both models were completed by the same firm, so there are only a few people who can look at the integration of the two systems. We are working towards a combined model so we can assess areas where if we were connected and there was an emergency we could evaluate how the systems would function if they helped us out or vice versa. Discussions have been had, but an MOU needs to be completed. So there are no specific projects at this time.	Volume 1, Section 5.4. Project MP-PW-Misc-04	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 9. I saw where you are trying to connect septic tanks and cesspools to the GWA sewer system. Do you have any provisions to help get the customers to connect as the sewer goes by their area?	Nothing more that what is already in place. So if we extend the sewer line and they are within 200 feet, the law says you need to connect. The connection is on the customers dime. But one thing I can tell you that's not part of the master plan is that we have an existing sewer connection revolving fund that was seeded with some funding from US EPA, a real small amount and it was put into place before the SDC plan. So customers could access that revolving fund as a loan but the funding is too small to reflect the current costs for what it would take to get connected to the system. So we are proposing to use some of the SDC money we have accumulated so far and use some of that to increase the fund level to a more reasonable amount, so the amount available to each customer/resident to draw out in terms of a loan would be increased. Tom has also worked on producing some standard details for the connections that they can use to go out to contractors and get quotes for the work. So we want to make it more useful and increase the turnover so more people can access the funds to get more people off of septic.	Volume 3, Sections 4.3, 4.7 and Project MP-WW-Pipe-27	No
	QUESTION 10. Your customers in the south, are they supplied off of FENA lake still or do you have connections to well water from Piti for that area.	Everything that we produce in the North that comes down the central area through Tamuning and Agana ends at Piti. On the other side of the island, we are able to move well water up Cross Island road to certain parts of Talafofo, Windward Hills and that area and Santa-Rita. What's left isn't enough for Santa Rita so it is still augmented by FENA water. On the Other side, everything from Talafofo south to Merizo and Umatac is all served from Ugum. We have plenty of capacity at Ugum to serve the South, except when we run into problems. Despite what you might hear from some individuals, Ugum water is great.	Volume 2, Section 8.	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	COMMENT 2. My water and sewer bill in the Houston area for July was $120.00. Much more than my GWA bill. Note that I own a home in Woodlands Texas and one here.	See, our rates aren't that bad. One of the questions that we get asked when we do the ratings presentations to the financial rating agencies is how do we compare to other areas and island utilities and if you look at Guam, Hawaii and areas like Saipan or American Samoa, we are kind of in the middle. Now if EPA comes in and says that we want you to do all these projects in the next 5 years then we will probably be at the higher end of the scale.	Volume 1, Section 12.	No
	QUESTION 11. Have you been paying any fines to EPA?	No. We try to avoid that. We have been a little bit late on certain things and missed some deadlines by a few weeks, but we communicate with them every two weeks, just on the court order side and there are other communications as well so they are kept apprised of all the projects that we have going on.	N/A	No
	QUESTION 12. Is the upgrade of the Hagatna WWTP included in the plan?	The design of the upgrade is included at the tale end of the plan. The construction work is outside the planning period. I don't know if it will stay that way, but that is our current plan.	Volume 3, Project MP-WW-WWTP-02.	No
July 26, 2018 Gov. and staff	QUESTION 1. Does complying with the Clean Water Act impact the WRMP update?	The project scheduling in the Master Plan Update is per GWA's proposed time table	Volume 1, Section 11.	No
	QUESTION 2. Regarding Ugum, how long has Ugum been stable?	Ugum has been operating as a membrane treatment plant since 2012	Volume 2, Section 3.2.	No
	QUESTION 3. Smell at/in Hagatna, does this plan help with smell?	Not specifically, but the odor issues could be addressed in one of the future Hagatna WWTP upgrade projects.	Volume 3, Section 7.	No
	QUESTION 4. Does project scope involve paving roads when roadwork is done?	Yes	N/A	No
	Comment 1. Discussion about GWA's paving efforts and coordination with DPW ongoing. Comment made that GWA should work with DPW to do pavement restoration after GWA make repairs.			
	QUESTION 5. There seems to be a lot of water leaks in Tumon around Treasure Island area. What is GWA doing to address those areas?	The issue here is that the pressure is too high causing the breaks. GWA has a project to install a PRV in Tumon as part of a Tank project which would address high pressures in Tumon and should reduce leaks in the area.	Volume 2 Section 8.	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 6. What is GWA's water loss?	With recent system audits and data the non revenue water is estimated to be about 40-45%.	Volume 2, Section 9.	No
	QUESTION 7. Does General System Improvements take into account security?	Yes, there is a section in the report and project adressing security.	Volume 1, Section 6.3 and Project MP-Gen-Misc-09.	No
	QUESTION 8. Does SCADA involve improvements to prevent cyber security?	Yes, part of on-going GPA-GWA project.	Volume 1, Section 6.3 and Project MP-Gen-Misc-09.	No
	Comment 2. Comment made from Governor noting that recycled rubber/glass can be used as a substitute for bedding of pipe.			
	QUESTION 9. Is the military factored into the WRMP?	Yes. The miltary build-up as well as growth associated with the build-up is included in the Master Plan.	Volume 1 Sections 4 and 6.	No
	QUESTION 10. Well water testing, does GWA test for heavy metals?	Yes	N/A	No
	QUESTION 11. Will GWA still require multiple bond borrowing?	Yes. There is a 20-year financial plan included that shows the proposed borrowing required to fund the CIP planned.	Volume 1, Section 12.	No
	QUESTION 12. When is HWWTP going to change to secondary treatment?	USEPA wants to change asap but GWA is working to extend to the end of WRMP update 20-year planning period. Meetings with EPA regarding HWWTP are ongoing.	Volume 3, Project MP-WW-WWTP-02.	No
	QUESTION 13. How many tons of sludge go to the Layon landfill?	I'm not sure on tonnage but we spend about $200K a month.	Volume 3 Sections 7 and 8.	No
	COMMENT 3. The sewer system in the north needs improvement.			
	QUESTION 14. Is SDC part of the WRMP?	Yes	Volume 1, Section 12.	No
	COMMENT 4. Comment was made about GWA discouraging development in central villages and that somehow GWA does not help development in central villages.	GWA is supportive of development.		
	QUESTION 15. The military is building water production wells, does GWA have any concerns?	No concerns.	Volume 1, Section 5.	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
July 27, 2018 Mayors Council of Guam	QUESTION 1. Regading central village improvements planned, where is the tank that you are mentioning here in Mangilao? Which tank are you replacing, in Mangilao?	For Mangilao tank, GWA has already completed the rehabilitation of the Mangilao reservoir, and we anticipate it to still have useful service life. However, if it will need replacement or expansion in the future, we do have a future tank replacement planned for Mangilao.	Volume 1, Section 6.	No
	QUESTION 2. The only reason why I'm concerned is I don't know if your guys are aware that we have residents… and just recently when we had a storm, it's like there is a different fluctuation now on the water system in this area. Did you guys have any planning on that? That's why I am inquiring about the pump and well thing.	We do have some work on a pressure zone realignment planned for this area, and we do have improvements planned for I think route 15, for improving the service pressure between the North and coming South along route 15. That might help alleviate some of those issues that are persistent. I am not aware of any major issues with the service in this area following the recent storm.	Volume 1, Section 8.	No
	COMMENT 1. I know, I am trying to follow-up because it happens at peak times and during the weekends. They are also doing other planning… right next to the area… a building, and the condos. Right now, as they are getting close to it… I can get the records and give them to your office. Their concern is, I am assuming this is during the peak time, early in the morning… of course during the day because nobody is really home but I think it is really during peak hours is when they have the fluctuations and the low pressure from the water pump.	So if you are close to the elevation of the tank, you will always see that because the whole purpose of the tank is to absorb the fluctuation and demand. So demand causes the fluctuation when there is a high period in the morning and then in the evening. So the levels in the tank fill up during time of low demand and then when people use it, it fluctuates. So when the level goes down, if you are close to the tank you will see it more because the pressure is associated with how much water is in the tank. So there is a natural fluctuation that you will see. The best thing that we can do is try to keep the tank full all the time. Again having that pump station, the booster will provide us better flow and better pressure from the north coming down here which is where more of the water is coming from.		
	QUESTION 3. With regard to your on-going reservoir projects, the Santa Rita tank, are you guys going to repair or replace it?	The Santa Rita Tank will be replaced. Design work for this project is on-going at the moment.	Project MP-PW-Tank-15	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 4. The reservoir in Talofofo, is that going to be replaced or what kind of renovation are you going to do with that tank? Can you make it bigger?	Major repairs are contemplated for that tank. For the repair, the tank will stay the same size. But if there is a capacity issue, we have the potential to be able to add another tank. We're doing that in areas, as previously mentioned, where projections indicate the existing tank will reach its capacity in the future, and there might be a need to be add another tank for the anticipated growth and demand.	Projects MP-PW-Tank-16A, and MP-PW-Tank-16B	No
	COMMENT 2. You know that we had a water tank that gravity flowed from Umatac, long time ago, and still its pouring out a lot of water coming from underground. Did you guys ever think of looking at that? We brought some senators in there. It is a small tank with a 2-inch water pipe and there is still some water flowing-out. It is in the center of, actually looking in to the mountain side. We took some people, senators, from Waterworks and EPA to see the place. A lot of water still shooting out and that is where the Umatac villagers used to get their water.	Right. In Volume 1 of the masterplan there was an assessment of water sources and additional potential sources of water that were identified in the event that we need them in the future. We didn't take a look at *Fai-Fai Springs* that you are mentioning, and we took a look at a couple of other spring sites in the south and then we also looked at the potential flows from another portion of the Ugum river to also capture for beneficial use. We did take a look at these sources, but we have no plan in this 20 year outlook to do anything with developing those sources.	Voume 2, Section 5	No
	QUESTION 5. Also in Umatac, we have constituents up the hill that don't have sewers, is there any plan for those? Because we have people calling me about their septic tanks getting full, sometimes during storms the water fills up the tank so they have to go and pay for that.	There isn't a specific plan identified for that area. But we do, as I mentioned earlier, include in the Master Plan a performance goal to reduce the number of septic tanks by extending the sewer system. That is a program that we've included in the plan. The specific areas, as we move forward with that plan, will be identified, evaluated, and prioritized. Our goal is to extend the sewer, but we're going to start with areas where having septic tank can have an adverse effect to water wells that are close-by. So those are the areas where we focus on first, we do have a program in place for that, but we don't have anything specific planned right now, for that area of Umatac.	Volume 3, Sections 4.3, 4.7 and Project MP-WW-Pipe-27	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 6. With regard to your hydrant replacement program, do you guys order your hydrants and stuff? Are there any plan to replace what is no longer there or has been damaged by accident or anything like that?	Yes we have plans for this work. Although, we have an inventory of new hydrants, we are currently putting together a bid package for the more complex replacement jobs we have, that we cannot do in-house, to have a contractor assist us with. So once we have that contractor on board, we will quickly burn through the supply of fire hydrants that we have. For in-house replacements, we now have a dedicated crew, which was only recently formed, to do nothing but fire hydrant replacement and maintenance. We have a priority list from the fire department, these are the ones that need to get done so we're trying to knock those out first. We do have inventory in stock, and this program in the master plan is intended to augment what we're already doing.	Volume 2, Section 10	No
	QUESTION 7. You are talking about wastewater projects, in Barrigada, we've got an issue at route 10, its been a problem for many years, where wastewater is coming out on the street. Do you have a plan for this issue?	Yes, there is a project planned for this area.	Volume 3, Section 11.1 (MP-WW-Pipe-02)	No
	QUESTION 8. I noticed, when you gave an overview of the central projects one of the things that wasn't mentioned was the Hagatna water waste treatment plant, isn't that one of EPA's requirements in that court order to establish a secondary treatment?	The design for upgrade to secondary is included in the Master Plan, but not the construction. The construction was projected to take place outside the 20 year planning period.	Volume 3, Section 7.8 and Project MP-WW-WWTP-02	No
	QUESTION 9. In addition to that, I noticed how you generally factored in the rates based on, if you are not on the sewer and if you are in the sewer. But on the same token you mentioned that the goal in the next 20 years is to try to close the gap between those that are on septic systems and upgrade them in to sewer system. So in essence what you are planning on doing is creating more of the potential revenue base. Was that factored into determining the 3% rate increases?	Yes - those factors were taken into consideration. GWA considered organic growth, planned developments, the Governor's tourism growth objectives, and all those revenues were factored in to our financial model. When we do our 5 year plan, that's an opportunity for us to say, "well, we assume that it's going to be coming online." It gives us an opportunity to check it and then make an adjustment.	Volume 1, Section 12 and Volume 3, Section 4	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 10. Because if you don't close that gap then what you are projecting, let's say like an average of 4.9 down to 3%, if GWA does not meet that goal that potential rate may go up?	That's correct, there is the potential that projected rate adjustments may go up, but on the CIP side if we don't bridge the gap that means that we are not spending that CIP money. So there will be a corresponding potential decrease in cost. Remember that this is a 20 year plan, right? So we can make adjustments in future years if things change. As we mentioned, in implementation, there will be a 5 year CIP plan and 5 year rate plan, but we also have built in 2-year progress reviews on the master plan.	Volume 1, Section 12 and Project MP-Gen-Misc-02A and 02B	No
	QUESTION 11. And then when you said that the secondary treatment plant design was planned beyond this 20 year masterplan, are we still looking at keeping it in Hagatna or are we looking at relocating it to another site?	We're still looking at keeping the WWTP in Hagatna for the planning period.	Volume 3, Section 7.8 and Project MP-WW-WWTP-02	No
	QUESTION 12. So you are, basically, expanding the existing man-made island?	No, not necessarily. When we design the upgrade, the need to expand the site is dependent on the process. employed to achieve secondary treatment. For example, if we employ the same technology that we used for the new Agat-Santa Rita plant, that's space intensive. But, that is not the only process that we can use to achieve secondary treatment. So we can use a different technology, different treatment process to get secondary treatment at Hagatna on the existing footprint, which may also become a matter of cost as well. That's why we need to do the design. We have that planned at the end of the 20 year planning period.	Volume 3, Project MP-WW-WWTP-02	No
	QUESTION 13. Was the secondary treatment upgrade in that court order?	No. The Court order was to bring it to chemically enhanced primary treatment which we've done and we're meeting the goals that were set in the court order for that. The regulation still requires an update to secondary but we're negotiating with the US EPA as to when that happens for us at Hagatna.	Volume 3, Section 7.8 and Project MP-WW-WWTP-02	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 14. I heard the word “organic”, is this something you are looking at, because you’ve got the leachate coming out of the Ordot dump now down to the Hagatna wastewater treatment plant, so doesn’t that have any impact as far as treatment?	We’re watching the flows from Ordot. But right now it hasn’t upset the treatment process. When you go to secondary, I think the processes are a little more sensitive to things that would upset the biological treatment that goes on at the plant. The upgraded plant will probably be a little more susceptible to that once we get to secondary. So it may require a pre-treatment the Ordot pump station.	Volume 3, Section 7.8	No
	COMMENT 3. Miguel, your presentation is beautiful but my immediate concern now is a lot of damaged roads that we have now because of Guam Waterworks. Remember that we had a meeting a couple of years ago or several months ago about how are you going to repair the roads as you repair the pipes. It’s unacceptable that our roads are not being repaired. We want our roads to be kept nice, so please if you can repair it the right way. We don’t want our roads collapse.	This is an area which GWA needs to improve, and we have tried to outsource the road repair work. GWA has put out 3 procurements for this and contractors have not bid for the work. We are using smaller procurements just to get smaller contractors to follow us and to make permanent repairs after we repair the pipe and temporarily patch the road.	N/A	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	COMMENT 4. Miguel, you know, really it's just the time. What you're saying, on a major thoroughfares, to some instance that is true. There may be a time gap. But on the major thoroughfare that is substantial. When you are talking about 20,000 vehicles passing that section of the road, every single day that is substantial. And even some of the villages' roads, if we're talking around 2,000 vehicles passing that area where the road is damaged every single day. As a matter of fact, believe it or not, I just got a photo and text from a resident on Mai-Mai road that got hit because one car avoided the pothole created by GWA and both cars were damaged and her husband was injured. That's what we have to contend with and they send us this information and provided us with these photos, and it's kind of like I don't know what to say. I sent them copies of all the correspondence I sent to DPW with regard to the maintenance of the road and coordinating with GWA in fixing this damaged section of this road. We're just concerned that something really has to get done.	I understand the frustration. We are trying to work on this. Before we did the presentation to you, we did the presentation to DPW and Guam EPA, exactly for purpose of (this is our 20-year plan) coordinating with them on what our improvements going to be and they did raise issues where they have their roadway projects scheduled, we need to sit down and coordinate. We have had some success coordinating recently, for example, on Macheche Road, when they had to repave the road and we knew we had a project going on, they waited a month for us to get started first, helped us to push our permits through, and our Contractor got through and put the sewer line in and then they came in behind him and paved the road. We're trying work on those issues, I recognize that there are shortcomings in the way that we're doing it but we're trying to get better.	N/A	No
	COMMENT 5. This really extends to a situation between Government of Guam (DPW) and private property owners regarding the right-of-way and encroachments. As an example on MaiMai Road, we really need to resolve this private property encroachment because you're trying to run a water line that needs replacement on an existing road where there is still some contention on boundaries. But instead of trying to resolve it, the decision was to try to delete or delay the minor road replacement. I know this is not a GWA issue as much as it is a DPW issue but we cannot just step back and say that "it is too big of a problem to resolve." Because it affects you, it affects DPW but more importantly, it affects the constituents living in that area and depending on the government to resolve this.	GWA supports getting this land issue resolved, but we only have the authority to do so much.		

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	QUESTION 15. There is a water well in Asan, and there is an old structure with a fence surrounding it. It's been going on for the longest time and we did a report then they came in and started fixing up those pipes. I believe those water valves need to be changed and even the building needs to be repaired.	The Asan Springs rehabilitation is in the master plan. One of the issues that we're facing there is that the government of Guam owned the property when the facility was built initially and then at some point after that, they deeded a portion of that property that Gov. Guam owned to the Department of Interior and National Park Service. So the boundary line is underneath the existing building and our plan now is to upgrade and get Asan Spring back online, but we can't do it because we don't own all the property on which the existing facilities sit . Last week, I submitted a petition to the Department of Interior and Parks Service for them to provide us use of their property. We also reached out to the Congresswoman's office to see if she could do something to get the property back to us, as part of the "net-negative" land impact for the build-up, the federal government is supposed to reduce its footprint. And so we're saying, "*we'd like to have some of the reduction of your footprint in this location and give us the property we need so that we can get this project off the ground*." We're starting to see some movement from that and we are working on it.	Volume 1, Section 11, Project PW-05-15	No
	QUESTION 16. In the Tiyan area. We're having issues in that area where the residents right behind Joaqin Court route 8 area. Is that going to be improved anytime soon? Because every week they call me to inform us that they have no pressure or water. What are we doing?	GWA is taking steps to adjust the system to alleviate these low pressure issues. We have deployed pressure loggers, we're trying to make some adjustment in the system, and we brought a lot of the wells that are serving the Barrigada reservoir back online. We're down to 3 or 4 wells that are down which is a pretty good number for us, out of 120. We are starting to see some positive progress.	Volume 2, Section 8	No
	QUESTION 17 Because there is a development going-on (I don't know if you are aware) between mobil and shell, there is a proposal to build an American Grocery there. So that's another issue that we might have once they start operating, what will happen to the residents at the back again?	Before a building permit is issued when they come in to us, we take a look at the model that Kurt referred to, the hydraulic model. We evaluate what are they planning to build, we put a demand on the model to see what will happen to the rest of the system before we approve their building permit application. So we don't anticipate that building coming online will have a degrading effect on the service surrounding customers.	Volume 2, Section 8	No

WATER RESOURCE MASTER PLAN QUESTIONS AND COMMENTS

Meeting Date	Questions and Comments	Responses	Reference Section from Master Plan	MP Revisions Necessary
	COMMENT 18. We had a public hearing on that and it is so sad that we only had DPR and DPW to put their comments. We were surprise that Waterworks did not put their comments in on water and sewer for that. There was nothing that came in when we had our public hearing.	We may not send a representative but we always submit our comments. We will check on that.	N/A	No
	COMMENT 6. As a matter of fact that is one of the fundamental changes in the zoning process. The Dept. of Land Management now is required to submit copies of all the ARC comments provided by all the agencies prior to the public hearing that was held in the village that is being impacted. Some of the concerns that we felt existed but we weren't sure what the positions of the agencies were with regard to this proposed development. And one of the things that they say, "We talked to GWA and they're okay with it," and this was at a GLUC hearing. And when I spoke with a GWA representative they said, "No, we've been asking them for more detailed information as far as anticipating demand before we could provide them a position statement and we haven't gotten that to date." The Mayors don't sit on the ARC, so it may be something worth considering is when you provide a response to the Commitee, provide a copy to the Mayor of the impacted village so we're not blindsided by what we get from DLM and you guys directly saying, "Hey! This is the village that is being impacted. We're providing you comments on something that they will have to deal with."	Sure. I think we can do that.		

GUAM WATERWORKS AUTHORITY

PRESENTATION ON OUTREACH PLAN FOR GWA'S WATER RESOURCE MASTER PLAN (WRMP)

Tuesday, June 26, 2018 at 6:00 p.m.
Yigo Village (Senior Citizen's Center)

No.	Name	Address	Email Address	Contact Number(s)
1.	Elizabeth Tunumgeg	116 Toria LN yigo		489-7624
2.	KEITY HAllucky	11-1 Gill Breze Yigo		864-5742
3.	Dorothy Lukeala	#170 Chlu SPC John T. Sablan, Yigo		482-0287
4.	Vangie Lugo	GWA		
5.	JUDY MANIBUSAN	YMO		653-5248
6.	Noel Carganilla	Gill Breeze		486-3712
7.	Arnaldo Aban	Gill Breeze		486-3497
8.	ALEXANDER PANGELINAN	Gill Breeze		486-4713
9.	ROXANN BORJA	Gill Breeze	roxxycamacho99@gmail.com	864-1901
10.	Billy Fejeran	Enrique Rosario	none	653-9446
11.	Eddie Villagomez	("	("	858-1357

GUAM WATERWORKS AUTHORITY

PRESENTATION ON OUTREACH PLAN FOR GWA'S WATER RESOURCE MASTER PLAN (WRMP)

Tuesday, June 26, 2018 at 6:00 p.m.
Yigo Village (Senior Citizen's Center)

No.	Name	Address	Email Address	Contact Number(s)
12.	Sandra Jacob	120 Stephanie E Mendiola Blvd Yigo	~~San~~ samonlijacob@gmail.com	987-5852
13.	Joseph / Mertle Quidachay	P.O. Box 22724 BARRIGADA	MERTLEQ@hotmail.com	969-6491
14.	Kenelly Reremel	135 VNL gillbreeze sub Yigo		480-3726
15.	MARILOU MARIANO	390-A BOBBY LANE TAKANO SUBD YIGO		653-61-46
16.	Erwin C. Leones	450 V chalan checho		653-2850
17.	Kolinda Ominore	Lot 1, Blk 7 Bhojwani Subd		858-8812/653-9446
18.	Jason Villagomez	Gayinero Yigo		971-0104
19.	Jaylyn KS. Sne	114 CHN. GOKO ELLWA ST.		998-8914
20.	JESSECA TAMANGIMED	Lot 10 Blk 2	Toneca@gmail.con	747-2637
21	Joy and Fred Cabral	Lot 16/15 Blk 15		864-7788
22.	Bellenger Atty	Lot 6 / Block 4		787-8886

GUAM WATERWORKS AUTHORITY

PRESENTATION ON OUTREACH PLAN FOR GWA'S WATER RESOURCE MASTER PLAN (WRMP)

Tuesday, June 26, 2018 at 6:00 p.m.
Yigo Village (Senior Citizen's Center)

No.	Name	Address	Email Address	Contact Number(s)
23.	Jones, Reber	Lot 5 Block 5		987-~~1797~~
24.	MELISSA ESPIRITU	306 CHALAN SANTA BERNADITA AGAPA GUMAS		482-2903
25.	Tanya taitano	160 Tan Franciscan Robert St.		653-5366
26.	Robert Taitano Jr	160 Tan Franciscan Robert St.		653-5366
27.	Eleanor Phillip	Lot 7 4160 Guam		997-1683
28.	Terry Rivers	1270 N. Marine Dr Suite 101 PMB 681 Tamuning 96913		632-9391
29.	Sioko H. Pickey	Gill Breeze		977-7832
30.	Flesihas Gurungin	lot 10 Blk-2 Gill Breeze		
31.	Laura C. Ruetamangmed	Gill breeze lot 10-1bk2		788-1090
32.	James Ruetamangmed	Gill Breeze lot 10 Bk 2		486-5989
33.	Jacalyn Taisacan	176 Chln Tun luis		788-7774

GUAM WATERWORKS AUTHORITY

PRESENTATION ON OUTREACH PLAN FOR GWA'S WATER RESOURCE MASTER PLAN (WRMP)

Tuesday, June 26, 2018 at 6:00 p.m.
Yigo Village (Senior Citizen's Center)

No.	Name	Address	Email Address	Contact Number(s)
34.	Lysander Starr II			788-3110
35.	Anita M. Matanane	333 Chun Paanian Lagu Yigo		653-3119
36.				
37.				
38.				
39.				
40.				
41.				
42.				
43.				
44.				

GUAM WATERWORKS AUTHORITY

PRESENTATION ON OUTREACH PLAN FOR GWA'S WATER RESOURCE MASTER PLAN (WRMP)

Wednesday, June 27, 2018 at 6:00 p.m.
Agat Village (Agat Mayor's Office)

No.	Name	Address	Email Address	Contact Number(s)
1.	FRANK HILL	TALOFOFO		689-3600
2.	Jose Charguala[illegible]	457 San Nicolas Rd		828-1217
3.	Isidro Yatar	406 Pale Ferdinand Way		989-7131
4.	Julie P. Taitague	Inarajan		
5.	Doris F. Luyan	Inarajan		482-8945
6.				
7.				
8.				
9.				
10.				
11.				

This page is intentionally left blank.

Meeting Title: 2nd QTR. General Membership Meeting
Meeting Date: 11:30a.m, Thursday, June 28, 2018
Meeting Venue: Outrigger Resort Guam

Company	NAME	pax	amount	cash	cc	check
CCU		1				
CCU	Simon Sanchez	1				
CCU	Francis Santos	1				
Docomo Pacific	Ashley Kirk	1				
Dusit Thani Guam	Todd Johnson	1				
Fiesta Resort	Emma Macalino	5				
G4S	Roxanne Quichocho	1				
Guam Chamber	Pinki Lujan	1				
GWA	Miguel Bordallo	1				
GWA	Kurt Bliz	1				
GWA	Greg Cruz	1				
Hard Rock Café	Chef Singh	2				
Hilton Guam Resort	Makoto Yasuhara	1				
Hotel Nikko	Ele Magdael	3				
IHP	Jim Brandt	1				
Jamaican Grill	Frank Kenney	1				
Leo Palace	Tina Aquiningco	3				
Onward Beach Resort	Peter Perez	6				
Outrigger Guam	Steve Solberg	3				
PDC Wholesale	Gavin Gaminde	5				
Plan B Corporation	Berna Espaldon	2				
PROA	Frank Toves	1				
SKAL	Raquel Maminta	1				
Sheraton Laguna	John Falan	2				
SPPC	Mark Sablan	3				
ST. Corp	Pele Torres	4				
Take Care	Greg Kerrebrock	1				
Triple J Five Star	Jim Herbert	1				
Westin Resort	Val Blas	1				
Wyndham Garden	Sinardi Li	1				
GHRA Staff		3				
		61	$ -		**0**	**0**

Pacific Daily News (MEDIA)		

Meeting Title: **2nd QTR. General Membership Meeting**
Meeting Date: 11:30a.m, Thursday, June 28, 2018
Meeting Venue: Outrigger Resort Guam

COMPANY/ PROPERTY	NAME	pax	invoiced	cash	credit card	check
G4S	Joe Benavente	1				
	Gabe Simeon	1				
GFS		1				
Hyatt	Madel	2				
		5	**0**	**0**	**0**	**0**

GUAM WATERWORKS AUTHORITY

PRESENTATION ON OUTREACH PLAN FOR GWA'S WATER RESOURCE MASTER PLAN (WRMP)

Thursday, June 28, 2018 at 6:00 p.m
Tamuning - Senior Citizen Center

No.	Name	Address	Email Address	Contact Number(s)
12.	GREGORY J. PEREZ	P.O. Box 8697 TAMUNING, GU. 96931	GPEREZ@PACIFICUNLIMITEDGUAM.com	727-3233
13.	Cheryl Dilks	Alupang Cove Tamuning, GU	cdilks@brwncald.com	480-5071
14.	Marie Alvarez	Dededo, Gu	mealvarez@gmail.com	9690943
15.	Eric Fallon	Alupang Cove Tamuning, GU		
16.				
17.				
18.				
19.				
20.				
21				
22.				

This page is intentionally left blank.

GCA GENERAL MEMBERSHIP LUNCHEON MEETING
18-Jul-18
DUSIT THANI RESORT GUAM

	COMPANY:	NAME:
1	AM Insurance	Tricia Granilo
2	Ambyth	Leona Topasna
3	Ambyth	Orlando Sawyer
4	American Pres. Lines	Michelle Quidachay
5	American Pres. Lines	Haydee Metzger
6	America's Best Electric	Mylyn Exner
7	America's Best Electric	David Hicks
8	America's Best Electric	Irene Hicks
9	ARS Aleut	Zenon Belanger
10	ARS Aleut	Frank Toves
11	Bank of Guam	Joseph Cruz
12	Bank of Hawaii	Brian Bliss
13	Barrett Plumbing	Jessica Barrett
14	Black Construction	Dean Bates
15	Black Construction	Bruce Johnson
16	Black Construction	Don McCann
17	Black Construction	Joseph Leasiolagi
18	Brown and Caldwell	Kurt Bilz
19	Brown and Caldwell	Joey Duenas
20	Cassidy's	Adam Barron
21	CRW	Ronald B.
22	CRW	Roy Demaala
23	Dusit Tani	Todd Johnson
24	Dylan Mechanical	Harold Cullick
25	Dylan Mechanical	Arminda Tuazon
26	GCATA	Frankie Tass
27	GCATA	Gerald Taimanglo
28	GCATA	Vince Benito
29	GCATA	Mark Quintanilla
30	GCATA	Leyton Borja
31	GCATA	Bryan Mattews
32	GCATA	Christian Cortez
33	GCATA	Norriel Tiru
34	GCATA	Steven Kang
35	GCATA	Albert Leano
36	GCATA	Patrick Leon Guerrero
37	GCATA	Pedrito Valencia
38	GCATA	Luciano Baltazar
39	GCATA	Roger Cruz
40	GSI	Rodelo Sardea
41	Guam Temps	Matt Apelo

42	GWA	Greg Cruz
43	GWA	Tom Cruz
44	GWA (Guest Speaker)	Miguel Bordallo
45	Hawaii Energy Systems	Noel DelRosario
46	Hawaiian Rock	Art Chan
47	Hawaiian Rock	Peter Errett
48	Hawaiian Rock	Jere Johnson
49	Hyatt	Roselyn Carandang
50	Isla Coating and Roofing Supply	Brian Kent
51	Island Tinting	Joe Roberto
52	LMS	Bob Salas
53	Mid Pac Far East	Mark Cruz
54	Mid Pac Far East	Chris Camacho
55	Mid Pac Far East	Dave Losongco
56	Mid Pac Far East	Joshua Reyes
57	Morrico	Michelle Bordallo
58	Moylans	Jeol Quitugua
59	Moylans	Steven T.
60	Moylans	Elizabeth C.
61	MSA	Valyne Solang
62	NAVFAC	Al Sampson
63	NOKAOI	Paul Romias
64	Pacific Data Systems	John Da
65	Pacific Data Systems	Jeff Tester
66	Pacific Human Resource	Gregorio Calvo
67	Pernix	John Wilson
68	Phoenix Pacific	Elizabeth Casas
69	Phoenix Pacific	Hung Phan
70	Phoenix Pacific	Jherany Eugenio
71	Phoenix Pacific	Joel Jones
72	Phoenix Pacific	Sharoll Mobel
73	Phoenix Pacific	Vince Castro
74	Self	Harold Gorre
75	TakeCare	Jeff Larsen
76	TakeCare	RJ Ricarte
77	Tech Plus	Joe Palacios
78	The Carpet Store	Leilani Flores
79	Traffic Tech	Evan Metzger
80	Triple J	Charles
81	Unitek	Tony Brinkley
82	Unitek	Susanne Brinkley
83	Utilities Specialist Inc.	Dianne Fredrick
84	Utilities Specialist Inc.	Bruce Fredrick
85	Wood	Dave Cook

GSPE 7.25.18

WESTIN HOTELS & RESORTS

NAME	ORG.	PD.
Jeff Wheaton	Self	$28.00
Betty Gyle	Setiadi	✓
John Jenkin	WERI	✓
Emil Santos		
Jon Mcdonald	~~F[illegible]~~	$56.00
B. Berry	FHG	28.00
Joe Rouse	UOG, WERI	✓
John Robertson	Amoricarb	$28.00
Mae Janer	WSP	$28
Lynden Kobayashi	WSP	$28.00
PRITCHARD	DEWPOINT	28 $
Bruce Perry	Self	✓
Hana Johnston	DCA	✓
Jeremy Mudd	DCA	✓
Thomas Cruz	GWA	✓
Mann Sutton	GHD	✓
ELIJAH SOTO	DCA	✓
Pete Diaz	AECOM	28
Miguel Bordallo	GWA	—
Celvin Pasco	DCA	✓
Mark Dorado	DCA	✓
Jerome	DCA	✓
NESTOR	DCA	✓
Jeff Bell	DCA	✓

westin.com

2

WESTIN HOTELS & RESORTS

NAME	ORG	PD
AJ LAYSON	TGE	✓
JACK EDWARDS	TGE	✓
Jim Gelli	TGE	✓
Ashley G	TGE	✓
JUN DAYO	TGE	✓
Tom Camacho	DCA	✓
RAMON JUANANE		✓
HAROLD JALIQUE	TGE	✓
Ken R		✓

westin.com

This page is intentionally left blank.