

**Water and Environmental Research Institute of the  
Western Pacific  
Annual Technical Report  
FY 2016**

# Introduction

The Water & Environmental Research Institute of the Western Pacific (WERI) is one of the 54 water research institutes established by U.S. Congressional legislation at each Land Grant University in the United States and its territories. Chartered in 1975, WERI is now in its 42nd year of operation.

**WERI's Federal Charter:** WERI's mission is to seek solutions through research, teaching, and outreach programs to improve exploration, production, distribution, and management of regional freshwater resources, with the ultimate aim of enhancing the prosperity and the quality of life for the citizens of Guam and the regional island nations. WERI research and educational activities are sponsored by a variety of federal and local funding sources, but the institute was originally created to administer Department of Interior funds (via the US Geological Survey) under Section 104-B of the Water Resources Research Act. WERI has responsibility for three 104-B base grants: one each for Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and the Federated States of Micronesia (FSM). This report summarizes WERI's regional activities under the USGS 104-B base grant program for the period March 1, 2016 to February 28, 2017 (FY16).

**WERI's Local Mandates:** Since 1998, WERI has also administered two locally-funded programs: the Guam Comprehensive Water Monitoring Program (CWMP), established under Guam Public Law 24-161, and the Guam Hydrologic Survey Program (GHS), established under Guam Public Law 24-247. These programs provide for island-wide hydrologic data collection and analysis in partnership with the USGS Pacific Island Water Science Center in Honolulu, Hawaii. The data, along with other basic and historical data are maintained in the Northern Guam Lens Aquifer Database, which is the foundation for WERI's aquifer mapping and groundwater modeling programs. With the information and understanding gained from these programs, WERI provides technical support services, including annual workshops and field trips, for Guam's public and private sector water resources professionals.

**WERI's Research and Teaching Activities:** Expertise at WERI spans the natural water cycle and the spectrum of human water use. Research specialties and graduate instruction offered include tropical meteorology, surface water hydrology, groundwater hydrology, water distribution systems, watershed management and soil erosion and mitigation, wastewater treatment, water quality, and the application of geospatial analysis to water resources problems. In support of these activities, WERI operates a state-of-the-art water analytical laboratory, and a geographical information systems laboratory. WERI faculty contribute to graduate instruction and student thesis research within the university's Environmental Science and Biology programs. WERI is also making a central contribution to the launching of the university's new School of Engineering by assisting with undergraduate instruction, student advisement, faculty recruitment, facilities planning, and liaison with regional and stateside partner universities.

**Staffing:** WERI is led by a full-time director appointed from among its faculty for three years at a time. The director's office is supported by a secretary and administrative assistant. WERI has six permanent faculty (one of whom is currently serving as Interim Dean of the School of Engineering) and two emeritus faculty. Its water quality laboratory is staffed by a laboratory manager, chemist, and technician. The CWMP and GHS programs are managed by WERI's groundwater hydrologist with the assistance of a Ph.D. research associate. WERI researchers currently support seven graduate research assistants who are completing their MS degrees in the UOG Environmental Science program.

**Funding and Sources:** During FY2016, WERI faculty served as principal investigators and/or advisors on more than twenty research, training, and outreach activities with a total budget of approximately \$1.5M. Funding sources for these projects, in addition to the US Geological Survey, included the National Oceanic and Atmospheric Administration, the National Weather Service, the National Science Foundation, USGS

Pacific Islands Climate Science Center, the US Department of Defense, and local agencies including the Guam Legislature, Guam Waterworks Authority, Guam Bureau of Statistics and Plans, and the Guam Environmental Protection Agency.

## Research Program Introduction

WERI has three community advisory councils that provide stakeholder advice and assistance for setting research goals and priorities, especially for the USGS 104-B program. The Guam Advisory Council includes representatives from local and federal civil agencies and military environmental and engineering offices that deal with water resources issues, as well as colleagues in the university research community. The advisory councils for the Commonwealth of the Northern Mariana Islands (CNMI) and the Federated States of Micronesia (FSM) include representatives from government departments that deal with water resources, private sector engineers, environmental regulators, faculty from the local colleges, and other University of Guam research faculty who work on these islands. The duties of the advisory councils are to identify research and training needs for each region. WERI maintains a list of each region's needs, which is updated after each annual meeting.

WERI held advisory council meetings in September through October 2015. Each council examined the research, education, and training priorities identified in past years and added or amended where appropriate. In early November, a Request for Proposals (RFP) letter was sent out by e-mail to over two hundred (200) regional representatives in Guam, the CNMI and FSM. Recipients included past and present advisory council members; faculty members at the University of Guam, the Northern Marianas College in Saipan and the College of Micronesia in Pohnpei, and water resource professionals from government agencies.

In December 2015, four regional review panels, each composed of well-qualified water resources professionals and advisory council members, evaluated the proposals and submitted their scores and comments to the WERI Director. The proposal scores were then tabulated and the projects ranked in descending order of average score. Projects approved for funding were selected based on their regional ranking and availability of funds.

# Expansion of baseline data for the Northern Guam Lens Aquifer and evaluation of innovative treatments to reduce contaminant input to the aquifer

## Basic Information

<b>Title:</b>	Expansion of baseline data for the Northern Guam Lens Aquifer and evaluation of innovative treatments to reduce contaminant input to the aquifer
<b>Project Number:</b>	2016GU296B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Engineering
<b>Focus Categories:</b>	Nitrate Contamination, Groundwater, Treatment
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Joe Rouse, Nathan C Habana, John W. Jenson

## Publications

There are no publications.

## **PROJECT SYNOPSIS REPORT**

**Project Title:** Expansion of baseline data for the Northern Guam Lens Aquifer and evaluation of innovative treatments to reduce contaminant input to the aquifer.

### **Problem and Research Objectives**

The Northern Guam Lens Aquifer (NGLA) is Guam's primary source of freshwater for potable use. This porous limestone formation currently provides approximately 90% of the island's municipal water supply. Aggressive production of groundwater has grown to 40 million gallons per day. With water demand rising and concerns over water quality increasing, proper management of this freshwater lens has become critical to the welfare of the island's increasing population of residents and tourists.

Preliminary inquiries have suggested that contaminants from anthropogenic sources are showing up in the NGLA. Much more baseline data is needed, though, to determine if the problem is greater in zones with sewer collection lines, or in zones that rely on household septic tanks. In addition, the determination of whether or not contaminant levels are increasing, has not been adequately addressed. This too, begs for the need to get more data from wells servicing the NGLA.

In conjunction with the above, the effectiveness of septic tanks, which are so prevalent over Northern Guam, is also an issue of concern. Septic tanks are not known to provide much treatment, other than the removal of readily settleable suspended solids, and it is not known how many of the existing tanks are even discharging to adjoining tile fields as intended. It is through the process of percolating evenly over the tile field that the actual reduction in contaminant loadings via natural processes is meant to occur. As an alternative to traditional septic tanks, consideration is increasingly given to use of single-family prefabricated, packaged treatment units, which achieve secondary to advance levels of treatment, and as such if applied to Northern Guam, would serve to greatly reduce the potential of contamination reaching the NGLA.

This proposal responds to the critical needs expressed at the Advisory Council Meeting to conduct research on spatial and temporal trends in levels of contaminants in Guam's groundwater, as well as the need for baseline studies on continuous levels of nitrogenous compounds, etc. with respect to time and location. In addition, it addresses the need for evaluation of pilot studies of innovative wastewater treatment units as alternatives to conventional septic tanks for individual homes.

The objective of the proposed project is to produce a report that will offer further enlightenment as to the transport and fate of contaminants of anthropogenic sources in the sub-surface, and anticipated trends for the near future. These results will strengthen modeling capabilities addressing the water quality of the NGLA, thus being of importance to human safety.

## **Methodology**

The methods employed over the course of this project incorporated civil and environmental engineering fieldwork. Fieldwork consisted of setting up testing equipment for on-site data collection at well heads servicing the NGLA. Furthermore, influent and effluent samples of package treatment plants in Northern Guam were collected and transported to the laboratory (at WERI, UOG) for water quality analyses. Prior to conducting any activities, meetings were held with officials of the Guam Waterworks Authority to get permission to set up testing equipment at well-head locations in Northern Guam. Upon completion of the fieldwork and laboratory testing, all information was processed and evaluated. Finally, results of this study would be presented at environmental conferences and published in a WERI Technical Report to be made available to all authorized stakeholders.

## **Principal Findings and Significance**

Preliminary inquiries have suggested that contaminants from anthropogenic sources are showing up in the NGLA. From the data obtained here it is not evident that ammonium and nitrate levels in the environment are changing with time. Results do show, though, that ammonium is nearly absent in the groundwater, indicating that biologically induced nitrification is occurring in the environment. The presence of low levels of nitrate (ca. 4 to 5 mg N/L) corroborate this, though there is no clear indication yet that denitrification is occurring, versus dilution. It is essential that these issues be further studied before actions are taken to extend sewer collection lines or even build new wastewater plants in Northern Guam. In addition, the effectiveness of septic tanks is also an issue of concern. As an alternative to traditional septic tanks, consideration is increasingly given to use of single-family prefabricated, packaged treatment units. These units could serve to reduce the potential of contamination reaching the water table, and indeed test results of effluent from a prefab-unit on island show far cleaner discharge (chemical oxygen demand (COD), ca. 100 mg/L) as compared to effluent from a conventional septic tank (COD, ca. 400 mg/L). Further comparative testing is to be conducted.

# Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 3 model implementation: determining ultimate yield

## Basic Information

<b>Title:</b>	Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 3 model implementation: determining ultimate yield
<b>Project Number:</b>	2016GU297B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Ground-water Flow and Transport
<b>Focus Categories:</b>	Groundwater, Hydrology, Hydrogeochemistry
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Nathan C Habana, John W. Jenson

## Publications

There are no publications.

## PROJECT SYNOPSIS REPORT

**Project Title:** Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management; Phase 3 – model implementation: determining ultimate yield

### **Problem and Research Objectives:**

The Northern Guam Lens Aquifer (NGLA) provides 90% of Guam's drinking water. The anticipated addition of US Marine Corps activities will require additional production, while ongoing economic growth will further increase demand. Policy makers and water managers want to know the volumes of water that can be sustainably withdrawn from various parts of the aquifer, and how increased withdrawal will affect salinity. This phase of WERI's ongoing modeling program, in partnership with USGS, explores combinations of volume and quality that might be obtained if the current number of production wells (about 130) was installed exclusively in the para-basal zone of the aquifer, where the freshwater lens is underlain by impermeable volcanic rock rather than saltwater.

### **Methodology**

The three-dimensional steady state numerical (SUTRA-3D) model of the NGLA developed by USGS and WERI during 2010-2013 to assess the performance of the current system (Gingerich and Jenson, 2010; Gingerich, 2013) is now being used to explore the ultimate hydrologic capacity of the aquifer, i.e., what quantity and quality of water could be extracted if well placement was not restricted by land-use or accessibility to roads and power, but was rather based solely on where hydrogeologic conditions are best. For this project, 130 hypothetical wells are set 25 ft and 40 ft below mean sea level, and pumped at increments of 100 gpm up to a maximum output of 500 gpm or maximum salinity of 250 mg/l chloride (a USEPA secondary water quality standard).

### **Principal Findings and Significance**

Groundwater models can explore the outcomes for hypothetical well configurations that cannot be tested in a real aquifer system. This project so far shows that confining production to the parabasal zone could result in much greater yields for the same or lower average chloride concentrations. Initial simulation results with 130 parabasal wells showed that 76 MGD could be obtained with acceptable chloride concentrations—nearly double the amount currently produced by the real system.

### **References**

Gingerich, S. B. and J.W. Jenson, 2010, Groundwater availability study for Guam; goals, approach, products, and schedule of activities: U.S. Geological Survey Fact Sheet 2010-3084.

Gingerich, S. B., 2013, The effects of withdrawals and drought on groundwater availability in the Northern Guam Lens Aquifer, Guam: *US Geological Survey Scientific Investigations Report* 5216.

# Enhancing Predictions of Average Flow and Flow Duration Curves at Ungauged Stream Sites in Guam Using the USGS South Guam Streamflow Model

## Basic Information

<b>Title:</b>	Enhancing Predictions of Average Flow and Flow Duration Curves at Ungauged Stream Sites in Guam Using the USGS South Guam Streamflow Model
<b>Project Number:</b>	2016GU298B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Climate and Hydrologic Processes
<b>Focus Categories:</b>	Hydrology, Surface Water, Water Quantity
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Leroy F. Heitz, Shahram Khosrowpanah, Mark Lander

## Publications

There are no publications.

# **PROJECT SYNOPSIS REPORT**

**Project Title:** Enhancement of Duration Curve Predictions in South Guam Using Short Time Low Flow Measurements

## **Problem and Research Objectives**

In order to properly carry out good water resources management on Guam, it is necessary to be able to define the variability of flow available in Guam's streams. This is normally done by direct analyses of streamflow data for the stream in question or by applying some sort of inferential technique from a gaged to an ungaged stream or from a gaged location on a stream to an ungaged location on that same stream. The problem on Guam, as in most locations, is that stream flow information is not available for all possible sites where information is required. The objective of this study was to provide a better means of estimating the variability of flow at ungaged locations that are likely to become candidate sites for water resources investigations. The study concentrated on using the historical record at presently active stream gage sites to predict duration curves at ungaged sites.

## **Methodology**

This project was divided into six phases as listed below:

1. Choose gaged stream sites and study periods to be used in the analysis.
2. Develop flow duration curves and parametric flow duration curves for the gaged stream sites. The parametric curves were used for predicting duration curves for ungaged sites in South Guam.
3. Develop a means of predicting average flow and flow duration values at ungaged points on streams in South Guam.
4. Develop a set of GIS based maps showing the location and flow information for all stream reaches and segments.
5. Test the hypothesis that dry season low flow high exceedance values can be predicted at an ungaged site by averaging the exceedance values of gaged flows for the same day.
6. Measure the streamflow at several ungaged sites during dry season and develop duration curves for the measured sites along with estimates of the dry season duration values using the average duration values at the gaged sites.

## **Principal Findings and Significance**

The information provided by the study and its accompanying GIS data bases can be most helpful to those performing studies such as the evaluation of surface water resources for water supply studies, hydropower design, and planning studies, low flow studies such as in-stream flow requirements and other studies where it is desirable to define the variability of the flows in streams. The low flow measurement methodology developed enables water resources managers to better predict the low flow high exceedance percentage flows at ungaged sites. The methodology involves making low flow measurements at the site of interest. The flow duration exceedance percentage for the measured flow is determined by averaging the exceedance percentages for flows at the gaged sites for the same day as the ungaged site flow measurement was made.

# Identification and Delineation of Land-Based Mercury Sources Impacting Fisheries in the Southern Central Coastal Region of Saipan Lagoon

## Basic Information

<b>Title:</b>	Identification and Delineation of Land-Based Mercury Sources Impacting Fisheries in the Southern Central Coastal Region of Saipan Lagoon
<b>Project Number:</b>	2016GU299B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Water Quality
<b>Focus Categories:</b>	Toxic Substances, Water Quality, Non Point Pollution
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Gary Denton, Michael Trianni, Michael C Tenorio, Hyun-Jong Hahm

## Publications

There are no publications.

# PROJECT SYNOPSIS REPORT

**Project Title:** Identification and Delineation of Land-Based Mercury Sources Impacting Fisheries in the Southern Central Coastal Region of Saipan Lagoon

## Problem and Research Objectives

The southern half of Saipan Lagoon is heavily impacted by urban runoff that primarily flows from roads (paved and unpaved) and properties (residential and commercial) within 0.5 km of the coast. Frequent mercury (Hg) detections have previously been reported in stormdrain discharges in this part of the lagoon (Environet Inc. 2007). Such findings are unusual because Hg is rarely detected in runoff outside of industrialized areas (USEPA 1983). Denton *et al.* (2014) noted unusual Hg distribution profiles in sediments from Saipan Lagoon and concluded that inputs washed into the ocean from land-based sources were superimposed upon a scattering of Hg contamination emanating from within the lagoon itself. They attributed this anomaly to the extensive use of Hg in artillery shells and other explosive devices manufactured during WWII, and to the heavy shelling of Japanese defenses positioned along the shoreline of the lagoon prior to the US invasion in 1944. This historic battle left behind a Hg footprint that remains on the island to this day (Denton *et al.* 2016) and almost certainly accounts for the unusual Environet findings noted above. Studies to delineate Hg hot-spots within the lagoon and determine their impact on marine resources harvested for food are ongoing (Denton *et al.* 2006, 2009, 2010, 2011 a&b). The current study was prompted by the discovery of elevated Hg levels in emperor fish (*Lethrinus atkinsoni*) from waters just north of the invasion beaches. These data are summarized in Fig 1 (see zone 7 plot) together with levels found in fish from more industrially impacted waters further north. The objectives of this work were to extend the Hg database for fish within zone 7 and evaluate drainage pathway deposits within the corresponding catchment area. The ultimate goal was to identify primary land- and/or lagoon-based Hg sources of concern.

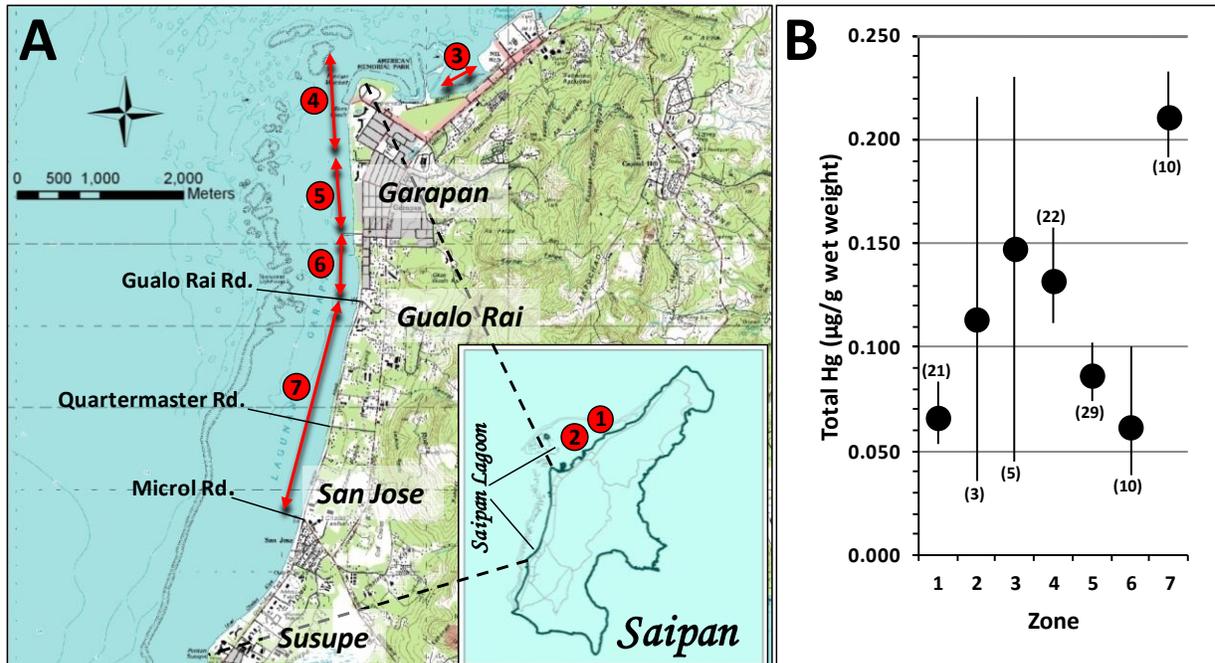


Figure 1: A = Emperor Fish capture zones; B = Mean Hg levels in muscle of standardized 20-cm fish; (# = n)

## Methodology

Zone 7 was arbitrarily defined by a third party who procured the original fish samples for mercury analysis in 2004 (Denton *et al.* 2010). It extends from Gualo Rai Road to Microl Road, a linear distance of approximately 2.8 kilometers. Twelve stormdrains discharge directly into the lagoon within this zone. Eight of the drains occur between Gualo Rai Road and Quartermaster Road (see Fig. 1) and include all outlets monitored during the aforementioned Environet study. During the present investigation surface deposits were taken from 29 sampling points along drainage pathways servicing all eight of these stormdrains. The deposits were scooped up in hand-held, pre-cleaned polypropylene vials and deep frozen within three hours of collecting. Visually they ranged in color and texture from light brown gravelly sand to darker clay substrates with varying amounts of organic matter. In the laboratory the thawed samples were dried to constant weight at 40°C and disaggregated by gently needing between finger and thumb in clean Ziploc bags. They were then sieved through a 1 mm nylon screen prior to digesting in a 2:1 mixture of concentrated nitric and sulfuric acids at 100°C for three hours.

The dominant emperor fish encountered in Saipan lagoon are *L. atkinsoni* and *L. harak*. Both species are nocturnal feeders and have restricted foraging ranges. Hence they provide a useful means of determining spatial differences in Hg availability over relatively short distances. They also have similar food preferences, growth rates and Hg affinities, which permit both species to be used in tandem for pollution monitoring and assessment purposes. In the current study, 21 fish were taken from four discrete locations within zone 7 between Quartermaster Road and Microl Road (Fig 1). All captured specimens were *L. harak* with the exception of one *L. atkinsoni*. Individual fork lengths ranged from 12.5-28.0 cm with an overall average body length of 19.3 cm. The fish were immediately chilled after capture and transported to the laboratory in insulated containers for processing. After weighing and measuring, axial muscle was removed on the left-hand side of each fish directly below the dorsal fin. The excised tissue was digested in the same hot acid mixture as described above for sediments.

All drainage pathway deposits and fish samples were analyzed for Hg by flameless (cold vapor) atomic absorption spectroscopy (AAS) using the syringe techniques described by Stainton (1971). Calibration standards (5-20 ng/l) were made up in 10% nitric acid containing 0.05% potassium dichromate as a preservative (Feldman 1974). Approximately 10% of all samples were run in duplicate and were accompanied by appropriate method blanks and matrix spikes. Accuracy and precision estimates were based on Hg recoveries from certified standard reference materials and were within acceptable limits.

## Principal Findings and Significance

Mercury levels in all drainage pathway deposits are summarized in Table 1. Overall levels were low and ranged from 2.45-76.8 ng/g dry weight (average: 17.6 ng/g). Baseline Hg levels in Saipan soils normally hover around 30 ng/g and rarely exceed 50 ng/g (Denton *et al.* 2016). Clean sandy deposits are typically an order of magnitude lower (Denton *et al.* 2014). The only sample to exceed 50 ng/g was retrieved ~100 m inside Pumpkin Street, which runs parallel to a car dealership and down gradient of auto repair/storage facilities. The evidence obtained suggests no major land-based sources of Hg are currently impacting the lagoon along this stretch of coastline. These results confirm earlier findings of little more than light Hg enrichment in beach sediments down gradient of zone 7 stormdrain discharge points (Denton *et al.* 2014).

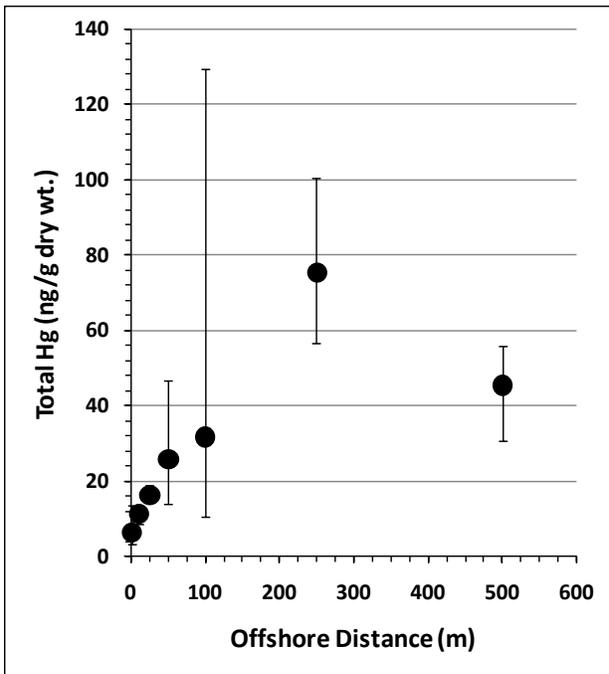
**Table 1: Mercury Levels in Drainage Pathway Deposits Examined**

Stormdrain Number (Location/Landmark) <sup>a</sup>	Coastal Coordinates. (15°N 145°E min/sec)	Drainage Pathways <sup>b</sup>	Statistic	Hg Levels (ng/g)
1 (Gualo Rai Road)	11' 42.20" N 42' 59.55" E	4	Mean: Range:	4.49 2.36-8.67
2 (Pupula Drive)	11' 36.63" N 42' 59.35" E	3	Mean: Range:	4.03 3.76-4.29
3 (Cabrera Center)	11' 31.84" N 42' 58.33" E	3	Mean: Range:	17.7 7.98-27.3
4 (Dotse Place - Moylan's Insurance)	11' 25.15" N 42' 55.89" E	4	Mean: Range:	18.6 9.20-30.1
5 Chaioti Place - China House restaurant	11' 19.94" N 42' 54.86" E	3	Mean: Range:	19.0 13.3-24.6
6 (Pumpkin Street - Triple J car dealership)	11' 04.06" N 42' 51.89" E	4	Mean: Range:	29.2 5.0-76.0
7 (50 m south of Triple J)	11' 01.04" N 42' 51.09" E	3	Mean: Range:	16.9 6.92-27.0
8 (Quartermaster Road)	10' 51.29" N 42' 49.03" E	5	Mean: Range:	24.6 11.9-40.5

<sup>a</sup>All the above storm drains pass under Beach Road, the main coastal highway, and discharge directly into Saipan Lagoon. Highway runoff on the landward side of Beach Road is channeled into underlying drains via gratings set into the roadside storm gutter

<sup>b</sup>Deposits were removed at intervals for analysis along all major drainage pathways servicing the above stormdrains

Mercury levels in the fish typically show a strong positive, non linear relationship with size. The pooled datasets obtained here were thus log-transformed and normalized to a standard 20-cm fish length using regression analysis. Baseline Hg levels in emperor fish of this standardized size are around 0.050 µg/g. The value obtained during the present work was 0.056 µg/g and suggests relatively clean conditions prevail within the area examined. The elevated Hg levels noted earlier in fish from this zone thus remain an enigma. Unfortunately, records of exactly where in zone 7 the original fish were captured are not available. It is known, however, that they were collected by boat, which suggests they may have been taken some distance offshore. This is important because a major Hg hotspot was recently discovered out from stormdrain 2 (see Fig. 2 opposite) and is believed to be an artifact of WWII as alluded to earlier. Having now ruled out the possibility of any significant land-based Hg sources entering the lagoon along this stretch of coastline, we are inclined to believe that the elevated Hg levels previously encountered in emperor fish from zone 7, were from individuals captured in the vicinity of this impacted offshore area. This hypothesis remains to be confirmed.



**Figure 2: Mercury levels in sediments collected along a seaward transect originating from storm drain 2. Plots are geometric means; whiskers are concentration ranges (from Denton *et al.* 2014)**

## Literature Cited

- Denton, G.R.W., Emborski, C.A., Hachero, A.A.B., Masga, R.S., and Starmer, J.A. (2016). Impact of WWII Dumpsites on Saipan (CNMI): Heavy Metal Status of Soils and Sediments. *Environmental Science and Pollution Research*, 23: 11339-11348.
- Denton, G.R.W., Emborski, C.A., Habana, N.C., Starmer J.A. (2014). Influence of Urban Runoff, Inappropriate Waste Disposal Practices and WWII on the Heavy Metal Status of Sediments in the Southern Half of Saipan Lagoon, Saipan, CNMI. *Marine Pollution Bulletin*, 81: 276-281.
- Denton, G.R.W. Trianni, M.S., Bearden, B.G., Houk, P.C., Starmer J.A. (2011a). Tracking down an Unusual Source of Mercury Enrichment in Fish from Saipan Lagoon, Saipan, Commonwealth of the Northern Mariana Islands. Proceedings of the 2011 International Symposium on Environmental Science and Technology, Dongguan, Guangdong Province, China, June 1-4, 2011. **In:** Li, S., Wang, W., Niu, P., Ann, Y. (Eds), *Environmental Sciences and Technology, Vol. III*. Science Press USA Inc., pp. 983-997.
- Denton, G.R.W. Trianni, M.S., Bearden, B.G., Houk, P.C., Starmer J.A. (2011b). Impact of a Medical Waste Incinerator on Mercury Levels in Lagoon Fish from a Small Tropical Island in the Western Pacific. *Journal of Toxicology and Environmental Health Part A*, 74, 823–827.
- Denton, G.R.W., Trianni, M.S. and Tenorio, M.C. (2010). Impact of Land-Based Sources of Pollution on Coastal Water Quality of Saipan, Commonwealth of the Northern Mariana Islands (CNMI): Arsenic, Mercury and PCBs in Popular Table Fish from Saipan Lagoon. *WERI Technical Report No. 130*, 98 pp.
- Denton, G.R.W. and R.J. Morrison (2009). Impact of a Coastal Dump in a Tropical Lagoon on Trace Metal Levels in Surrounding Marine Biota: A Case Study from Saipan, Northern Mariana Islands (CNMI). *Marine Pollution Bulletin*, 58: 424-455.
- Denton, G.R.W., Bearden, B.G., Concepcion, L.P., Wood, H.R., Morrison, R.J. (2006). Contaminant Assessment of Surface Sediments from Tanapag Lagoon, Saipan, Commonwealth of the Northern Mariana Islands. *Marine Pollution Bulletin*, 52: 696-710.
- Environet Inc. (2007). Draft Environmental Restoration Report, Aquatic Ecosystem Restoration Study, at Saipan, Commonwealth of Northern Marianas Islands. Prepared for US Army Core of Engineers, Honolulu Engineering District by Environet Inc., Honolulu, Hawaii, under Contract No. DACA83-00-D-0037, February, 2007. 126 pp.
- Feldman, C. (1974). Preservation of Dilute Mercury Solutions. *Analytical Chemistry*, 46: 99-102.
- Stainton, M.P. (1971). Syringe Procedure for the Transfer of Nanogram Quantities of Mercury Vapor for Flameless Atomic Absorption Spectrophotometry. *Analytical Chemistry*, 43: 625-627.
- USEPA (1983). Results of the Nationwide Urban Runoff Program, Volume I, Final Report. *Water Planning Division, U.S. Environmental Protection Agency, NTIS No PB84-185552*, Washington, D.C.

# Real-time investigation of the impacts of the 2015-16 El Niño on water resources in the CNMI

## Basic Information

<b>Title:</b>	Real-time investigation of the impacts of the 2015-16 El Niño on water resources in the CNMI
<b>Project Number:</b>	2016GU300B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Climate and Hydrologic Processes
<b>Focus Categories:</b>	Drought, Climatological Processes, Water Quantity
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Mark Lander, Shahram Khosrowpanah

## Publication

1. Pacific ENSO Update: A Quarterly Bulletin of the Pacific El Niño-Southern Oscillation Applications Climate (PEAC) Center, 3rd Quarter 2016, Vol. 22 No. 3.  
([www.weather.gov/media/peac/PEU/PEU\\_v22\\_n3.pdf](http://www.weather.gov/media/peac/PEU/PEU_v22_n3.pdf)) (Principal Author: M.A. Lander)

## PROJECT SYNOPSIS REPORT

**Project Title:** Real-time investigation of the impacts of the 2015-16 El Niño on water resources in the CNMI

### Problem and Research Objectives

The major El Niño event of 2015-16 reached its peak (Rasmussen and Carpenter 1982, Ropelewski and Halpert 1987, and PEAC 2015) in December 2015. Commonly used indices of El Niño rose to levels seen only two other times in the past 60 years: the epic El Niño events of 1982-83 and 1997-98. All the Mariana Islands from Guam through the Commonwealth of the Northern Mariana Islands (CNMI) are vulnerable to damaging extremes of weather during the roughly 18-month course of an El Niño event. The year 2015 indeed saw weather extremes, with several named tropical storms and typhoons passing through regional waters. A particularly severe typhoon (Typhoon Soudelor) heavily damaged Saipan during the night of August 02-03. This typhoon was at the Category 4 level of intensity and caused severe damage on Saipan. Shortly after the event, Dr. Mark Lander and Mr. Charles P. “Chip” Guard compiled a meteorological assessment of Soudelor on Saipan (Guard and Lander 2015). Another storm in mid-October (Tropical Storm Champi) dumped enormous amounts of rainfall on Tinian and Saipan, with some additional wind damage. Rain gauges installed on Saipan by Dr. Lander for a previous USGS project were destroyed in Soudelor. Saipan is still recovering from the typhoons of 2015. To make matters worse, in the first half of 2016, widespread dry conditions that typically follow a strong El Niño occurred on Saipan and on the other islands of the CNMI. Streamflow was sharply reduced, forests and grasslands dried to the point that wildfires became a problem, and there were deleterious impacts to the municipal water supply.

The project objective was to monitor the progress of the impact of the El Niño drought on Saipan while the drought was in-progress! The WERI team conducted site visits and interviewed several local water resource managers. Preliminary one-on-one and small-group discussions have been had by the WERI project team on routine visits to Saipan, but there are plans in-place for a more comprehensive workshop to discuss the findings with local water resource managers, local educators, local media representatives and the general public.

### References

Pacific ENSO Applications Climate Center (PEAC Center), 2015: Pacific ENSO Newsletter Quarter 4, 2015 Vol. 21, No. 4 (November 2015). U.S.-Affiliated Pacific Islands Current Conditions and Island Variability Summaries.  
[http://www.weather.gov/media/peac/PEU/PEU\\_v21\\_n4.pdf](http://www.weather.gov/media/peac/PEU/PEU_v21_n4.pdf)

Rasmussen, E.M. and T.H. Carpenter, 1982: Variations in Tropical Sea Surface Temperature and Surface Wind Fields Associated with the [ENSO]. *Mon. Wea. Rev.*, 110, pp 354-384.

Ropelewski, C.F., and M. S. Halpert, 1987: Global and Regional Scale Precipitation Patterns Associated with the El Niño/Southern Oscillation. *Mon. Wea. Rev.*, 115, 1606–1626.  
doi: [http://dx.doi.org/10.1175/1520-0493\(1987\)115<1606:GARSPP>2.0.CO;2](http://dx.doi.org/10.1175/1520-0493(1987)115<1606:GARSPP>2.0.CO;2)

## Methodology

The WERI project team has completed a comprehensive meteorological and hydrological assessment of the harmful impacts to Saipan's water resources by the adverse weather associated with the 2015-16 El Niño (including the continual passage of tropical cyclones in 2015, and the extended drought of 2016). The content for the assessment was obtained during several on-site visits (from August 2015 through 2016) that featured field trips and face-to-face meetings with CNMI water resource managers. The WERI project team has a close working relationship with CUC laboratory personnel and with other agencies. Very useful post-Typhoon Soudelor recovery data and statistics of the impacts to the quantity and quality of the Saipan's municipal water supply through the period of the 2016 drought were obtained in meetings with the CUC water utility director J. Riegel and U.S. Public Health Service Officer (and Saipan BECQ advisor), Captain (O6) Derek Chambers. Efforts taken by local water resource managers to recover from the severe damage of Typhoon Soudelor and to prepare for, and withstand, the drought of 2016 were catalogued. The WERI project team also spent time exploring the island of Saipan to visualize the impacts of extensive wildfire, and to examine the condition of important water sources (e.g., the Donni Spring). The compiled information obtained in the on-site interviews and field trips form a large part of the project assessment report. Workshops prepared to discuss the findings at each locale with local water resource managers have yet to be arranged; although preliminary findings were presented at the 2016 CNMI water resources advisory council meeting, and other *ad hoc* meetings with CUC managers and BECQ personnel.

## Principal Findings and Significance

1. Climatic data for Saipan (at the NOAA first-order site at the Saipan International Airport, and from other local and WERI project-sponsored sites) was obtained and analyzed to place the 2015-16 strong El Niño event into its historical context. Whereas at Micronesia locations to the west of the CNMI (e.g., Palau and Yap -- about 1000 km west-southwest of Saipan) the prolonged dryness during 2015 into 2016 broke many historical records and caused severe ecological damage and degradation of municipal water supplies, the dryness of 2016 was not a record historical extreme value, but was in the lowest quintile of the (somewhat piecemeal) climate record at Saipan.
2. Although rainfall accumulations for several months were in the lower 20% of the historical distribution, the impacts of the 2016-16 drought were moderately severe on Saipan and other islands of the CNMI. During the course of the 2016 drought, Saipan water resources were managed well, particularly after major system repairs were made after the severe impacts and damage by Typhoon Soudelor; however, there were some water system disruptions. The biggest problem was the complete loss of water from the Donni Spring, which went totally dry by May 2016. The Donni Spring is a major source of potable water for Garapan (Saipan's most extensively developed tourism site). Twenty-four hour water availability was cut-off there and not restored until abundant rainfall returned in August 2016.
3. There were extensive wildfires across Saipan during the late spring of 2016. Hundreds of acres were scorched in several major fires along the high ground along the ridge from Capitol Hill to Marpi. The WERI team was on-site during a major fire that burned through grasslands and ironwood pine forests on the slopping terrain east of Capitol Hill.

4. Saipan and the other islands of the CNMI were well-prepared for dry conditions during the first half of 2016. Forecasts of impending El Niño drought conditions were provided to Saipan water resource managers well in advance of the onset of dry conditions, based in-part by early outreach efforts of the regional and local weather office, and the outreach efforts of the WERI project team and the project PI (wearing his hat as a member of the Pacific ENSO Applications Climate (PEAC) Center). In his PEAC role, the WERI project PI provides long-lead forecasts of rainfall, typhoon distribution and sea level to all regions of Micronesia and to American Samoa.
5. The WERI project team is still developing outreach material (e.g., PowerPoint presentations, and informational hand-outs) detailing the impacts of ENSO-related drought in the CNMI. These will be used in future visits-of-opportunity within the CNMI, with the arrangement at the next water advisory council meeting of a special workshop on “*climate, climate change and drought impacts in the CMNP*”.
6. The final WERI technical report containing the description of this project and its findings is in preparation.

# Beneficial use of Piggery Waste with a Focus on Energy Production

## Basic Information

<b>Title:</b>	Beneficial use of Piggery Waste with a Focus on Energy Production
<b>Project Number:</b>	2016GU303B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Social Sciences
<b>Focus Categories:</b>	Wastewater, Management and Planning, Treatment
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Joe Rouse, Hyun-Jong Hahm

## Publications

There are no publications.

## **PROJECT SYNOPSIS REPORT**

**Project Title:** Beneficial use of piggery waste with a focus on energy production.

### **Problem and Research Objectives**

In the Federated States of Micronesia (FSM), pig farming is a common agricultural practice. Due to a lack of oversight, the actual density of the animals is unknown and the impact on the environment is difficult to quantify, though it is commonly believed that runoff from all sizes of such operations does have a detrimental effect on river and coastal water quality. With proper management and treatment, manure can be used as a fertilizer or soil conditioner. This has the added benefit of abating air and water pollution and leading to improved human and animal health. Problem-solving strategies for local communities are known to be more effective when they stem from an understanding of regional knowledge and practices. This can include traditional environmental or ecological knowledge, rural knowledge, and farmers' knowledge, which is often endangered since it is transmitted by word of mouth in oral cultures, as in the FSM. This project, therefore, also attempts to collect pig farmers' knowledge addressing their farming practices and related impacts on the environment.

This proposal responds to the critical needs expressed at the Advisory Council Meeting to conduct research on the impact of pig pens on public health and to investigate the development of innovative pig waste disposal systems that emphasize 'value added' benefits (e.g., methane gas collection and use). In addition, it potentially addresses the need to refine educational materials on relevant aspects of environmental stewardship, including innovative ideas such as the implementation of portable pig pens. The objective of this project is to produce a report that will empower the local people to further enhance their independence from use of petroleum products, protect their environment, and improve their overall standard of living.

### **Methodology**

The methods employed over the course of this project incorporated civil and environmental engineering fieldwork. Prior to commencing fieldwork, points of contact in each state were established to clarify the purpose of the investigation. The actual fieldwork started by gathering information about locations and specific details of pig pens and farming operations. As permissible, dimensions were measured and photographs were taken for inclusion in the final report. Every effort was made to obtain a complete overview of the regional pig farming practices as pertaining to production and handling of related waste. As possible, the opinions and expectations of local farmers and operators were collected to glean cultural perspectives. Prior to leaving any particular area, findings were reconsidered to see if any outstanding questions or problems still needed to be dealt with.

## **Principal Findings and Significance**

In Micronesia, pig farming is a common practice. Households may have one to three animals for personal use and sometimes as many as ten. Results of field surveys on the main island of Pohnpei State revealed considerable progress in applying composting practices for constructive use of pig waste by NGOs. In addition, over the past three years 25 household-scale anaerobic digesters have been installed with assistance from a Chinese Aid project, which would not otherwise have been possible. However, in Yap State, much less progress has been made mainly due to cultural concerns, including some hesitation in allowing for input from a foreign government. Conversations with the local Yapese, though, revealed a great interest in making progress in this area with some first fruits of their entrepreneurial spirit already evident. Of unique interest was the discovery of the ruins of a digester plant at a defunct piggery that incorporated a clever arrangement of biogas collection and treatment of digester effluent by using hydroponics in one compact, self-sustaining framework. The owner of the property expressed an interest in restoring the plant to use for educational purposes. It is hoped that this discovery can be employed to educate the local community and further encourage ecologically minded waste management on the island. A WERI Technical Report will be developed to bring this vision to fruition.

## Real-time investigation of the impacts of the 2015-16 El Niño on water resources in the FSM

### Basic Information

<b>Title:</b>	Real-time investigation of the impacts of the 2015-16 El Niño on water resources in the FSM
<b>Project Number:</b>	2016GU304B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Climate and Hydrologic Processes
<b>Focus Categories:</b>	Drought, Climatological Processes, Water Quantity
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Mark Lander, Shahram Khosrowpanah

### Publication

1. Pacific ENSO Update: A Quarterly Bulletin of the Pacific El Niño-Southern Oscillation Applications Climate (PEAC) Center, 3rd Quarter 2016, Vol. 22 No. 3.  
([www.weather.gov/media/peac/PEU/PEU\\_v22\\_n3.pdf](http://www.weather.gov/media/peac/PEU/PEU_v22_n3.pdf)) (Principal Author: M.A. Lander)

## PROJECT SYNOPSIS REPORT

**Project Title:** Real-time investigation of the impacts of the 2015-16 El Niño on water resources in the FSM

### Problem and Research Objectives

The major El Niño event of 2015-16 reached its peak (Rasmussen and Carpenter 1982, Ropelewski and Halpert 1987, and PEAC 2015) in December 2015. Commonly used indices of El Niño rose to levels seen only two other times in the past 60 years: the epic El Niño events of 1982-83 and 1997-98. All states of the FSM are vulnerable to damaging extremes of weather during the roughly 18-month course of an El Niño event. Through the first year of a strong El Niño, the region typically experiences an abundance of typhoons, other extremes of heavy rainfall, and high surf raised by the typhoons and unusual monsoonal winds. The year 2015 indeed saw such conditions, with nearly all the islands of the FSM experiencing damaging effects from typhoons and other severe weather conditions. Two particularly intense typhoons caused severe damage: Typhoon Maysak destroyed much of Ulithi Atoll in April, and a month later, Typhoon Dolphin tracked across the Chuuk Lagoon, bringing destructive winds to most of the islands therein. In the first few months of the calendar year that follows a strong El Niño (as was the case during the first half of 2016), the rainfall across all of Micronesia tends to be well below normal. Sharply reduced rainfall can quickly become a life-threatening emergency as reservoirs and rain catchment systems run dry, and agricultural plants are damaged. This is especially true on atolls where the water lenses are thin and rain catchment is a prominent source of drinking water. Micronesia-wide severe droughts in 1983, 1992 and 1998 required the deployment of U.S. military assets to the islands of the FSM to help transport and generate drinking water supplies.

The project objective was to monitor the progress of the impact of the 2015-16 El Niño drought on the islands of the FSM *while the drought was in-progress!* The WERI team conducted site visits and conducted interviews with local water resource managers. Visits to Pohnpei and Yap were taken during June 2016 and October 2016, respectively. The WERI team interviewed personnel from a wide variety of sectors, including: the local government executive branch (Office of the Governor and of the Lt. governor); local office of the National Weather Service; water utility managers; the local fire department; local media; local environmental protection agency managers; and, health officials. The WERI team also extensively explored the islands to examine the water utility physical infrastructure (such as municipal reservoirs), the extent of wildfire and other physical manifestations of drought. Workshops prepared to discuss the findings at each locale with local water resource managers have yet to be arranged; although preliminary findings were presented at the 2016 water resources advisory council meetings

In summary, the WERI team performed the following tasks:

- (1) Traveled to Yap and Pohnpei in June 2016 and October 2016, respectively. A trip to Kosrae is to be completed by the end of May 2017;

- (2) Visited with representatives of water resource management (e.g. water treatment facility operators) to get a detailed picture of the impacts in each state of the 2015-16 El Niño-related typhoons, extreme rains, sea inundations and drought.
- (3) Determined the efficacy of practices taken to lessen the impacts of the 2015-16 El Niño.
- (4) Developed an outreach itinerary for group discussion of drought during FSM visits.

## **Methodology**

The WERI project team has a good working relationship with all FSM weather officer staff and managers. The project PI also works closely with NOAA's Guam Weather Forecast Office Warning Coordination Meteorologist. This allows the project PI to have access to the most complete set of climate records available in the FSM. The project PI is a member of the Pacific ENSO Applications Climate (PEAC) Center, with ongoing duties to provide operational long-range climate forecasts to Guam, the CNMI, FSM, Palau, the RMI, and American Samoa. NOAA is currently attempting to place the U.S.-affiliated Pacific Islands onto the U.S. National Drought Monitor. The information gathered in the proposed project will help to inform the organizers and authors of the Drought Monitor. The good working relationship with the meteorological partners helped the team develop the background material to inform their assessment of the impacts of the 2015-16 El Niño in each of the FSM states.

The WERI project team also has good working relationships with FSM water resource managers, regulators and administrators. They have extensive field experience in each of the FSM states through their participation with the water utilities personnel and other non-governmental organizations (e.g., the Conservation Society of Pohnpei) in USGS-funded studies of local watersheds

The principal accomplishment of this project is a comprehensive meteorological and hydrological assessment in each of the FSM states of the harmful impacts to water resources by the adverse weather associated with the 2015-16 El Niño. Most of the content forming the assessment was obtained during on-site visits and in face-to-face meetings of the WERI project team with water resource managers of the FSM states. Efforts taken by local water resource managers to recover from and mitigate the harm done by this event were studied and form a large part of the team assessment. The final set of outreach products and the project WERI technical report are all in draft form, and should be in final publication by July 2017.

## **Principal Findings and Significance**

1. Climatic data for all FSM first-order stations was obtained and analyzed to place the 2015-16 strong El Niño event into its historical context. Whereas at Palau (about 600 km west-southwest of Yap State) the prolonged dryness during 2015 into 2016 broke many historical records and caused severe ecological damage and degradation of municipal water supplies, the dryness was not an historical record-breaking extreme at Yap, Chuuk, Pohnpei or Kosrae. However, in some carefully arranged statistics, such as the rainfall during certain months, or during certain arbitrary multi-month periods, the 2015-2016 statistics could be manipulated to show that the dryness during some of 2015-16 was near record-low values.

2. Although rainfall accumulations for several months were in the lower 10% of the historical distribution, the impacts of the 2016-16 drought were not severe at Yap Island, and the water resources were managed well there. Some impacts included the near depletion of the Yap Island municipal reservoir and some very large wildfires. On account of wells, and three one-million gallon water tanks (providing a 90-day supply when all three are full), the municipal water supplies were adequate to last for the duration of the drought. Voluntary conservation measures were put in-place. Some of the Yap State outer islands (e.g., Ulithi, Fais, Woleai, Euripik and Lamotrek) had more serious impacts from prolonged dry weather and were in need of emergency transport of drinking water and Reverse-Osmosis (RO) equipment. The logistics of the emergency provision of potable water was handled by the local office of the International Organization for Migration (IOM).
3. The impacts of rainfall reduction on Pohnpei Island and throughout Pohnpei State during dry phase the 2016-16 El Niño were not severe. The islands were well-prepared for dry conditions, and an El Niño task force was set-up on Pohnpei Island well in advance of the onset of dry conditions (based in-part by early efforts of the regional and local weather office, and the outreach efforts of the Pacific ENSO Applications Climate (PEAC) Center (the WERI project PI is also a member of the PEAC team). When dry conditions arrived in January 2016, there were some minor wild fires. Municipal water supply was largely unaffected, but a brief interruption of the municipal water supply on Pohnpei Island was caused by a diversion of water from the Nanpil Reservoir to test the Hydropower plant at a time when flow in the Nanpil River was too low to quickly replenish the supply to the threshold level of the diversion channel to the water treatment plant. On the near-equator atoll of Kapingamarangi, a later dry spell (September through November 2016) caused depletion of on-site drinking water supply, and emergency water supplies had to be delivered there by shipping from Pohnpei Island.
4. Although prolonged dryness on Kosrae and in Chuuk State for several months at the end of 2015 through the first half of 2016 resulted in the some of the lowest multi-month rainfall totals in their historical record, there were no serious ecological impacts or disruptions to the municipal water supply. The WERI team has only recently visited these locations, and the nature of the impacts there is still being analyzed.
5. Development of outreach material (e.g., PowerPoint presentations, and informational hand-outs) is ongoing. These will be used in visits-of-opportunity within the FSM.
6. The final WERI technical report containing the description of this project and its findings is in preparation.

## Information Transfer Program Introduction

WERI's research focuses on local water resources problems and issues identified largely through discussions with regional stakeholders at our annual advisory council meetings. Disseminating research results and insights gained from them to our stakeholders is a top priority for WERI researchers. Our principal audiences include engineers and managers in the local water utilities and the engineering and environmental consulting firms that support them; environmental managers and regulators in local and federal agencies, including local military installations; local legislators and other policy makers; and increasingly, local secondary and primary school teachers. Institutional technical reports remain a primary vehicle for transmitting information to our target audiences, many of whom are remotely situated and do not have access to the scientific literature, or require a greater degree of detail than is normally permissible in a standard journal publication. WERI technical reports are also published on the WERI website ([www.weriguam.org](http://www.weriguam.org)) from which they can be downloaded. WERI faculty also continue to be major and effective participants in water-related law and policy making on Guam by serving as committee members and chairs on inter-agency advisory boards and by giving invited testimony at legislative oversight hearings.

Every WERI faculty member attends at least one national or international professional meeting, conference, workshop each year in North America, Asia, or Europe. We continue to improve the WERI website, which has become our primary link to the professional and educational communities, both at home and abroad, and is now accessible to the great majority of our stakeholders throughout the region, including even some of the more remote islands. Our annual advisory council meetings in Guam, the CNMI, and the FSM bring together people who typically have little to no contact with one another during the rest of the year. These meetings have become important annual local conferences for information exchange and discussion on common issues, problems and needs in the water resources arena. WERI remains committed to teaching and training the tomorrow's water resources professionals, in addition to conducting workshops, courses and seminars for the current professional community. Educating students and teachers on the importance fresh water resource management and conservation remains one of the institute's high priorities.

# Building the Resilience of Communities and their Ecosystems to the Impacts of Climate Change through an Integrated Natural Resource Management, Education, and Outreach campaign in Pohnpei, Federated States of Micronesia

## Basic Information

<b>Title:</b>	Building the Resilience of Communities and their Ecosystems to the Impacts of Climate Change through an Integrated Natural Resource Management, Education, and Outreach campaign in Pohnpei, Federated States of Micronesia
<b>Project Number:</b>	2016GU301B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Not Applicable
<b>Focus Categories:</b>	Drought, Groundwater, Water Quantity
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Francisca Sohl Obispo, Joseph Eugene

## Publications

There are no publications.

## **PROJECT SYNOPSIS REPORT**

Project Title: Building the Resilience of Communities and their Ecosystems to the Impacts of Climate Change through an Integrated Natural Resource Management, Education, and Outreach campaign in Pohnpei, Federated States of Micronesia

### **Problem and Research Objectives**

The small island developing state of Pohnpei, in the Federated States of Micronesia (FSM), located in the north Pacific region, is directly facing challenges associated with climate variability and change. Notable climate change impacts are: extreme temperatures, sea level rise, ocean acidification, drought, storm surges, coastal inundation and salinization of water lenses and heavy rainfall leading to flooding and landslides. Such impacts are threatening marine and terrestrial environments, which include water resources and livelihoods that depend on them. Pohnpei has also experienced the cyclical effects of the EL Nino/Southern Oscillation (ENSO)-related weather anomalies. Such climate variability is associated with drought, which often leads to: water shortages, crop failures, food shortages and fires.

This project aims to build the resilience of vulnerable communities in Pohnpei to climate change and natural hazards. Utilizing an ad-hoc group called Pohnpei Climate Change Outreach Committee (PCCOC), which is comprised of local partners and key community champions led by CSP, this committee's existing presence in Pohnpei and expertise in climate change adaptation and disaster preparedness is essential to ongoing efforts. CSP and partners will target at least two but not limited specific communities and school age children across Pohnpei under the proposed project.

### **Methodology**

CSP has prior experience engaging communities in participatory climate adaptation initiatives. CSP previously conducted the participatory Hazard, Vulnerability, Capacity, Mapping exercise with communities in Pohnpei to support the IOM Climate Adaptation, Disaster Risk Reduction and Education (CADRE) program and the European Union funded GCCA participatory V&A process to facilitate climate adaptation. CSP is planning to create a hybrid process based on what aspects worked best in the past. A guideline document regarding the specific methodology and order of operations for community engagement under The *Building the Resilience of Communities and their*

*Ecosystems to the Impacts of Climate Change through an Integrated Natural Resource Management, Education, and Outreach campaign in Pohnpei, Federated States of Micronesia* project will be developed in coordination with the donor prior to the roll out of implementation. CSP hopes to maintain inclusion of traditional leaders, respect for traditional culture, historical time line activity, and community profile worksheet as components of the agreed approach as these elements were important for success of the activity in the past. Another important technique to ensure active and diverse participation in the exercise is to divide women, men, girls, and boys into distinct working groups. CSP will work directly with Pohnpei Environmental Protection Agency (EPA) and forest rangers to collect data on ground water supply. These data will be analyzed by EPA staff and the result will be share with the communities and at the same time to support water policies.

## **Principal Findings and Significance**

### **1.1. Project steering committee (PSC) meetings to select schools and communities benefiting from the Building the Resilience of communities and their ecosystems to the impacts of climate change through and integrated natural resources management, education and outreach on campaign in Pohnpei. March -April 2016.**

CSP was able to organize partnership meeting with Pohnpei Climate Change Committee to select schools and communities that the committee can work with on the climate change outreach campaign. CSP and partners has met and agreed to work with at least two communities and schools on the climate change outreach. Based on the selected communities, the climate change committee has scheduled visits with the communities and completed climate change outreach program with two communities and the schools. CSP and partners has completed community climate change outreach visit with one community in Madolenihmw and one community in Kitti. And CSP has work with 28 public schools in Pohnpei and completed the school year 2016 -2017 with climate change outreach program.

For the objective development and endorsement of a household survey template related to climate change adaptation practices in selected communities. CSP and partners has completed the household survey for two selected communities. With these two communities, CSP and partners has worked with these two communities and conducted a climate change adaptation plan for two days workshop with each community. Through

the workshop the two communities has identified the impact of climate change and at the same time find ways to help cope with these impacts. Both communities identified that when there's drought or no rain for two weeks or more they have problem with water. They have shortage of water.

**Integration of climate change adaption into the Green Road Show curriculum for grade- September-November 2016. Creation of local language posters for information campaign-July-August 2016.**

The GRS Educators was able to successfully complete one round of school visit for the second quarter of the school year.

1. The visit covered waste management and climate change in Pohnpei. Specific subject regarding waste management and climate change in Pohnpei includes:

- Managing waste in Pohnpei
- How to use the 4R's (Reuse, Reduce, Refuse, and Recycle)
- Non-Biodegradable waste affecting and causing problems to Pohnpei ecosystems.
- What is climate change
- What are the effects of climate change
- How to cope with climate change in Pohnpei

Based on the needs for the green road show CSP has developed a green road show booklet for the schools. This booklet consist of all the topics that needed for the 5<sup>th</sup> graders.

**Survey and collect data in regards to climate change (drought) effect on ground water and springs-May-July 2016.**

The Pohnpei Forest Rangers conducted survey and data collection in regards to the watershed forest monitoring and climate change effect on ground water and springs. With this survey data collection they have identified several sites that have ground water and springs. The monitored sites in Madolenihmw were Pihs, Nihpit, Sapwalap and Senpehn. And in U the monitored sites were Nawelin Rohi, Tipwen and Pahntakai. They have identified 6 ground water from Madolenihmw and 5 from U forest. For these springs they have notice that if there's rain than these ground water or springs has water if no rain than there's no water. With these survey they have identified that the streams are not the same as before as well.

# Information Transfer

## Basic Information

<b>Title:</b>	Information Transfer
<b>Project Number:</b>	2016GU305B
<b>Start Date:</b>	3/1/2016
<b>End Date:</b>	2/28/2017
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	N/A
<b>Research Category:</b>	Not Applicable
<b>Focus Categories:</b>	Education, Management and Planning, None
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Shahram Khosrowpanah

## Publications

1. A Natural Resources Atlas of Southern Guam: [www.hydroguam.net](http://www.hydroguam.net), Water & Environmental Research Institute of the Western Pacific, University of Guam, Mangilao, Guam.
2. A Digital Atlas of Northern Guam: [www.hydroguam.net](http://www.hydroguam.net), Water & Environmental Research Institute of the Western Pacific, University of Guam, Mangilao, Guam.
3. Denton, G.R.W., 2016, Fish Sentinels Identify Mercury Hotspots in Saipan Lagoon, Asia-Pacific Academy of Science Conference, November 15-17, 2016, Saipan
4. Khosrowpanah, Sh., 2016, UOG Emerging School of Engineering: Training Tomorrow's Engineers to Meet Today's Community Needs, Asia-Pacific Academy of Science Conference, November 15-17, 2016, Saipan.
5. Khosrowpanah, Sh., 2016, Developing Stage-to-Flow Relationships of the Toguan River, Guam, Asia-Pacific Academy of Science Conference, November 15-17, 2016, Saipan.

## PROJECT SYNOPSIS REPORT

WERI recognizes that disseminating our research findings to our community stakeholders and to our colleagues in the scientific and professional communities is the essential final step for effective research. We also recognize that technical information must be communicated not only to a broad audience but also in ways that make it accessible and comprehensible to people in many disciplines, and at educational levels ranging from elementary school students to fellow researchers. Information transfer media include paper brochures and pamphlets as well as web sites, by which we publish or provide access to technical reports, journal articles, and book chapters. We also provide articles and interviews to local news media. The audience for the results of USGS sponsored research is widely varied geographically and by education level.

The WERI website, funded by this project, is the institute's primary information transfer and dissemination medium. The home page, shown below, is located at <http://www.weriguam.org/>. It features informational links to WERI faculty, staff and Institutional facilities, our current research, education and training activities, primary sponsors and most recent publications. The user-friendly format helps increase visibility of the institute's research programs, particularly for our stakeholders in remote locations where state-of-the-art internet services and computer technology are often lacking.

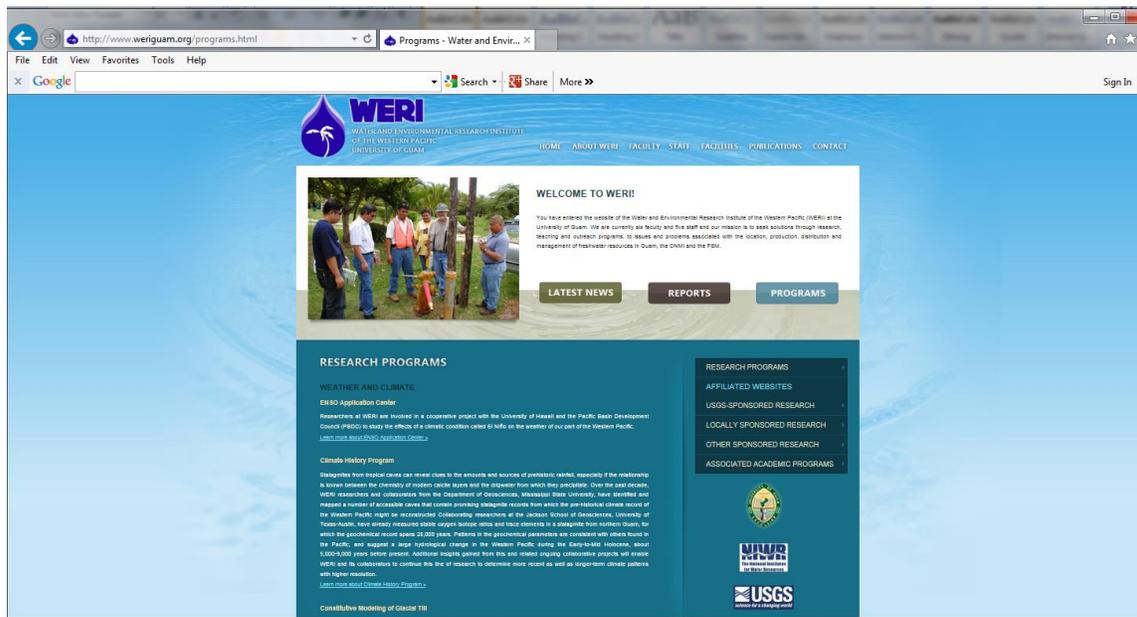


### WERI Website Home Page

This project also funds the design, layout and printing of technical reports resulting from USGS funded research projects. All WERI technical reports are available in downloadable PDF format on the WERI web-site at <http://www.weriguam.org/reports/list>. Selected reports are also published in hard copy, especially for dissemination to users where computer access is limited.

The technical report library is updated as each new report is published. The database search engine process for accessing these reports on line utilizes a composite 'Abstract' database for key word searches. Searches based on 'Author' now search all authors in the author string not just the lead author as before. Upon selection of a particular report, site users are presented with

the complete abstract, which may be viewed prior to downloading the main report. An example is shown below.

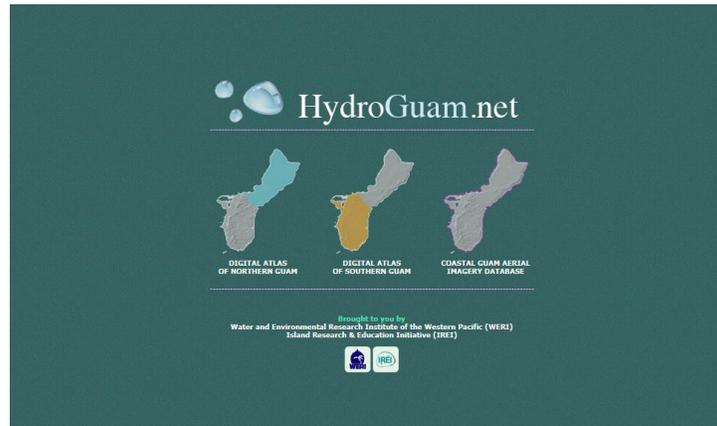


### WERI Reports Page

Because of Guam’s remote location, and the escalating costs of air travel, it is difficult and costly for researchers to present their findings at technical conferences and symposiums in other parts of the Globe. A portion of the current Information Transfer Project was earmarked for off-island travel expenses for WERI researchers and graduate students presenting refereed professional papers on current or past USGS 104-B projects.

Since 2005, WERI has maintained a unique digital resource for Guam, at [www.hydroguam.net](http://www.hydroguam.net). This project began with the *Natural Resources Atlas of Southern Guam*, which was inspired by the need for up-to-date baseline information for sustainable natural resource management and development. Its mission was to provide a comprehensive picture of the natural resources found within the fourteen southern Guam watersheds and make that information instantly available to users. The atlas proved to be a highly effective data dissemination hub, as well as a much-used awareness and educational tool. At its core lay a wide range of Geographical Information System (GIS) data for southern Guam, providing valuable support for resource management and research, including hydrologic modeling, pollution prevention, soil conservation, and coastal zone management. The tool became very popular in Guam thanks to its simple and user-friendly data dissemination approach: all geospatial data are stored and formatted in such a way that the full content is freely accessible on the Internet via [www.hydroguam.net](http://www.hydroguam.net) address. Within a relatively short time, the *Natural Resources Atlas of Southern Guam* became so successful that in 2012 it inspired a follow-on project, which was to develop a comparable resource for Northern Guam. That work was completed in late 2013. In 2014, the southern Guam was updated to reflect the new additional information. The new product is entitled *Digital Atlas of Northern Guam* and encompasses many of the strengths of the previously created *Natural Resources Atlas of Southern Guam* with a series of significant improvements. The *Digital Atlas of Northern*

Guam is freely accessible on the Internet via: [www.hydroguam.net](http://www.hydroguam.net) address. The web interface offers a range of textual, graphical, statistical, and geographic information to any interested user.



# USGS Summer Intern Program

None.

<b>Student Support</b>					
<b>Category</b>	<b>Section 104 Base Grant</b>	<b>Section 104 NCGP Award</b>	<b>NIWR-USGS Internship</b>	<b>Supplemental Awards</b>	<b>Total</b>
<b>Undergraduate</b>	1	0	0	0	1
<b>Masters</b>	4	0	0	0	4
<b>Ph.D.</b>	0	0	0	0	0
<b>Post-Doc.</b>	0	0	0	0	0
<b>Total</b>	5	0	0	0	5

## **Notable Awards and Achievements**

WERI Graduate Research Assistant Kaylyn K. Bautista received the 2017 University of Guam President's Award for the Outstanding Graduate Thesis of Academic Year 2016-2017, for her Master's of Science Thesis in Environmental Science, "Vadose Hydrology of Jinapsan Cave, North Guam."

WERI Graduate Research Assistant Ida Shalilian received a 2017 Student Travel Grant from the Research Corporation of the University of Guam to extend the work on her Master's of Science Thesis in Environmental Science, "Hydrogeology of Finegayan Basin, Northern Guam Lens Aquifer."

## Publications from Prior Years

1. 2011GU200B ("Environmental Impact of FUDS and Brownfields Sites in Watersheds on the Eastern Side of Saipan. Phase 1: Contaminant Analysis of Soil and Sediments") - Articles in Refereed Scientific Journals - Denton, Gary R.W., Carmen A. Emborski, April A.B. Hachero, Ray S Masga, and John A. Starmer, 2016. Impact of WWII Dumpsites on Saipan: Heavy Metal Status of Soils and Sediments. *Environmental Pollution and Research*, 23: 11339-11348
2. 2014GU275B ("Impact of Stormwater Discharges and WWII on the Mercury Status of Fish from the Southern Section of Saipan Lagoon") - Other Publications - Denton, Gary R.W., and Jennifer Cruz, 2016, Fish Sentinels Identify Mercury Hot-Spots in Saipan Lagoon. (Abstract) Asia Pacific Academy of Science, Education and Environmental Management (APASEEM) Annual Conference, American Memorial Park Auditorium, Saipan, November 15-17, 2016.
3. 2015GU285B ("Impact of Multiple Mercury Sources on Edible Quality of Fish from American Memorial Park Nearshore Waters, Saipan, CNMI") - Water Resources Research Institute Reports - Gary R.W., Michael J. Gawel, Justin S. Mills, Karl G. Brookins, 2017, Heavy Metal Assessment of Selected Biota from American Memorial Park Nearshore Waters, Saipan, Commonwealth of the Northern Mariana Islands (CNMI). Water and Environmental Research Institute (WERI) Technical Report No. 162, University of Guam, Mangilao, Guam, 56 pp.
4. 2015GU289B ("Continuation and expansion of data collection for sewage treatment pilot study on Yap with addition of a composting pilot test for reuse of waste sludge") - Other Publications - Rouse, J.D., 2016, "Use of Sustainable Methods for Municipal Wastewater Treatment and Reuse of Excess Sludge on the Island of Yap," Island Sustainability Conference: Islanded Communities, of the Univ. of Guam & the Univ. of Alaska Fairbanks. Tumon, Guam, April 11-15, 2016.
5. 2015GU289B ("Continuation and expansion of data collection for sewage treatment pilot study on Yap with addition of a composting pilot test for reuse of waste sludge") - Water Resources Research Institute Reports - Rouse, J.D., 2016, "Biofilm Pilot Study for Sewage Treatment with Composting of Waste Sludge on Yap," University of Guam, WERI. Technical Report No. 161, Oct. 2016, 23 pages.
6. 2015GU284B ("Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 2 implementation of a numerical model") - Other Publications - Habana, N.C., J.W. Jenson, and S.B. Gingerich, 2015, Abstracts and Program: Exploring Best-Practice Capacities for the Northern Guam Lens Aquifer. Second Conference on Water Resources Sustainability Issues on Tropical Islands, 1-3 December 2015, Honolulu, Hawaii.
7. 2014GU271B ("Prediction of Flow Duration Curves at Ungaged Stream Sites in Guam") - Other Publications - Heitz, L. and S. Khosrowpanah, 2015, Using a Geographic Information System to Predict Flow Duration Curves at Ungaged Stream Sites in Guam, Second Conference on Water Resources Sustainability Issues on Tropical Islands, 1-3 December 2015, Honolulu, Hawaii.
8. 2015GU284B ("Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 2 implementation of a numerical model") - Other Publications - Habana, N.C., J.W. Jenson, and S.B. Gingerich, 2015, Abstracts and Program: Exploring Best-Practice Capacities for the Northern Guam Lens Aquifer. Second Conference on Water Resources Sustainability Issues on Tropical Islands, 1-3 December 2015, Honolulu, Hawaii.
9. 2015GU284B ("Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 2 implementation of a numerical model") - Other Publications - Habana, N.C., J.W. Jenson, and S.B. Gingerich, 2016, Exploring the Ultimate Capacities of the Northern Guam Lens Aquifer: With Some New Ways of Thinking About Sustainable Limits, Presentation to Guam Waterworks Authority senior management, 19 January 2016, Fadian, Guam.
10. 2015GU284B ("Exploring the natural limits of the Northern Guam Lens Aquifer: A step toward optimum sustainable management, Phase 2 implementation of a numerical model") - Other Publications - Habana, N.C., J.W. Jenson, and S.B. Gingerich, 2016, Exploring the Ultimate

Capacities of the Northern Guam Lens Aquifer: With Some New Ways of Thinking About Sustainable Limits, Presentation to WERI Guam Advisory Council, 17 November 2016, Tumon, Guam.

11. 2011GU194B ("Comprehensive Analysis of Salinity Trends in Northern Guam Lens Aquifer") - Other Publications - Simard, C.A., J.W. Jenson, M.A. Lander, M.Q. McDonald, & N.C. Habana, 2016, Salinity in the Northern Guam Lens Aquifer: Natural and Human Factors, American Water Works Association-Hawaii Section, Western Pacific Subsection, Annual Conference, 11-12 April 2016, Tumon, Guam.
12. 2011GU194B ("Comprehensive Analysis of Salinity Trends in Northern Guam Lens Aquifer") - Conference Proceedings - Simard, C.A., J.W. Jenson and M.A. Lander, 2015, Analysis of Salinity in the Northern Guam Lens Aquifer, Proceedings of the 16th Symposium on the Geology of the Bahamas and other Carbonate Regions, Gerace Research Center, San Salvador Island, Bahamas.
13. 2014GU280B ("Sustainable Conjunctive use of Groundwater and Rain Catchment Water under Variable Climatic Scenarios for Atoll Island Communities") - Water Resources Research Institute Reports - Wallace, C.D., R.T. Bailey, and J.W. Jenson, 2015, Atoll Island Freshwater Resources: Modeling, Analysis, and Optimization, WERI Technical Report #155, 147 p.
14. 2014GU270B ("One-Day Field Course for Water Resource Professionals and Island Educators, with Educational Webpage on the Northern Guam Lens Aquifer") - Other Publications - Jenson, J.W., N.C. Habana, 2016, Limestones of Guam: Geologic Characteristics and Engineering Properties, Presentation to Guam Chapter, Society of American Military Engineers, 18 August 2016, Tumon, Guam.