



# **INTRODUCTION TO RESEARCH ACTIVITIES & TEACHING PROGRAMS**

by

**Shahram Khosrowpanah Ph.D., P.E.  
Director**



# **WERI**

**WATER AND ENVIRONMENTAL RESEARCH INSTITUTE  
OF THE WESTERN PACIFIC  
UNIVERSITY OF GUAM**

**February 2013**

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University of Guam







**WERI Graduate Research Assistant Vivianne Bendixson and USGS Hydrogeologist Todd Presley Downloading Data from an Observation Well on Andersen Air Force Base as Part of the ongoing Collaborative Comprehensive Monitoring Program.**





**Graduate Students in one of the Courses offered by WERI Explore Asiga Cave on a Field Trip to Study the Properties of Karst Aquifers.**



# WERI

## Water & Environmental Research Institute of the Western Pacific University of Guam



The Water & Environmental Research Institute of the Western Pacific (WERI) is one of 54 water research institutes established by U.S. Congressional legislation at each Land Grant University in the U.S. and in several territories. The institute is now in its 38<sup>th</sup> year of operation.

WERI's mission is to seek solutions through research, teaching, and outreach programs, to issues and problems associated with the location, production, distribution, and management of freshwater resources. WERI provides technical expertise, and conducts vigorous research and both undergraduate and graduate teaching programs aimed at improving economic conditions and the quality of life for citizens of Guam and various regional island nations. WERI also runs a state of the technology water analytical laboratory and geographical information systems facility.

WERI administers and carries out research, training, and other information transfer programs under a variety of federal and local funding sources, but the institute was created specifically to administer Department of Interior (US Geological Survey) money under Section 104-B of the National Institute of Water Research (NIWR) 104-B Program. WERI has responsibility for 104-B monies on Guam, in the Commonwealth of the Northern Mariana Islands (CNMI), and in the Federated States of Micronesia (FSM).

In FY-2012 WERI faculty were involved as Principal Investigators and/or advisors on 28 research and training projects with a combined budget of approximately \$1,106,251. Of this, \$277,005 was awarded through the Water Resources Research, Institute Program administered by USGS,

while \$378,000 was received as a special appropriation from the Guam Legislature. The remainder came from Federal sources awarded directly to the Institute, or indirectly through local Government Agencies.

Currently, WERI has six fulltime research faculty, one of whom serves as Director on a rotational basis; one emeritus research faculty; a water analysis laboratory manager and technician; two office staff, as well as several graduate and undergraduate research assistants. WERI faculty collectively teach six undergraduate courses in UOG's Pre-Engineering Program and more than double that number of graduate course in the Environmental Science MS Program.

Over the last ten years, WERI faculty have collectively published their works in 70 refereed journal articles, 51 technical reports, and well over 100 conference proceedings. They have also given numerous professional presentations and training workshops. Following our most recent 5-year evaluation, WERI was once again congratulated by the evaluation panel for continuing to promote an exemplary program appropriately focused in a programmatically separate way on the water problems of Guam, the Commonwealth of the Northern Mariana Islands (CNMI) and the Federated States of Micronesia (FSM). For more information on WERI's research and academic programs please see us on the web at: <http://www.weriguam.org> or contact:

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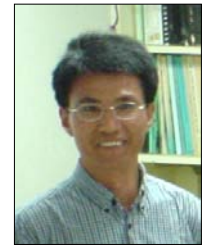
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# ACTIVE PROJECTS (Initiated March 1, 2013)



US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM



## GUAM:

Development of a Hydrogeologic Map Series for the Northern Guam Lens Aquifer.

One-Day Professional Educators Field Course, with Educational Webpage on the Northern Guam Lens Aquifer.

Expanding Guam Water Kids Teachers to Training Other Teachers and Integrating Guam Water Kids in Guam Public School Instructional Programs.

## CNMI:

Heavy Metal Status of Nearshore Fisheries Impacted by Old Military Dumpsites on the Eastern Side of Saipan, CNMI.

Preliminary Investigation of Groundwater Impacts on Near Shore Benthic Communities in Garapan Lagoon, Saipan.

Development of Optimum Water System Operation for Saipan Water Distribution System.

Land Cover Change Detection in Saipan.

## FSM:

Improving the Pohnpei Water Distribution System Using Hydraulic Modeling and Geographic Information Systems.

Development of Environmentally Sustainable methods for Treatment of Domestic Wastewater and Handling of Sewage Sludge on Yap Island.

Sustainable Conjunctive use of Groundwater and Rain Catchment Water under Variable Climatic Scenarios for Atoll Island Communities.

Water System Leak detection Training for Yap State Public Services Corporation (YSPSC).

## OTHER FUNDED PROJECTS

### NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center (ongoing)

### GUAM BUREAU OF STATISTICS AND PLANS (NOAA)

- a. Degradation/Restoration Assessment of the Piti-Asan Watershed
- b. Development of a Digital Watershed Atlas for Northern Guam (ongoing)

### GUAM EPA (USEPA)

GWUDI Study: Precision Mapping of Isohyets in Target Storms over the Northern Guam Lens Aquifer (ongoing).

### USGS

- a. Hydrological Database for Northern Guam (ongoing)
- b. Pacific Islands Climate Center (ongoing)

### NATIONAL SCIENCE FOUNDATION

Holocene Hydrological Variability across the Western Pacific Warm Pool (ongoing)

### DIRECT LOCAL FUNDING

- 1. GUAM HYDROLOGIC SURVEY  
Spatio-temporal Analysis of Groundwater Quality in Guam (ongoing)
- 2. WATER RESOURCES MONITORING PROGRAM  
Stream-flow, Sediment Discharge, Rainfall and Groundwater Characteristics Data Collections in Guam (ongoing)





## Development of a Hydrogeologic Map Series for The Northern Guam Lens Aquifer



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigator:**  
**John Jenson**

The military expansion and economic growth anticipated for Guam during the coming decade has raised concerns regarding sustainable development and management of the island's groundwater. The most fundamental tool for development and management of groundwater in any aquifer is a set of accurate and precise maps of its hydrologic components. The proposed project would apply the latest technology to provide such maps. Although modest in cost, it is arguably the single most important project for Guam's aquifer at this time, because accurate hydrogeologic maps are the starting point for all other groundwater research and development, including the development and application of numerical models and other tools. WERI researchers and their collaborators have already developed a sophisticated conceptual model of island karst and numerous maps of the karst features that constitute the "plumbing" of Guam's aquifer. This information and the availability of several new GIS techniques and technologies have now made it possible to produce detailed hydrogeologic maps to support ongoing and future research exploration, development, management, and regulation.

This work will involve several steps:

- (1) Assembling existing maps and geographic data, from both paper and digital resources and assuring consistent parameters (*e.g.*, projections, attributes, etc.)
- (2) High-resolution LIDAR mapping of the sinkholes of Guam and field-checking of selected features to verify accuracy and resolution of the LIDAR map.
- (3) High-resolution field mapping of a selected part of the discharge zone of aquifer that builds on previous work and is representative of the basic modes of discharge.

- (4) Overlaying selected feature data sets to produce a set of maps that describe surface conditions, water table and interface geometry, aquifer sub-basins, groundwater zones (basal, para-basal, supra-basal), and water quality (*e.g.*, salinity)
- (5) Producing digital 2-D cross-sections and 3-D graphic images of selected features and combinations of features.

The map should ultimately contain at least the following coverage:

- (1) Updated surficial geology of northern Guam (at 1:24000 scale)
- (2) Updated volcanic basement map of northern Guam
- (3) New LIDAR surface imagery overlay
- (4) Karst features, including maps of sinkholes and caves of northern Guam
- (5) Coastal discharge features: seeps, springs, and flowing fractures and caves
- (6) Generalized mean groundwater elevation map
- (7) Generalized mean freshwater-saltwater interface map
- (8) Selected infrastructure
- (9) Zones of estimated hydraulic conductivity and porosity
- (10) Zones of varying salinity
- (11) Soil map of Guam



## One-Day Professional Educators Field Course, With Educational Webpage on the Northern Guam Lens Aquifer



**Funded by:  
US Geological Survey, Water Institute Program**

**Principal Investigator:  
John Jenson**

The military buildup and ongoing economic growth anticipated on Guam over the next decade has raised concerns regarding sustainable management of Guam's groundwater resources. Besides educating policy-makers and agency heads it also essential that island water resource professionals and educators be equipped with an accurate and up-to-date understanding of the essential characteristics of the island's aquifer and the factors that must be considered to frame and implement sustainable management practices. Professional people, including working-level technical professionals in the water resources industry, university instructors, and school teachers, have extremely limited time to engage in instructional opportunities. This proposal is for development and delivery of a course that could be completed in a single-day to professional educators at the university, community college, and secondary school levels. It would consist of (1) a single day of intensive personal instruction delivered in the field, with (2) a binder of materials and a supporting webpage containing the instructional materials plus additional references and links to other relevant and useful resources, and forums for maintaining continuing educational interaction and information-sharing.

The proposed program of instruction would consist of at least two separate course offerings in one year. Each offering would consist of a single full day of instruction delivered at selected field sites, with instruction also delivered during transit using handouts and course materials contained in a binder that would be provided to each participant. Materials for the course will be extracted and modified from existing materials

developed for a successful previous engineering professional development course and tailored for the proposed course. In addition, a new permanent web-page will be set up and equipped with a discussion board where former students and other users can engage in discussions or ask questions, etc. New features for the webpage will include additional maps and cross-sections that can be accessed and used by course participants and other users. Each set of users will have access to resources designed to support their various needs: technical professionals, university and community college instructors, and secondary school educators. The instruction will carry professional development credit through the University of Guam's Office of Professional and International Programs (PIP) and will be offered during the summer and winter breaks to accommodate the schedule of educators.

The scope and objectives of the work include:

1. Preparation of instructional materials, including handouts and references
2. Delivery of a one-day course in the field, to selected field-trip stops in a bus, with instruction delivered not only at the field sites, but on the bus during transit to each site
3. Introduction to a webpage containing not only instructional materials but downloadable references and links to other relevant and useful resources

A forum on the webpage for subsequent correspondence among course participants and instructors to provide a permanent venue for information-sharing and updates on topics of interest.



## Expanding Guam Water Kids Teachers to Training Other Teachers and Integrating Guam Water Kids in Guam Public School Instructional Programs



**Funded by:**  
**US Geological Survey, Water Institute Program**

**Principal Investigator:**  
**Ann Card**

The WERI Advisory Council for Guam has identified two critical water resources needs targeted to Education and Professional Training: (1) the development of teacher training courses about water resources, and (2) educational training and outreach programs about the importance of protecting and preserving watersheds and water resources, which is specifically advised should begin with elementary schools in order to instill the important of these issues at a young age. In addition, in Advisory Council meetings concerns have been raised about the sustainability of the program with the need to institutionalize the program into the Guam Department of Education (GDOE) as of primary importance.

In response to these needs, we are requesting support of the following two goals: (1) to continue our success in training teachers to use Guam Water Kids with an expansion to 3 credit hours to accommodate instruction and experience in mentoring fellow teachers in use of the Guam Water Kids program, and (2) to make strides toward integrating Guam Water Kids at the GDOE instructional curriculum level and updating them to Common Core Learning Standards recently adopted by the Guam Department of Education. The project goals are:

1. Expanded Teacher Education Course—to build on the success of the 1-credit-hour teacher training course offered this year, we will develop and deliver an expanded 3-credit-hour version of Teaching Teachers about Guam Water Kids course. Adding 2 credit hours of instruction will allow the participating classroom teachers to receive

training in peer mentoring and field experience in sharing Guam Water Kids with other teachers at their respective schools. The 3-credit-hour course will be open to all educators and offered through the University of Guam Professional International Programs.

2. Institutionalizing Guam Water Kids—while there is no centralized curriculum of instruction at GDOE, two specialized instructional divisions of GDOE have offered the opportunity to integrate Guam Water Kids at the system-wide instructional level. Both the Chamorro Studies Division (136 teachers in all schools/mandated for all students) and from the English as a Second Language Division (150 ESL specialists in all schools/serving 40% of students) have offered to lend enthusiastic support and have tendered specific invitations that will allow us to reach all grades at all Guam public schools. The scope of including Guam Water Kids in Chamorro Studies will require introduction of a Chamorro version of the presentation in August.

Update to Lesson Plans—two Guam Water Kids Lesson Plans will be revised to follow the STEM (Science, Technology, Engineering and Math) format and aligned to the new national Common Core Learning Standards. The Guam Water Kids program will be among the first materials available to Guam teachers as GDOE begins a 2-year transition to Common Core Standards in 2013.





## Heavy Metal Status of Nearshore Fisheries Impacted by Old Military Dumpsites on the Eastern Side of Saipan, CNMI



**Funded by:**  
**US Geological Survey, Water Institute Program**

**Principal Investigator:**  
**Gary Denton**

Although wartime dumpsites are scattered all over Saipan, the great majority are located in watersheds and on the eastern side of the island. Inventories of materials disposed of at these old dumpsites show that unexploded ordnances, munitions and demolition materials are among the most obvious wastes present. What little chemical data there are indicate that heavy metals, chlorinated hydrocarbons, petroleum and polycyclic aromatic hydrocarbons are the most commonly encountered contaminants. No data exist regarding the movement of any these dumped chemicals into other quarters of the environment via drainage pathways leading to the coast. Of particular importance in this regard are the more recalcitrant, lipophilic compounds like heavy metals, pesticides and PCBs. These contaminants readily accumulate in living organisms and can be concentrated to levels several orders of magnitude above ambient. Their stormwater induced mobilization from dumpsites on Saipan could therefore impart undesirable characteristics to aquatic resources harvested for food at down-gradient locations, rendering them unfit for human consumption.

In an attempt to bridge this information gap, we recently examined a suit of heavy metals in soils/sediments taken in the vicinity of several land-based dumpsites on the eastern side of Saipan. Where applicable, samples were also taken from surface water drainage pathways leading to the coast. Of thirty two sites examined, soil from seven exceeded Saipan's currently adopted soil screening levels for one or more metals. When weighed against USEPA's more conservative ecological screening levels, samples from all sites yielded heavy metal exceedences for at least one element. Currently we are attempting to delineate the magnitude of metal contamination in nearshore waters associated with these dumpsites using established aquatic bioindicators (algae and limpets). These

organisms were collected from surface water discharge points along the eastern seaboard in areas known or suspected to be impacted by land-based dumpsites. Preliminary data from the bioindicator survey indicate that metal enrichment of biotic components has occurred at some of these locations.

Based on the above findings, it is proposed here to extend the heavy metal monitoring program to fisheries resources along the eastern seaboard with emphasis on dominant representatives harvested for food. Sample collection points will focus on habitats influenced by metal enriched coastal discharges or impacted by metallic wastes bulldozed into the ocean at the end of WWII. The study addresses critical concerns voiced by CNMI stakeholders at our 2012 Advisory Council meeting regarding the impact of *Formerly Used Defense Sites* (FUDS) on Saipan's aquatic resources. Potential health risks associated with the long-term, unrestricted consumption of fish taken from any contaminated waters will be identified as will any need to impose future cleanup activities, or fishing restrictions in such areas. The study will additionally provide the necessary foundations for any future monitoring program conducted in these waters and compliment the overall chemical database currently available for aquatic resources on the other side of the island.



## Preliminary Investigation of Groundwater Impacts on Near Shore Benthic Communities in Garapan Lagoon, Saipan



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigator:**  
**Ryan Okano**

There have been recent efforts by the CNMI resource management community to focus conservation efforts on key resource targets of benthic habitat and water quality in the Saipan lagoon along the Garapan coast. This area has noted water quality problems impacting the health of coastal ecosystems; and according to data collected by the CNMI marine monitoring team, indicators exist attesting to poor ecosystem health in the lagoon. A patch reef site fronting Garapan has the lowest coral percent cover when compared to the rest of CNMI monitoring sites, while two lagoon sites in Garapan have the first and third lowest seagrass to algae ratio. A recent visual survey of near shore benthic habitat revealed *Enhalus acroides* (seagrass) beds in Garapan were unhealthy and subjected to epiphyte colonization. This colonization was not apparent in nearby lagoon areas of Southern Garapan. Initial salinity tests revealed significant differences in groundwater presence between the two areas, indicating this may be a factor in benthic health. Initial testing also showed proximity to stormwater drainages did not appear to impact *Enhalus acroides* health. *Enhalus acroides* serve as habitat for fisheries and are an important component of a healthy benthic ecosystem. Understanding specific positive and negative impacts to *Enhalus acroides* is important for effective management of the entire near shore ecosystem.

This study is a preliminary investigation of the health of the near shore benthic community in Garapan, specifically with regard to *Enhalus acroides*. Systematic water quality samples of salinity, temperature, pH, conductivity, turbidity, total suspended solids, fecal coliform, nitrite, nitrite/nitrate, ammonium, total nitrogen, total phosphorus, and ortho-phosphorus, will be taken from both Garapan (unhealthy) sites and Southern Garapan (healthy) sites to assess what parameters may be impacting the *Enhalus acroides* communities. The samples will be

collected monthly during lowest possible morning tides. Measurements will be obtained in situ with a YSI Model 556 MPS and HACH 2100P Turbidimeter, total suspended solids and fecal coliform samples will be tested by DEQ lab, and nutrient samples will be tested by WERI lab. Detailed field assessments will be conducted at the start and end of the project to assess any change in *Enhalus acroides* health over the life of the one-year project. The assessment will evaluate health by noting presence or absence of epiphytes, disease, and density of the beds.

Objectives of this project include assessing the health of the benthic community, specifically *Enhalus acroides*, in relation to the presence or absence of groundwater; compiling a list of constituents in the near shore marine waters in relation to the presence or absence of groundwater at those sites; identifying whether specific water quality parameters are associated with areas of poor benthic health and good benthic health; determining management steps needs to increase benthic health based on the study results, or identify additional studies required to clarify impacts to *Enhalus acroides*. The goal is that resource agencies in CNMI will be better informed as to the causes, and thus better define the impacts, of groundwater discharge on the near shore marine environment in Garapan. The study may also provide secondary benefits to CUC, as study results may inform them of the effects of the residential sewer connection program they will begin this year.



## Development of Optimum Water System Operation For Saipan Water Distribution System



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigators:**  
**Shahram Khosrowpanah & Mariano R. Iglecias**

The Saipan water distribution system has been divided into 15 sub-regions. Each region is expected to operate somewhat independently. However, due to inadequate inflow to some of the sub-regions, system leakage, and lack of knowledge of system operation, the system is unable to provide 24-hour water services. A stated goal of the Commonwealth of the Northern Marianas Islands (CNMI) government is to provide 24-hour water to all residents served by the Commonwealth Utility Corporation (CUC) water system. The CNMI Governor created a task force whose primary purpose was to find funding and oversee the CUC accomplishments toward the 24-hours water service goal. To assist in reaching their goals, the CUC commissioned the University of Guam Water and Environmental Research Institute of the Western Pacific (WERI) to develop a hydraulic model of the Saipan water system and to train CUC water division staff in the use of that model. WERI researchers have developed computerized models of each of the fifteen sub-regions of the CUC water system using the Haestad WaterCad water system modeling program. They also developed a source transmission and storage model of the Saipan water system. This includes a skeleton of the existing 15-region water system models that are joined together at the boundary points. For the model to provide optimal results and improve the operation of the system it is essential to a) have a good knowledge of the residential and commercial demands being placed on the distribution system and how these demands change during the day, and b) how the pressure through the system changes with time. Without this knowledge it is

difficult to develop system operation and to calibrate the hydraulic model of the water system.

This project proposes; a) to better refine estimates of both the quantities and spatial distribution of water demands and how these demands change with both residential and commercial customers of the Saipan CUC water system, and b) to define the impact of demand changes on system pressure during the day and the month. The specific objectives of this project will be to:

1. Determine the average use rate for residential customers in Saipan and to determine the actual use rate for high commercial consumers.
2. Develop Diurnal demand pattern (changes of water demand during the day and month) for residential and commercial customers.
3. Develop a relationship between demand and the system pressure.
4. Export the data developed in Step 1 and 2 into the Saipan Water System hydraulic Model, and run the model in extended period simulation mode.





## Land Cover Change Detection in Saipan



**Funded by:**  
**US Geological Survey, Water Institute Program**

**Principal Investigator:**  
**Yuming Wen**

Land cover change (LCC) has been a subject of concern for the past few decades. Land cover change is not only affected by human-induced activities, but also biophysical drivers such as droughts, flooding, earthquakes, climate change and sea level rise. Traditionally, many of the changes have been recorded qualitatively through the use of comparative photographs and historical reports. With advancement and development of geospatial technologies, it is possible to monitor land cover change and determine impacts of human activities on environment and ecosystem in islands, particularly tropical islands where water quantity and quality is essential to sustainable development and quality of life. Satellite remote sensing, spatial statistics, geographic information systems (GIS), and global positioning system (GPS) can be used to identify land cover information and determine land cover changes if temporal data are employed. Considering the global warming, sea level rise and human induced activities, many island nations or regions are facing serious problems with environmental sustainability, water resources and water quality. In order to mitigate the impacts of biophysical and human factors on environment, it is important to obtain land cover information, and determine land cover change, and evaluate whether human induced activities affect environment and water quality.

The land cover changes and the Impact of historical and recent land use activities on ground and surface water quality and production were identified as one of the highest research needs for Saipan on the CNMI Research Advisory Meeting of

October 16, 2012. This project will focus on derivation of land cover information from satellite images and or aerial photos, and land cover change detection in Saipan, CNMI. Available data for this project include DRG data of 1925 and 1980, Landsat MSS image of 1978, Landsat ETM+ imagery, and Aster L1B imagery. The DRG data of 1925 may be used as comparison purpose, and the DRG data of 1980 may be utilized with Landsat MSS data for land cover classification. This project will use moderate spatial resolution data for land cover classification and land cover change detection. Higher spatial resolution data including QuickBird, GeoEye, IKONOS data, and historical aerial photos may be employed as reference data. Geospatial technologies such as GIS, spatial analysis and remote sensing will be applied to complete the project. The main objectives of this project are:

1. Apply moderate satellite imagery such as Landsat and ASTER data to derive land cover information to determine land cover change from late 1970s to late 2000s or most recently depending on whether such data are available, i.e. about three decades period,
2. Preprocess the images such as georeference, projection and georectification if such procedures have not been done,
3. Classify land cover information using satellite images and/or aerial photographs,
4. Determine land cover changes, and Provide land cover and land cover change detection data and maps.



## Improving the Pohnpei Water Distribution System Using Hydraulic Modeling and Geographic Information Systems



**Funded by:  
US Geological Survey, Water Institute Program**

**Principal Investigators:  
Leroy Heitz & Shahram Khosrowpanah**

Water hours and low delivery pressure have long been a part of the daily lives of the people in the Micronesian Islands. The problems with delivery of adequate supplies of water to the customers at appropriate pressure have become more and more of a challenge to public utilities throughout these islands. Part of these problems is due to phenomenal growth rates occurring in the island centers. This is particular true on the island of Pohnpei in Pohnpei State, Federated States of Micronesia (FSM).

Over the years the Pohnpei Utility Commission's (PUC) water distributions system has grown without adequate documentation as to the extent and size of supply and transmission resources and where these resources are located. Recently new wells were added to the PUC's water supply system. In 1987 investigators from WERI developed a preliminary map and non graphical model of the water delivery system. Since then many changes and additions have made to the delivery system.

This project will result in the development of a set of management and engineering tools, which the planning, operation, and engineering staff at PUC can use to better plan, operate, and maintain the water delivery system. These tools will assist PUC to develop a water system that can deliver adequate water to all the households in Pohnpei on a continuous basis with sufficient pressure.

The first management tool that will be developed will be a computerized water system network

model. This model will be developed using information gathered from PUC sources and from field gathered location and component description information. Other information such as system pressure and flows will be gathered as part of the calibration process of the model. The model will be available to the PUC engineering and planning staffs to help in pinpointing problems areas and to explore operation options for improving system performance. The model will be developed using the free water distribution modeling program "EPANET". This model was developed by the U.S. Environmental Protection Agency.

The second tool will be a Geographic Information System based (GIS) inventory of system resources. This GIS system will describe the water sources available, the well systems in place, water storage facilities and major transmission lines in the distribution system. The GIS system will consist of maps showing the location of the various components of the water transmission system and ancillary equipment. The GIS will be available to managers and engineers so that they can explore various scenarios for long range planning for system maintenance and improvements. The GIS will also be available to the operations personnel so that they can maximize their resources for responding to emergencies, planning repairs, and purchasing the inventory of spare parts needed by the utility.



## Development of Environmentally Sustainable Methods for Treatment of Domestic Wastewater and Handling of Sewage Sludge on Yap Island



**Funded by:**  
**US Geological Survey, Water Institute Program**

**Principal Investigator:**  
**Joe Rouse**

Inadequate treatment of domestic wastewater (sewage) in the Pacific Islands has been responsible for serious human and environmental health problems due to contamination of water supplies and damage to the natural environment. The reasons for this can often be attributed to poor management and the lack of functional technology. On Yap Island in the Federated States of Micronesia, the treatment being provided at the centralized wastewater treatment plant with over 300 household connections is clearly insufficient with essentially raw wastewater being discharged to the ocean. In addition, the numbers and locations of pit latrines and septic tanks on the main island are not adequately inventoried and the degree of treatment being provided is unknown. Furthermore, excess sludge being produced by the treatment plant is taken and directly used for domestic purposes without prior treatment to meet regulatory standards; thus, improved management of this potential resource is

urgently needed; as would also apply to the sludge yield that would be realized if septic tanks were operated and maintained properly.

Accordingly, the objective of the proposed project is to compile a concise inventory of up-to-date information on the existing pit latrines, septic tanks and wastewater collection and treatment system and sludge handling practices on Yap Island. Furthermore, solutions to existing problems will be developed, including issues pertaining to managerial practices and the need for new and innovative technologies. The findings of this project would assist in identifying and prioritizing areas where further work would be merited to improve the sustainability of wastewater treatment and related practices. Thus, the final technical report would serve as a planning tool to give guidance for potential courses of corrective action on Yap Island and possibly also serve as a guide for other locations in Micronesia.





## Sustainable Conjunctive use of Groundwater and Rain Catchment Water under Variable Climatic Scenarios For Atoll Island Communities



**Funded by:**  
**US Geological Survey, Water Institute Program**

**Principal Investigator:**  
**John Jensen**

Water shortages are a persistent concern for residents of atoll islands. Under normal rainfall conditions, water demand is able to be met by rooftop rain catchment, but prolonged droughts, such as those associated with ENSO events in the western Pacific region, can exhaust water storage, leaving resident dependent on groundwater or imported water from distant islands. With island residents dependent upon both rain catchment water and groundwater, a complete assessment of water resources available to atoll island communities must include a time-dependent analysis of both stored rain catchment water and available fresh groundwater. Furthermore, the conjunctive dependence on both sources of water varies in time according to climatic stresses such as decadal patterns in rainfall variability, drought, and sea-level rise, and hence these must be taken into account in the analysis. In order for conclusions of such an analysis to be adopted by local island communities, clear and concise presentations and training for the water resource managers and government officials of the FSM should be conducted, and basic water conservation practices should be communicated to the general population.

In response to the recommendation by the FSM Advisory Council meeting of October 23, 2006 in Pohnpei, WERI researchers have developed an accurate, readily portable groundwater management spreadsheet tool that is based on results from numerical modeling simulations. Beginning in April and May 2008, and continuing into August 2009, October 2010, and October 2011, the developers of the model presented demonstrations of the groundwater management tool to a limited number of available water resource managers and government officials, and during 2011-2012 the model was calibrated against observations in the

FSM and used to predict the estimated freshwater lens thickness during average rainfall and intense drought conditions for each atoll island within the FSM (Bailey and Jensen, 2011; Bailey et al., 2012). During the previous year, a new spreadsheet tool was created that incorporates results of the groundwater modeling tool with daily rain catchment estimates using generic rain catchment storage dimensions and daily rainfall data. For the daily rain catchment storage estimates, a simple mass balance approach is used. The tool can be used to assess groundwater and rain catchment volumes during average rainfall or drought conditions, and can also be used to design a community's rain catchment system that will maintain adequate freshwater volumes during drought conditions. The tool was presented to the FSM Advisory Council and other water and environment conditions on Yap in October 2012, and training was conducted.

This project aims to building on the previous year's results by using the new groundwater-rain catchment storage calculator to assess daily freshwater water supply for specific islands in the FSM. This assessment will be performed under various climatic scenarios, such as rainfall variability, drought, and sea-level-rise to provide a broad range of application. Presentation and training to the FSM water and environmental officials will occur at the FSM Advisory Council in October 2013, and educational pamphlets will be created for distribution to FSM atoll island schools. To date, demographic and rain catchment infrastructure information is available for several islands (Mwoakilloa, Pohnpei; Pakein, Pohnpei) (Taboros'i and Martin, 2009; Taboros'i and Collazo, 2010), which will be used as test cases.



## Water System Leak detection Training for Yap State Public Services Corporation (YSPSC)



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigator:**  
**Shahram Khosrowpanah & Charles Falmeyog**

Water system leakage is a serious problem for all utility agencies throughout the Western Pacific. It reduces the performance of the system and a big money lost for utilities. The development of the modern water distribution system for most of the islands in this area started in 1970. Since then the system has been upgraded through a series of US sponsored capital improvements projects. However, the system leakage for some of these islands is as high as 60%. Utility agencies are suffering from lost revenues and are not able to provide 24- hour water service to their customers. Leak detection is one of the most cost effective and efficient ways to reduce non-revenue water. In fact, a leak detection program should be the highest priority with each utility agency. It is cost effective, and has the immediate result of increasing the system performance. The Federated States of Micronesia (FSM) Research Advisory Council met in Yap State on October 8, 2012 identified “conducting leak detection in Yap State” as a high priority under the Education and Professional Training needs for the FSM.

We are proposing a one week long training on water system leak detection for Yap State Public Services Corporation

(YSPSC). The training will provide an understanding of the leak detection theory, causes, and how to find leaks and fix them.

The training will provide a mix of classroom, laboratory and field site training. A summary of the topics that will be presented during the classroom and field site are listed below:

- 1) Leak Detection Theory, and how to determine when a leaky survey is required.
- 2) Economic benefits of a leak detection survey.
- 3) How to incorporate a leak detection survey and/or permanent leak detection crew for your water facility.
- 4) How to become familiar with various sounds created by leaks and type of leaks encountered.
- 5) Types of leak detection surveys and proper record keeping.
- 6) Get familiar with various leak detection equipment and techniques.
- 7) Field demonstration and actual leak detection scenarios and exercises. This includes: field demonstration, general Survey, general Pinpointing, emergency Pinpointing, estimating Leakage, reporting, and vehicle setup.



# PROJECTS

## (Completed February 28, 2013)



US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM



### GUAM:

Teaching Teachers about Guam's Water Resources and 'Guam Water Kids': 1 Credit Hour Continuing Education Course with Guam Department of Education, Professional & International Program-University of Guam, and WERI.

One-Day Executive/Professional Field Course, with Webpage on Sustainable Management of the Northern Guam Lens Aquifer

Spatial and Temporal Analyses of the Relationship between Groundwater Salinity and Rainfall Amounts, Timing, and Intensity in the Northern Guam Lens Aquifer.

LiDAR-based Delineation and Hydrologic Modeling of Southern and Central Guam Watersheds.

### CNMI:

Presenting 'CNMI Water Kids': Private Elementary/Middle Schools and Northern Marianas College of Education Outreach/Teacher Relations Program.

Development of Water Usage Pattern (Diurnal Demand Pattern) for Saipan Water Distribution System.

Environmental Impact of FUDS and Brownfields Sites in Watersheds on the Eastern Side of Saipan: Phase 2. Impact on Aquatic Resources.

### FSM:

Inventory and Assessment of Existing Sewage Treatment Facilities and Excess Sludge Handling Practices in the Federated States of Micronesia.

Improving the Weno, Chuuk Water Distribution System Using Hydraulic Modeling and Geographic Information Systems.

Identifying Sustainable Water Storage Infrastructure for Atoll Island Communities.

Water System Leak Detection Training for Pohnpei Utilities Corporation (PUC), the Federated States of Micronesia.

## OTHER FUNDED PROJECTS

### NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center (ongoing)

### GUAM BUREAU OF STATISTICS AND PLANS (NOAA)

- c. Degradation/Restoration Assessment of the Piti-Asan Watershed
- d. Development of a Digital Watershed Atlas for Northern Guam (ongoing)

### GUAM EPA (USEPA)

GWUDI Study: Precision Mapping of Isohyets in Target Storms over the Northern Guam Lens Aquifer (ongoing)

### USGS

Hydrological Database for Northern Guam (ongoing)

### DIRECT LOCAL FUNDING

1. GUAM HYDROLOGIC SURVEY  
Spatio-temporal Analysis of Groundwater Quality in Guam (ongoing)
2. WATER RESOURCES MONITORING PROGRAM  
Stream-flow, Sediment Discharge, Rainfall and Groundwater Characteristics Data Collections in Guam (ongoing).



## Teaching Teachers about 'Guam's Water Kids': 1-Credit Hour Continuing Education Course with Guam DoE, PIP at UOG & WERI



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigator:**  
**Ann Card**

The WERI Advisory Council for Guam has identified two critical water resources needs for research, education and training that have not as yet been fully addressed. They are: (1) the development of a teacher training course about water resources and (2) educational training and outreach programs about the importance of protecting and preserving watersheds and water resources, which as specifically advised "should begin with elementary schools in order to instill the importance of these issues at a young age."

In response to these needs and other indicators as described herein, funds are requested to:

1. Develop a continuing education course with the objective of offering an opportunity for Guam elementary and middle school teachers to gain knowledge and awareness of fresh water issues and sufficient science background and instructional methods for effective use of the "Guam Water Kids" educational program for ongoing, extensive classroom use;
2. Offer 15 hours of instruction (1-hour continuing education credit) in Fall 2012 to 25 course participants recruited from the Guam school teachers and conducted in a team teaching format using academic and community professionals in "hands on" experiences;
3. Chronicle class meetings especially demonstrations in classroom, field discovery and the "learning experiences" developed by course participants to be

- saved for use in future semesters;
4. Survey course participants; evaluate and analyze and report areas for improvements.

The course will be offered in collaboration with the Guam Department of Education (GDOE) for credit under the Professional & International Program (PIP) at the University of Guam. The development and initial offering of the course will be chronicled in order to preserve and allow evaluation of the learning experiences and provide additional teacher/classroom learning materials at [www.guamwaterkids.com/educators](http://www.guamwaterkids.com/educators). The course will follow the same outline presented in the "Guam Water Kids: an Educational Campaign for Children to Learn about Guam's Water and How to Protect It" and cover the same topics in greater depth.

The administration of the Guam Department of Education is in support of this course and has indicated willingness to collaborate in offering a continuing education course on water resources and the "Guam Water Kids". Specifically, GDOE will provide the venue for class meetings, recruit teachers to enroll in the course, and interface with the UOG Professional & International Programs (PIP) to make the course available for continuing education and professional development credit.





## One-Day Executive/Professional Field Course, with Webpage on Sustainable Management of the Northern Guam Lens Aquifer



**Funded by:  
US Geological Survey, Water Institute Program**

**Principal Investigator:  
John Jenson**

The military buildup and associated economic growth anticipated on Guam over the next decade has raised concerns regarding sustainable management of Guam's groundwater resources. To arrive at appropriate policy, regulations, and management practices and obtain public support it is essential that policy-makers, water resource professionals, and island educators be equipped with an accurate and up-to-date understanding of the essential characteristics of the island's aquifer and the factors that must be considered to frame and implement sustainable management practices. A universal challenge, however, is that policy-makers, community leaders and other professional people have extremely limited time to engage in instructional opportunities. This proposal is for development and delivery of a course that could be completed in a single-day to island policy-makers, agency heads, and other executive-level people, as well as to island water resource professionals and professional educators. It would consist of (1) a single day of intensive personal instruction delivered in the field, with (2) a binder of materials and a supporting webpage containing the instructional materials plus additional references and links to other relevant and useful resources, and forums for maintaining continuing educational interaction and information-sharing.

The proposed program of instruction would consist of at least two separate course offerings in one year. Each offering would consist of a single full day of instruction delivered at selected field sites, with instruction also delivered during transit using handouts and course materials contained in a binder that

would be provided to each participant. Materials for the course will be extracted and modified from existing materials developed for a successful previous engineering professional development course and tailored for the proposed course. In addition, a new permanent web-page will be set up and equipped with a discussion board where former students and other users can engage in discussions or ask questions, etc. New features for the webpage will include additional maps and cross-sections that can be accessed and used by course participants and other users. Each set of users will have access to resources designed to support their various needs: policy makers and senior executives, regulators and managers, technical professionals, and secondary school educators.

The scope and objectives of the work include:

4. Preparation of instructional materials, including handouts and references to be contained in a binder;
5. Delivery of a one-day course in the field, in which course participants travel to selected field-trip stops in a bus, with instruction delivered not only at the field sites, but on the bus during transit to each site;
6. Introduction to a webpage containing not only instructional materials but downloadable references and links to other relevant and useful resources;

A forum on the webpage for subsequent correspondence among course participants and instructors to provide a permanent venue for information-sharing and updates on topics of interest.



# Spatial and Temporal Analyses of the Relationship between Groundwater, Salinity & Rainfall Amounts, Timing, & Intensity in the Northern Guam Lens Aquifer



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigators:**  
**John Jenson & Mark Lander**

The Northern Guam Lens Aquifer (NGLA) provides 80% of Guam's drinking water. Total withdrawal by all producers is currently about 45 million gallons per day (mgd), against a currently estimated sustainable yield of about 80 mgd. The anticipated military buildup during the next decade is expected to require an additional 5-6 mgd of drinking water to support the new military activities alone, and additional economic growth on the island will certainly further increase demand for municipal and private production as well.

Recent study of the temporal trends in salinity show long-term increases in most wells and substantial increases since 2006 at some wells. The reason for the observed increases in the salinity of wells tapping the NGLA is not know. It may be the result of changes in pumping volume and pumping distribution across the aquifer, or changes in the character of Guam's rainfall, which has undergone substantial changes across the decades of the 1990s into the 2000s. There have also been some dramatic changes in Guam's climate during the past two decades (air and sea temperature rise, substantial – 12 cm – sea level rise, and abrupt changes to the typhoon distribution). It is possible that these climatic changes (whether temporary or permanent) are having (or will have) effects (possibly adverse) to the quantity and quality of the water in the NGLA.

The proposed project will compile and evaluate historical and current data from existing sources to support statistical and graphical analyses of well data and local climate data. Spatial relationships and trends will be identified by using GIS applications to display them on 2-D and 3-D maps of the aquifer and Guam's groundwater production infrastructure. The data will thus be evaluated to determine not only the current distribution of relatively low- and high-chloride zones in the aquifer, but also the

historical spatial and temporal trends in the relationships between chloride concentrations in Guam's freshwater lens and production wells on the one hand, and spatial and historical trends in production rates and recharge on the other hand. The resulting graphics, maps, and analyses will published as a WERI technical report, which will be placed on WERI's website. The work will be done primarily in WERI's meteorology and hydrology laboratories, by a WERI-sponsored graduate research assistant under the supervision of WERI hydrologists. If separate funding can be obtained from other local and federal sources, this project will be augmented by piloting a new methodology to the determination of chloride profiles in existing and perhaps additional new deep penetrating observation wells. Enhanced climatic monitoring by the local water agency, WERI, and the Guam EPA at well sites across the NGLA can also be leveraged to supply data for the study.

The objectives of this project are to:

1. Update the analyses of historical trends in chloride profiles observed in the CWMP observation wells;
2. Update the analyses of historical trends in water levels and chloride concentrations documented in Guam's production wells, alongside the record of production rates;
3. Compile the rainfall and evaporation histories for the applicable portions of the aquifer;
4. Compare the patterns and trends of the data sets.



## LiDAR-based Delineation & Hydrologic Modeling of Southern and Central Guam Watersheds



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigator:**  
**Maria Kottermair**

Watersheds as hydrologic units define geographic boundaries used for natural resource management and for hydrologic and related modeling. A "ridge-to-reef" (watershed)-approach to management of natural resources, especially freshwater resources, has been promoted since the establishment of the Clean Water Action Plan (CWAP) for Guam - Unified Watershed Assessment in 1998 to restore and protect freshwater resources. The CWAP includes a watershed map and a list of all watersheds categorized by need for restoration. Northern Guam covered by a limestone plateau with no defined surface flow is considered one watershed, whereas Southern and Central Guam are divided into 19 watersheds according to a NRCS classification outlined in the CWAP. Over the last decade, considerable efforts through erosion modeling and actual restoration projects have been made and are still on-going to improve water quality in priority watersheds. A number of water resources projects of critical need have been identified at the Advisory Council Meetings of the Water and Environmental Research Institute of the Western Pacific (WERI) over the past years. Many of these projects focus on surface water quality and quantity and are watershed-based. The modeling of fresh water resources is nowadays usually done entirely or at least in parts using a geographic information system (GIS). Currently, two data sets outlining watershed boundaries are available in GIS format. One is based on USGS topographic maps, the other one on a 10-meter by 10-meter resolution digital elevation model (DEM). In 2007, the Government of Guam acquired high-resolution Light Detection and Ranging (LiDAR) data for the entire island of Guam. Few watersheds and drainage basins have been delineated using LiDAR data, but only on a project by project basis. No attempts have been made to update all of Guam's watershed and sub-watershed boundaries using LiDAR despite the need to have more accurate boundaries that are

also consistent with other LiDAR-derived data such as slope or a relief.

This project proposes to create an updated comprehensive hydrologic GIS dataset that includes watershed characteristics in addition to terrain characteristics using 2007 LiDAR data. Such high-resolution and up-to-date geospatial information is going to be a vital resource for researchers, managers, technical staff and others.

The specific objectives of the project are to:

1. Utilize LiDAR data to create a hydrologic model of Southern and Central Guam that includes watershed and sub-watershed boundaries, flow direction, flow accumulation, river delineation, as well as terrain characteristics, such as slope and aspect;
2. Survey major culverts and drainage points along the coast and highways;
3. Calculate geometric parameters (area, length) and label watersheds and rivers;
4. Prepare report including a tutorial for the hydrologic model and its applications;
5. Incorporate data into a web-based educational application and information server;
6. Conduct a half-day workshop for government agencies working on watershed management and surface water monitoring.

This project provides important base data for hydrologic and other modeling and defines geographical boundaries for management purposes in conservation efforts. The data set will be made readily available to all entities involved in watershed-related work on Guam through direct distribution, a website, and a workshop on the applications. The utilization of this new data set as a widely-available standard will ensure consistency within and across projects.



## Presenting CNMI Water Kids: Private Elementary/Middle Schools & Northern Marianas College of Education Outreach/Teacher Relations Program



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigator:**  
**Ann Card**

Recognizing a need to familiarize teachers and students with the "CNMI Water Kids" water resources educational materials for ages 9-12 and to demonstrate the value of incorporating them into education curricula, WERI funded 11 on-site presentations made to public schools in the CNMI on the islands of Saipan, Rota and Tinian during the Fall 2011 semester. To date, 655 elementary students and their 36 teachers have seen eight presentations on Saipan and one on Rota. A presentation in Tinian and two on Saipan are scheduled. In addition, we presented the "CNMI Water Kids" teaching materials at the CNMI Public School System's (PSS) fall professional development event in October, 2011. Teachers attending the 3-hour workshop were drawn from elementary, junior high and high schools throughout the region.

We are requesting the opportunity to further share the "CNMI Water Kids" materials in Fall 2012 in the following manner:

- Present to 6th graders and their teachers in 8 private schools on Saipan, Rota and Tinian;
- Conduct a workshop or class presentation to education majors at the CNMI School of Education in the Northern Marianas College (SoE-NMC) in Saipan;
- Identify a plan for offering CNMI elementary and junior high teachers a 1 credit hour continuing education course in water resources as a collaborative effort with the CNMI PSS.

The proposed study will proceed as follows:

- Contact and offer materials to the

head administrators of private institutions of learning for approval and scheduling, and likewise with the CNMI SoE-NMC;

- Conduct eight team presentations of the "CNMI Water Kids" to students in private schools and leave participating teachers with educational materials, including the CD presentation, printed copies of the two related *Lesson Plans and Activities*, and WERI contact information, as appropriate;
- Conduct a survey of participating educators to evaluate the "CNMI Water Kids" presentation and related materials. Include additional questions about specific needs teachers may have and poll their interest in participating in future teacher-training courses in water resources protection and conservation. Analyze and report survey results. All contact information to be preserved in order to facilitate future communication with participating educators;
- Conduct presentation(s) to education majors at the SoE-NMC.
- Contact the CNMI PSS Chancellor and appropriate education specialists regarding offering a future continuing education course on this topic.





## Development of Water Usage Pattern (Diurnal Demand Pattern) for Saipan Water Distribution System



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigators:**  
**Shahram Khosrowpanah & Mariano Iglecias**

The US Environmental Protection Agency (EPA) recently stressed that the water treatment system in Saipan, CNMI is still in need of improvement. The EPA acknowledged that the lack of safe drinking water is among the top environmental challenges that the EPA found to be facing the CNMI, particularly Saipan. In a previous assessment, the EPA found Saipan to be the only municipality of its size in the United States without 24-hour water delivery. The agency reported that the water on island is not drinkable due to its high salinity, and water flows through the pipes only a few hours per day for almost half of the island's residents.

One important step in establishing 24-hour water delivery and improving water quality in the system is for the Commonwealth Utility Corporation (CUC) to have a better understanding of how their distribution system delivers water to customers and what improvements are needed to meet operational and water quality goals. To assist in reaching their goals, the CUC commissioned the University of Guam Water and Environmental Research Institute of the Western Pacific (WERI) to develop a hydraulic model of the Saipan Water System and to train CUC water division staff in the use of that model.

In order to improve the system operation it is necessary to have a good knowledge of the residential and commercial demands being placed on the distribution system and how these demands change during the day

and during the month. Without this knowledge it is difficult to develop system operation and to calibrate the hydraulic model of the water system.

This project proposes to better refine estimates of both the quantities and spatial distribution of water demands and how these demands changes with both residential and commercial customers of the Saipan CUC water system.

The specific objectives of this project will be to:

5. Determine the average use rate for residential customers in Saipan and to determine the actual use rate for high commercial consumers;
6. Develop Diurnal demand pattern (changes of water demand during the day and month) for residential and commercial customers;
7. Export the data developed in Step 1 and 2 into the Saipan Water System hydraulic Model, and run the model in extended period simulation mode.

The resulting improvements to the demand estimates and its changes with time will provide the CUC water division the capability to: a) determine the amount of the water that is being lost through the system, b) implement various operational systems for transferring water among the 15-sub regions for providing 24-hour water service to the customers, and c) improve water system maintenance.

# Environmental Impact of FUDS and Brownfields Sites in Watersheds on the Eastern Side of Saipan. Phase 2: Impact on Aquatic Resources



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigators:**  
**John A. Starmer & Gary R.W. Denton**

The massive clean-up and redevelopment of Saipan at the end of WWII presented waste disposal problems that were largely solved by either bulldozing unwanted materials into the ocean, burying them in caves, or dumping them at specific locations on land. Virtually every kind of material used in warfare were among the items disposed of in this way, in addition to demolition and construction debris and other residual materials associated with the rebuilding effort. At the time, little if any thought was given to the impact of these dumpsites on the surrounding environment. As a consequence, the majority of disposal sites that arose out of that period in Saipan's history were soon overgrown by natural vegetation and largely forgotten within the space of a few years. Renewed interest in their existence did not come until almost half a century later following the implementation of the Department of Defense (DOD) Formerly Used Defense Site (FUDS) Environmental Restoration Program in 1986 and the Brownfields Program that evolved out of the Brownfields Revitalization and Environmental Restoration Act of 2001. Shortly thereafter, thirty two confirmed FUDS were identified throughout the CNMI. Twenty three of these were located in Saipan along with forty one other suspected Brownfields sites.

To date, inventories of materials disposed of in the FUDS and Brownfield sites of the CNMI are based largely on visual assessment with unexploded ordnances, munitions and demolition materials ranking among the more obvious wastes present. What little chemical data there are indicate that heavy metals, pesticides, PCBs, organic solvents (TCE, PCE, vinyl chloride, methyl tertiary butyl

ether), petroleum and polycyclic aromatic hydrocarbons are the most commonly encountered contaminants. Few studies have attempted to quantitatively delineate the extent of any chemical contamination at these sites and no definitive watershed studies, other than those conducted by WERI along the western seaboard of Saipan, have assessed the impact of any bioaccumulative compounds present (e.g., metals, pesticides and PCBs) on the edible quality of aquatic resources harvested for food in downgradient locations.

The study described herein builds upon the earlier WERI studies by extending them to the eastern seaboard of Saipan where no such information currently exists. It is being conducted in two discrete phases. Phase 1 is currently underway and is examining chemical contaminants in soils from around potentially troublesome dumpsites in watersheds on the eastern side of the island, and along drainage pathways leading to the coast. Phase 2 is the subject of this proposal and will determine contaminant levels in aquatic resources from impacted areas as well as evaluate potential health risks associated with their long-term consumption by local residents. Overall, the study will add significantly to the existing contaminant database and command the interest of all involved with environmental remediation and resource management in the CNMI. It will also provide the necessary foundations for the continued monitoring and assessment of pollution problems in the area. Such information is vital for the overall protection and sustainable development of aquatic resources in Saipan's watersheds and coastal waters.



## **Inventory & Assessment of Existing Sewage Treatment Facilities & Excess Sludge Handling Practices in the Federated States of Micronesia**



**Funded by:  
US Geological Survey, Water Institute Program**

**Principal Investigator:  
Joseph Rouse**

The existing wastewater treatment facilities in the Federated States of Micronesia are not adequately inventoried. Furthermore, the limited information that is available is largely esoteric in nature, being available only to a few persons engaged at the local level. Items of concern include the types of unit processes being used, degrees of treatment being targeted, design capacities, degrees of treatment being achieved, and locations where treated effluents are being discharged. Of equal concern would be the processing of excess sludge generated at wastewater treatment plants, including the methods being used for treatment and disposal of the sludge (or reuse of bio-solids). In addition, the current conditions of wastewater collection lines and their extent of service coverage and the presence of industrial wastewater inputs are of concern. A concise, detailed inventory of the above items is lacking. Accordingly, the objective of the proposed project is to

compile a technical report with up-to-date information on the existing wastewater collection and treatment systems and sludge handling practices in the major population centers of Yap, Chuuk, Pohnpei, and Kosrae states of the Federated States of Micronesia. The findings of this project would assist in identifying and prioritizing areas where further work is needed to improve wastewater treatment practices. Furthermore, it would be useful as a planning tool by allowing for comparisons of results obtained at different locations throughout the expansive reaches of the Federated States of Micronesia. As a conclusion to the study, an overview will be compiled to tie together the above observations and itemize possible courses of corrective action with a goal of developing sustainable wastewater treatment infrastructures throughout the Federated States of Micronesia.



## Improving the Weno, Chuuk Water Distribution System Using Hydraulic Modeling & Geographic Information Systems



**Funded by:  
US Geological Survey, Water Institute Program**

**Principal Investigators:  
Shahram Khosrowpanah & Leroy Heitz**

Water hours and low delivery pressure have long been a part of the daily lives of the people in the Micronesian Islands. The problems with delivery of adequate supplies of water to the customers at appropriate pressure have become more and more of a challenge to public utilities throughout these islands. Parts of these problems are due to phenomenal growth rate occurring in the island centers. This is particular true on the island of Weno in Chuuk State, Federated States of Micronesia (FSM).

Over the years the Chuuk Public Utility Commission's (CPUC) water distributions system has grown without adequate documentation as to the extent and size of supply and transmission resources and where these resources are located. Just at the turn of the century several new wells were added to the CPUC's water supply system. In 2003 and 2004 investigators from WERI gathered water quality information from all the existing wells and developed a preliminary map of the water delivery system. Since then many changes and additions have made to the delivery system.

This project will result in the development of a set of management and engineering tools, which the planning, operation, and engineering staff at CPUC can use to better plan, operate, and maintain the water delivery system. These tools will assist CPUC develop a water system that can deliver adequate water to all the households in Weno on a continuous basis with sufficient pressure.

The first management tool that will be developed will be a computerized water system network model. This model will be developed using information gathered from previous studies and additional information documenting changes and additions to the system since the original data was gathered. Other information such as system pressure and flows will be gathered as part of the calibration process of this model. The model will be available to the CPUC engineering and planning staffs to help in pinpointing problems areas and to explore operations options for improving system performance. The model will be developed using the free water distribution modeling program "EPANET".

The second tool will be a Geographic Information System based (GIS) inventory of system resources. This GIS system will describe the water sources available, the well systems in place, water storage facilities and major transmission lines in the distribution system. The GIS system will consist of maps showing the location of the various components of the water transmission system and ancillary equipment. The GIS will be available to managers and engineers so that they can explore various scenarios for long range planning for system maintenance and improvements. The GIS will also be available to the operations personnel so that they can maximize their resources for responding to emergencies, planning repairs, and purchasing the inventory of spare parts needed by the utility.





## Identifying Sustainable Water Storage Infrastructure for Atoll Island Communities



**Funded by:**  
**US Geological Survey, Water Institute Program**

**Principal Investigator:**  
**John W. Jenson**

Water shortages are a persistent concern for residents of atoll islands. Under normal rainfall conditions, water demand is able to be met by rooftop rain catchment, but prolonged droughts, such as those associated with ENSO events in the western Pacific region, can exhaust water storage, leaving residents dependent on groundwater or imported water. In response to the recommendation by the FSM Advisory Council meeting of October 23, 2006 in Pohnpei, WERI researchers have developed an accurate, readily portable groundwater management spreadsheet tool that is based on results from numerical modeling simulations. Beginning in April and May 2008, and continuing into August 2009, October 2010, and October 2011, the developers of the model presented demonstrations of the groundwater management tool to a limited number of available water resource managers and government officials. These presentations also included general knowledge transfer of atoll island hydrology and methods to conserve water quantity and water quality on atoll islands. During the previous year, the groundwater management tool was also calibrated against atoll island groundwater observations in the FSM and used to predict the estimated freshwater lens thickness during average rainfall and intense drought conditions for each atoll island within the FSM (Bailey and Jenson, 2011; Bailey et al., 2011).

A complete assessment of water resources available to atoll island communities, however, must include an analysis of store rain catchment water, which is the primary source of potable water for island residents. This project aims at providing such an assessment, and will combine model-calculated available groundwater volumes with available rain catchment volumes. With knowledge of the number

of inhabitants for an atoll island, the water demand per inhabitant, and the daily rainfall, coupled with accurate results of groundwater volumes from groundwater modeling results, a calculation of daily available potable water for the island community during both average rainfall and intense drought conditions can be made. This assessment will be performed within the context of a new spreadsheet tool, derived from the existing groundwater management spreadsheet model, and will provide a readily-portable tool for water resource managers. Upon completion of the spreadsheet tool and publishing an associated user's manual, FSM officials will be trained on the use of the model.

The objectives of this project are hence two-fold. First, it is a research project that uses state-of-the-art modeling results as well as field-collected demographic information to obtain available water supply volumes for atoll island communities. Such information is vital for atoll island residents and policy makers in the FSM. Second, it is an information transfer project in which water resource managers and government officials will be provided results of the research within the timeframe of the project. Within this second objective, the water resource managers will be trained to use the new spreadsheet model. This will be done through workshop training, at which time a user's manual for the spreadsheet will also be provided. A poster outlining keys to water management and conservation will also be created for distribution to schools within the FSM. Furthermore, an ongoing technical support relationship will be established between the authors and end-users so that there will be a continuing dialogue to support continued successful use and application of the model to water resource management in the FSM.



## Water System Leak Detection Training for Pohnpei Utilities Corporation (PUC), Federated States of Micronesia



Funded by:  
US Geological Survey, Water Institute Program

**Principal Investigator:**  
**Shahram Khosrowpanah**

Water system leakage is a serious problem for all utility agencies throughout the Western Pacific. It reduces the performance of the system and represents a big money loss to water utility agencies. The development of modern water distribution systems in the FSM started in 1970 with periodic upgrades sponsored through a series of US capital improvements projects. Despite this, the majority of systems operating today suffer from excess water leakages, some as high as 60% on some islands. Aside from the negative impact on revenues, such losses all too often result in water utility agencies being unable to provide their customer base with a reliable 24-hour water service. One relatively rapid and cost-effective means of overcoming this problem is to implement a simple leak detection program with appropriate equipment and training for water utilities personnel. At its 2009 meeting, the FSM Water Resources Advisory Council requested that WERI carry out a leak detection training program on all the major islands of the FSM (Yap, Chuuk, Pohnpei and Kosrae). In keeping with this request, WERI organized a leak detection training program in Kosrae, in 2010. At the recent request of the Pohnpei Utilities Corporation (PUC) funding is hereby sought to conduct a similar training program on the island of Pohnpei, which currently ranks among the most severely affected islands, insofar as no-revenue water losses from leaks are concerned. One representative from each of the other islands will participate in the program. We anticipate conducting a

similar training program in Yap and Chuuk in future years.

The proposed training will be conducted over a one week period and will provide participants with a workable knowledge of leak detection theory. It will also consider common cause of water leakages in distribution systems and provide participants with hands-on field experience on how to find leaks and fix them. The topics to be presented at this proposed training exercise are summarized below:

1. Leak detection theory and how to determine when a leaky survey is required;
2. Economic benefits of a leak detection survey;
3. How to incorporate a leak detection survey and/or permanent leak detection crew for your water facility;
4. How to become familiar with various sounds created by leaks and type of leaks encountered;
5. Types of leak detection surveys and proper record keeping;
6. Getting familiar with various leak detection equipment and techniques. This will include field demonstrations, leak detection scenarios and exercises, general survey techniques, pinpointing strategies, estimating different kinds of leakages, reporting, and vehicle setup.



## Environmental Science Graduate Program University of Guam



The Environmental Science Program is designed to provide students with an appreciation of the interdisciplinary nature of environmental problems that exist in the world today and prepare them for professional employment, teaching, or advanced studies in diverse areas of environmental science, or related disciplines. The program also serves working professionals in local schools, government agencies and the private sector who are seeking career advancement and/or professional enrichment, e.g., educators, regulators, administrators and planners.

The interdisciplinary focus of the program is intended to train students to identify and understand environmental problems and exercise sound judgment in effecting their remediation. This is accomplished through a careful blend of core courses and electives in an integrated teaching-research approach. Students are required to conduct a research project and document their study in thesis form. They are encouraged to present their findings in a variety of forums (e.g., society meetings, conferences, workshops, seminars, peer-reviewed journals, technical reports, newsletters and the local newspaper). Students also have the opportunity to serve out an internship with a local environmental or engineering firm, or an appropriate Government of Guam or Federal Government Agency. This permits them to gain professional problem solving skills in the environmental arena. Students who graduate from the MS program can, therefore, reasonably expect to enter professional employment in a variety of areas in the public and private sectors where an understanding of the complex interdisciplinary scientific, social, and political dimensions posed by

environmental problems is increasingly necessary.



### **Graduate students in a WERI hydrology Field Trip Examining Coastal Spring on the Beach in Guam's Tumon Bay**

The Environmental Science Program strives to promote educational and service projects within island communities of the Western Pacific, and attract a broadly based group of scholars committed to seeking answers to the many environmental questions that are arising in developing island nations of the tropical Pacific Basin. Areas of faculty expertise center around three broad areas of concentration namely, biology-ecology, geosciences and engineering, and management. Further information may be obtained from the Program Chair, **Dr. Ross Miller**, 'phone: 671-735-2141, e-mail: [rmiller@ugam.uog.edu](mailto:rmiller@ugam.uog.edu).



## Pre Engineering Program University of Guam



Engineers are society's problem solvers. They take the theoretical ideas of the scientist and bring them into reality in today's world for the benefit of mankind. Engineers are involved with projects that vary from the design and construction of transportation systems to the planning of the space stations of the future. Nearly all aspects of our lives are touched by the projects worked on by people in the various engineering fields.

### **WHAT IS PRE-ENGINEERING AT THE UNIVERSITY OF GUAM?**

The University of Guam offers a program in Engineering Science that parallels the engineering programs offered during the first two years at major colleges and universities.

The first two years of engineering study places emphasis on learning the tools and theories and providing the background for all engineering fields. Rigorous studies in mathematics and the physical sciences are required of all students. Students are also required to take courses in the social sciences and humanities to round out their educational experience.

Each fall semester the University of Guam offers a course titled "**INTRODUCTION TO ENGINEERING**". This course is designed to acquaint students to the engineering profession. Discussions are held on all of the various engineering fields. Educational and professional registration requirements are also introduced. Various guest speakers relate their experiences in the real world of engineering. Finally,

students get a taste of the problem-solving techniques used by engineering students and practicing engineers.

### **WHAT IF I HAVE A WEAK BACKGROUND IN MATHEMATICS AND THE PHYSICAL SCIENCES?**

Engineering requires a strong aptitude for both math and science. For students with these kinds of aptitudes but with weaknesses in prior training, there are remedial classes available to help bring the student up to a competitive level. These students will require more than the normal two years to complete the Pre-Engineering Program.



**Engineering Students in WERI  
AUTOCAD/GIS Computer lab**

### **WHERE TO GET MORE INFORMATION**

For more information on the Pre-Engineering Program and the soon to be built School of Civil and Environmental Engineering, contact the Dean of the College of Natural and Applied Sciences, at the University of Guam or Program Chair, **Dr. Shahram Khosrowpanah**, 'phone: 671-735-2685, e-mail: [khosrow@ugam.uog.edu](mailto:khosrow@ugam.uog.edu)





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