

INTRODUCTION TO RESEARCH ACTIVITIES & TEACHING PROGRAMS

by

**Gary R.W. Denton Ph.D.
Director**



WERI

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

February 2012

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



WERI hydrogeologist, Dr. John Jenson (left), and karst geologist, Dr. John Mylroie (second left), of Mississippi State University, share a light hearted moment of conversation with WERI graduate student, Rob MacCracken, and host and field guide, Jesse Haulifar, during their field study of the groundwater resources of Fais Island, a low lying atoll Island in Yap State, Federated States of Micronesia.



WERI hydrology students in the Environmental Science MS Program learn how to calculate stream flow measurements in the Lonfit River, Guam



WERI

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



The Water & Environmental Research Institute of the Western Pacific, or WERI, is one of 54 water research institutes established by U.S. Congressional legislation at each Land Grant University in the United States and in several territories. The institute is now in its 37th 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-2011 WERI faculty were involved as Principal Investigators and/or advisors on 16 research and training projects with a combined budget of approximately \$1,000,000. 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 either 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 65 refereed journal articles, 44 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:

Dr. Gary Denton. gdenton@ugam.uog.edu
Director, WERI, University of Guam
UOG Station, Mangilao, Guam 96923
Phone: 1-671-735-2690
Fax: 1-671-734-8890



WERI FACULTY, STAFF & STUDENTS



DIRECTOR



Dr. Gary Denton
Prof. Environmental Toxicology

FACULTY:



Dr. John Jenson
Prof. Hydrogeology



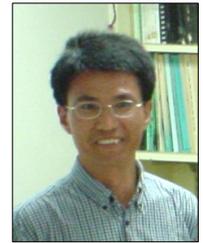
Dr. Shahram Khosrowpanah
Prof. Civil Engineering



Dr. Mark Lander
Assist. Prof. Meteorology



Dr. Joe Rouse
Assoc. Prof. Environmental
Engineering



Dr. Yuming Wen
Assoc. Prof. GIS

STAFF:



Gwendolyn Manglona
Administrative Assistant



Norma Blas
Secretary



Jennifer Cruz
Lab Manager



Cris Tagudin
Lab Technician



Nathan Habana
Staff Hydrologist

Research Assistants:



Sydonia Manibusan
Graduate RA



Vivianna Bendixson
Graduate RA



Christine Simard
Graduate RA



Walter Kelly
Graduate RA



Kennedy Tolenoa
Graduate RA



Von Apuya
Undergraduate RA



ACTIVE PROJECTS (Initiated March 1, 2012)



US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM



NIWR
The National Institutes
for Water Resources

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.

Atoll Island Sustainability: Information Transfer and Training for the Federated States of Micronesia (FSM).

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.

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

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**

Funding: \$10,725

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. 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

Funding: \$8,970

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:

1. Preparation of instructional materials, including handouts and references to be contained in a binder;
2. 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;
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.



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

Funding: \$36,821

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 Investigators:
Maria Kottermair

Funding: \$13,800

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

Funding: \$13,673

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

Funding: \$26,172

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:

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. 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

Funding: \$29,784

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:
Joe Rouse**

Funding: \$21,407

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

Funding: \$27,912

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

Funding: \$12,946

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**

Funding: \$17,848

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.



PROJECTS

(Completed February 29, 2012)



US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM



GUAM:

Presenting 'Guam Water Kids': Private, DoDEA School Outreach/Teacher Relations Program

Comprehensive Analysis of Salinity Trends in the Northern Guam Lens Aquifer

Reconstructing the Sea Surface Temperature and Wet-Dry Climate History of Guam

CNMI:

Environmental Impact of FUDS and Brownfields Sites in Watersheds on the Eastern Side of Saipan. Phase 1: Contaminant Analysis of Soil and Sediments

Presenting 'CNMI Water Kids': Public School Outreach/Teacher Relations Program

Reconfiguration of Saipan's Water Distribution System Model

Water System Leak Detection Training for Saipan, Commonwealth Utilities Corporation (CUC)

FSM:

Heavy Metal Status of Soils and Stream Sediments Impacted by Leachate from a Municipal Dump in Yap, Federated States of Micronesia (FSM)

Identifying Watershed Discharge Patterns and Linkages with Ecological Assemblages in Nimpal Area, Yap State, Federated States of Micronesia

Developing Flow Duration Curves for Use in Hydropower Analysis at Ungaged Sites in Kosrae, Federated States of Micronesia

Atoll Water Budget Modeling: Information Transfer and Training for the Federated States of Micronesia

OTHER FUNDED PROJECTS

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center

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

NSF

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

USGS

Hydrological Database for Northern Guam (ongoing)

DIRECT LOCAL FUNDING

1. GUAM HYDROLOGIC SURVEY
Spatial and Temporal Analysis of Groundwater Contamination on Guam Using GIS Technology

2. WATER RESOURCES MONITORING PROGRAM
Stream-flow, Sediment Discharge, Rainfall and Groundwater Characteristics Data Collections in Guam (ongoing)



Presenting 'Guam Water Kids': Private, DoDEA School Outreach/Teacher Relations Program



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

**Principal Investigator:
Ann Card**

Funding: \$7,620

Recognizing a need to familiarize teachers with the environmental educational materials for students age 9-12, "Guam Water Kids," and to demonstrate the value of incorporating them into curriculum. WERI funded six on-site presentations in Guam *public* schools which were conducted during the Fall 2010 semester. Some 1,150 6th grade students and 40 teachers were engaged in these presentations. The teachers who attended these sessions received a follow up survey. Preliminary results from this survey indicate that the teachers found the presentation effective, appropriate to grade level, and all indicated they are likely to use the materials on their own in future school terms.

In addition, the "Guam Water Kids" presentation was also screened in fall 2010 at the UOG Conference on Sustainability, in a small group session at the International Reading Association, and at the annual Leadership Forum sponsored by the 4-H youth organization. A number of teachers in attendance requested that the presentation also be made at private schools. Additional interest was shown by members of the home school association, teachers from the gifted and talented GATE programs, and teachers of other grade levels.

Based on this response, we intend to offer the Guam Water Kids presentation to 6th graders in private schools and the Department of Defense school system on Guam by making six presentations in fall 2011. Specifically, we intend to offer the presentation to private schools scheduling them on a first come, first served basis and the DoDEA school system following their guidelines to schedule presentations follow the presentations with an evaluation by educators involved in teaching

subjects related to water resource issues. Pending the acquisition of requested funds, our projected work plan will proceed as follows:

1. Contact and present materials to the head administrators for approval and scheduling.
2. Conduct six team presentations of the "Guam Water Kids" program led by Ann Card and educational consultant. Leave participating teachers with a packet of the educational materials including the CD presentation, printed copies of the two related Lesson Plans and Activities, and WERI contact information as appropriate.
3. Conduct a survey of participating educators to evaluate the "Guam Water Kids" presentation and related lesson plans. Include additional questions about needs teachers may have and specifically poll interest in participating in future teacher-training courses in water resources, a critical need which has been identified by the advisory council. Contact information will be preserved in order to facilitate future communication with educators. Analyze and report survey results



Comprehensive Analysis of Salinity Trends In the Northern Guam Lens Aquifer



Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
John Jenson & Mark Lander

Funding: \$25,595

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. It has now been a full decade since the most recent comprehensive survey of the incidence and trends of chloride concentrations in Guam's water production wells. Moreover, the past decade has been relatively dry; some of the reported recent upward trends in chloride in production wells may therefore be driven by natural processes, but no study has yet been undertaken to ascertain how much of the observed increases, if any, may be due to the recent natural decline in recharge. There is thus a compelling need for a new survey, incorporating historical knowledge, to (1) precisely determine the current salinity trends in the freshwater lens and in particular drinking water production wells, (2) investigate the possible causes of the trends, and (3) recommend appropriate responses to the trends to promote sustainable development of additional capacity.

The proposed project will compile and evaluate historical and current data from existing sources to support statistical and graphical analyses. 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 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.

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, and statistically evaluate how (a) the *chloride profiles in the observation wells* and (b) the *chloride concentrations in production wells* may be responding to changes in (c) drinking water *production rates* and/or (d) natural aquifer *recharge*.



Reconstructing the Sea Surface Temperature And Wet-Dry Climate History of Guam



Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
John Jenson & Mark Lander

Funding: \$30,475

Following the 1997-1998 El Niño, which brought to Guam one of the severest droughts in living memory, the governor and legislature of Guam committed the island to research, development, and maintenance of long-term drought planning and management. Long-term planning has received additional emphasis lately, given the economic and population growth that will accompany the relocation of thousands of US military members and families from Okinawa during the next decade-and-a-half. The *Critical Water Resources Research Needs* identified by the 2010 Guam Advisory Council, for example, now include (1) developing water budgets for Guam's surface and groundwater watersheds, (2) re-evaluation of sustainable development estimates for the island's principal aquifer, and 3) expanding and updating the rainfall database of Guam to include long-term rainfall variability. In addition, the USGS-NIWR program has encouraged research related to climatic effects on the water cycle. For long-term planning it is necessary to have a long-term record of past climatic cycles, however. Unfortunately, the historical record of El Niño-related rainfall and drought for Guam is very limited, dating back only to the end of World War II.

Climate research has shown that climate trends (e.g., rainfall, drought, sea-surface temperature) in tropical areas correlate well with chemical signatures in the annual growth layers of local corals. In Guam, it is well known that El Niño brings higher sea surface temperature and lower precipitation. Sea surface temperature, for example, which is the best index of El Niño strength, rose 4° C in the Western Pacific in 1997. Guam is fortunate to have robust coral growth in its coastal waters. In August, 2010, WERI researchers extracted a coral core of the central west coast of Guam. Analysis has already begun on this specimen by collaborators at the University of Texas, Austin, and the initial results show that it will be possible to reconstruct

the past sea surface temperature history from this specimen. WERI researchers have also been collecting real-time seawater and temperature data at the sampling site since September 2009. These data will be compared with the 60-year instrumental record, which will provide a basis for interpreting the record through the past two centuries.

The immediate objective is to identify the rhythms and strengths of past El Niño events from Guam coral skeletons and correlate, and correlate them with observed conditions in the current and historical instrumental record. Guam is especially well suited for such work. Previous similar studies lack long-term *in situ* ocean environment monitoring of coral because academic facilities tend to be remote from study sites. The resources from the proposed project will enable WERI to take advantage of being able to continue ocean environmental monitoring at the coral collection sites. Moreover, WERI researchers are also collecting prehistoric climate data from stalagmites in nearby caves, which when correlated with the coral record, may provide accurate estimates of drought/rainfall cycles for the past several millennia. Ultimately, by combining the coral record with the cave record, WERI researchers and their collaborators at the University of Texas may ultimately produce a very-long-term (10s of thousands of years) record of climate history for the entire West Pacific region. Revealing these dramatic past climate cycles on Guam will allow water resource managers to more reliably predict and model the future climate trends and contribute to the preparation for drought in the future. The proposed project thus provides the seed for a very productive long-term endeavor.



Environmental Impact of FUDS and Brownfields Sites in Watersheds on the Eastern Side of Saipan. Phase 1: Contaminant Analysis of Soil and Sediments



Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
John A. Starmer, Brian G. Bearden & Gary R.W. Denton

Funding: \$29,379

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 will be conducted in two discrete phases. Phase 1 is the subject of this proposal and aims to identify potentially troublesome dumpsites in watersheds on the eastern side of the island, along with potential drainage pathways that could facilitate the movement of chemical contaminants downgradient towards the coast. Extensive soil and sediment sampling within impacted watersheds and along the coast will delineate the existence and severity of any such contamination. Phase 2 will follow at some later date and determine contaminant levels in aquatic resources from impacted areas as well as evaluate potential health risks associated with their long-term consumption. 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.



Presenting 'CNMI Water Kids': Public School Outreach/Teacher Relations Program



Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Ann Card

Funding: \$17,887

The environmental educational materials for students age 9-12 about fresh water resource issues on Saipan, Rota and Tinian, CNMI, have been developed recently. The "CNMI Water Kids" materials emphasize the importance of fresh water as a key natural resource, explain hydrological concepts, and introduce a sense of stewardship for conserving and protecting fresh water in the CNMI. These materials include a pre-recorded presentation, teacher's lesson plans and suggested activities, a Chamorro language glossary, and a companion website. The educational materials are correlated to learning standards used by the CNMI Public School System. The materials were developed, in part, to support outreach efforts by WERI. There is a need to familiarize teachers with the materials and demonstrate the value of incorporating them into curriculum. Working directly with these educators will increase awareness of WERI as a resource for water related issues and will open opportunities for WERI to engage educators in the future. As materials are employed and as teachers become engaged in water resource issues, an evaluation is needed to assess the effectiveness of the "CNMI Water Kids" materials and to explore additional needs teachers may report such as a willingness to participate in water related courses for educators which may be developed in the future.

Specifically, we intend to follow the public schools' chain of approval, schedule a presentation targeted to reaching the 6th graders at each public elementary school (9 on Saipan, 1 on Rota, 1 on Tinian) and follow the presentations with an evaluation by educators

involved in teaching subjects related to water resource issues. Procedures include:

- Contact and present materials to the CNMI Public School System's Chancellor's Office for approval as required and schedule presentations to all sixth grade sections to be conducted in the fall 2011 semester.
- Conduct 11 team presentations of the "CNMI Water Kids" program led by Ann Card to include the educational consultant Jennifer Berry and one technical assistant. Leave participating teachers with a packet of the 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 lesson plans. Include additional questions about needs teachers may have and specifically poll interest in participating in future teacher-training courses in water resources, a critical need which has been identified by the advisory council. The survey will be conducted online with an "on paper" option in order to facilitate participation. Contact information will be preserved in order to facilitate future communication with educators.
- Analyze and report survey results.
- Make any appropriate adjustments to existing "CNMI Water Kids" materials indicated by educators' assessments.



Reconfiguration of Saipan's Water Distribution System Model



Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah, Leroy F. Heitz, & Mariano R. Iglecias

Funding: \$26,355

Water hours and low delivery pressure have long been a part of the daily lives of the people in the islands of the Western Pacific. In Saipan, Commonwealth of the Northern Mariana Islands (CNMI), large investments have been made in system improvements, but delivery problems still exist. A stated goal of the CNMI government is to provide 24-hour water to all residents served by the Commonwealth Utilities Corporation (CUC) water system.

Recently, Stipulated Orders have been filed in the US District Court for the Northern Mariana Islands to compel the utility company to adhere to federal regulations governing water, sewer, and power (Eaton, 2008). As part of this act, CUC should develop a hydraulic model of the water distribution system that will be used for system improvement, system operation, and future system expansion.

Researchers at the University of Guam Water and Environmental Research Institute of the Western Pacific (WERI) developed computerized models of each of the fifteen sub-regions of the CUC water system using the Haestad WaterCAD water system modeling program. Later on, they developed a source, transmission and storage model of the Saipan water system, and a GIS data base of the system. Recently CUC has been added many additional sources of water, new tanks and pipes have been added to the system, and system operation has been changed. To comply with the stipulated order and enable CUC to provide a 24-hour water service, there is a need to reconfiguring the skeleton model of

the water distribution system reflecting new changes in physical and operation of the system. The goal of this project is to:

1. Gather new data on the physical and hydraulic description of all the new water system development for the last three years.
2. Connecting the sub-region according to the new CUC water routing plans.
3. Input the water production to the model and run the model in steady state and time simulation modes.
4. Export the information from Saipan's Haestad model into the GIS layers.
5. Updating the GIS data base and develop the most efficient and cost effective means of transmitting water from water supply rich regions to those that have supply shortages.

The benefit to the CUC will be the ability to: a) determine the amount of water that is being lost through the system (un-accounted for), b) implement various operational systems for transferring water among the 15-sub region for providing 24-hour water service to the costumers, and 3) comply with stipulation order.



Water System Leak Detection Training for Saipan, Commonwealth Utilities Corporation (CUC)



Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Shahram Khosrowpanah

Funding: \$14,180

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 for most of the islands in this area 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 the 2010 Water Resources Advisory Council meeting in the CNMI, the Saipan Commonwealth Utilities Corporation (CUC) requested that WERI carry out a leak detection training program for their water distribution system. This proposal seeks funding to implement such a training program on the island of Kosrae, which currently ranks among the most severely affected islands, insofar as no-revenue water losses from leaks are concerned.

The proposed training will be conducted over a period of one week 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.

Field demonstration and actual leak detection scenarios and exercises. This will include field demonstration, general survey, general pinpointing, emergency pinpointing, estimating leakage, reporting, and vehicle setup



Heavy Metal Status of Soils and Stream Sediments Impacted by Leachate from a Municipal Dump in Yap State, Federated States of Micronesia



Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Christina Filledmed

Funding: \$4,500

The main public dump in Yap State, FSM, is an open, unsanitary facility located approximately 2 miles west of Colonia in the municipalities of *Rull* and *Dalipebinaw*. It was officially opened by the State government in the late 1970s and has served as the main repository of non-segregated wastes from Yap Proper/Main Island since then. The dump receives around 4 tons of garbage and other residential wastes per day from Colonia town area and surrounding rural communities. Currently, it covers an area of approximately 1,460 square meters, and rises to a height of 10 meters at its highest point.

The dump is maintained by the Department of Public Works & Transportation who focuses largely on trash compaction and site stability. While soil cover is used to reduce odor, flies and vermin, it is applied only intermittently and largely inadequate. Of far greater concern, however, is the fact that the dump is not lined and there are no leachate retention systems in place. As a consequence, leachate that exudes at intervals around the dump perimeter during wet weather conditions flow down gradient into a nearby stream known as *Lul nu Tamthaw*. This stream flows east for about 1 km before emptying into a forest of mangroves at the coast. Both the stream and the mangroves are popularly used by local residents for fishing, food gathering and recreational activities. The potential impact of the raw leachate on aquatic resources in these areas has been of long-standing concern to the people of Yap both from an ecological and human health standpoint.

The proposal described herein seeks funding to perform preliminary heavy metal analysis of soil and stream sediments down gradient of the Yap

dump and addresses a critical need recently identified by the FSM-WERI Advisory Council Meeting at their annual meeting in Yap. Heavy metals are common contaminants of concern in unmitigated leachate flows from such solid waste facilities as the one described above. Moreover, certain metals some such as lead, cadmium and mercury are highly persistent poisons that are readily accumulated by fish, shellfish, crustaceans and other aquatic resources commonly harvested for food.

Soil samples will be collected for heavy metal analysis at strategic points around the dump perimeter and down gradient of the facility. Sediments from the impacted *Lul nu Tamthaw* stream (upstream and downstream of the dump) will also be examined at discrete intervals between the dump and the coast. All Chemical analysis will be performed by the WERI Water Quality Testing Laboratory at the University of Guam where adequate facilities and infrastructure exist.

Results are especially crucial at this juncture in view of heightened community concerns, as well as need for baseline information to aid Government & Non-Government planning for improved management and rehabilitation of the dump site over the next five years. The project receives support from the Department of Public Works & Transportation and the Safe Disposal Management Group which leads waste improvement efforts in the State. This project follows current efforts for information gathering and collection in and relating to the current dump site and its possible effects on the surrounding environment and people.



Identifying Watershed Discharge Patterns and Linkages with Ecological Assemblages in Nimpal Area, Yap State Federated States of Micronesia



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

**Principal Investigators:
Peter Houk & Yimnang Golbuu**

Funding: \$20,240

Throughout Micronesia the impacts of land-based sources of pollution to nearshore marine resources are increasing in severity. Numerous conservation planning documents cite land-based pollution among the highest priority items for improved science and management to address, evidenced through WERI's 2010 critical needs list. Briefly, much of the scientific insight to date surrounding land-based pollution and coral reef assemblages has emerged through examining 'heavily polluted' locales and drawing comparisons with 'pristine' locales to define somewhat obvious conditions on reef assemblages that are associated with watershed status. Yet, throughout Micronesia the overwhelming majority of sites lie somewhere between these extreme pollution endpoints. It is critical that we collectively build upon the science to identify more relevant thresholds for efficiently identifying and quantifying sources of water quality impairment. This should include building new science and using the existing body of evidence to approach numerous, site-specific management needs that exist.

Here, we propose to conduct coupled water quality and ecological sampling in Yap State, along the coastline associated with the Nimpal marine conservation area (MCA). The MCA was established in May 2008 by the community to address growing concerns of marine resource depletion and declining coral reef 'health'. Our project would build upon an existing community-led watershed project awarded by the Micronesian Conservation Trust (MCT) that led to the general characterization of discharge patterns and relative volumes of freshwater input, both inside and outside of the MCA. As a result of MCT-funded efforts, the extent of each sub-drainage is becoming better defined, paving the way for enhanced data collection within each to identify where, and what type of improvements to community-based

management will best facilitate success. Here we propose to:

- Build a better statistical understanding of the pertinent water quality and discharge patterns in the nearshore environment,
- Enhance water quality data collection to begin approaching sub-drainage patterns,
- Draw affinities with the contemporary seagrass and macroalgae assemblages.

Following these steps our project aims to approach local concerns regarding macroalgae proliferation over the years. The proposed methods are all collaborative in nature, with an underlying theme of producing sound science through partnerships that build local capacity. All data collection will be conducted with community-based monitoring teams that already have positive relationships with both principle investigators (PI's). Methods include:

- Surface current data collected using GPS-mounted drones,
- Water quality profiles collected using high-resolution, continuously-recording, water quality instrumentation. These data would be integrated with locational data to yield GIS layers for interpretive purposes,
- Enhanced nutrient sampling of priority nearshore waters,
- Ecological data collection to investigate ecological-environmental coupling.

Initially habitat maps will be created that will define the boundaries of relevant ecological assemblages. For this project we will focus on submerged aquatic vegetation habitats, and will establish several study locations in the project vicinity, parallel to shore. Each study site will consist of 5 x 50 m transect lines where replicate estimates of seagrass and macroalgae abundances, and associated datasets described within, are derived with statistical confidence.



Developing Flow Duration Curves for Use in Hydropower Analysis at Ungaged Sites in Kosrae, Federated States of Micronesia



Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Shahram Khosrowpanah & Leroy F. Heitz

Funding: \$23,462

The cost and availability of energy resources is one key factor in the economic development and quality of life of any developing country. This is especially true in the Kosrae, Federated States of Micronesia (FSM), where essentially all of the energy produced is from costly, non-renewable, and potentially environmentally damaging fossil fuel (oil) resources. The cost of fuel to operate the local power plant has risen dramatically over the past years and no doubt will continue to rise in the future. With these increases of fuel costs, it becomes more and more important to explore other means of providing energy to the islands power grid.

Kosrae is blessed with an abundance of surface water resources and because of the extreme topography of the island many of these streams have very high slopes. This combination of abundant streamflow and high stream gradient or slope is ideal for the application of run-of-river-hydropower development. This kind of hydropower development has the least environmental impact and is generally less capital intensive than typical hydropower plants built in conjunction with high dams with large amounts of water storage. While in general hydropower plants are high in first cost, the cost per kilowatt hour of energy production is lower than fossil fuel plants and has the advantage of remaining relatively stable over the life of the project.

In order to explore the feasibility of using hydropower as an additional energy source for Kosrae, it is necessary to be able to define the variability of flow available in the streams where the hydropower plants might be constructed. This is normally done by direct analyses of streamflow data for the stream in question or by applying some sort of inferential techniques from

a gaged to an ungaged stream or from a gaged location on a stream to an ungaged location on that same stream. What is needed in Kosrae is a better means of predicting the variability of flow at ungaged locations that are likely to become candidate sites for future water resources development.

The results of this project will be the development of a means of predicting flow duration curves at ungaged sites in Kosrae. All of the major streams of the island will be divided into stream reaches, or homogenous sections of a stream, that have similar flow properties. These reaches will be identified on maps developed from the detailed Geographic Information System (GIS) map inventory of Kosrae available at WERI. Various statistical and analytical methods will be applied to the existing streamflow data and physically characteristics of the reaches in order to predict the streamflow in each stream reach.

The final results will be a series of GIS maps of the streams of Kosrae with each stream reach identified. By selecting a reach on the provided GIS maps, the user will be able to obtain the average flow in a reach. Those wishing to explore the feasibility of hydro power at the site will be able to enter the average flow information into a simple spreadsheet application which will be provided as part of the study. This application will allow the user to explore various turbine sizing and economic consideration to determine the preliminary feasibility of developing a hydropower facility at a particular site.



Atoll Water Budget Modeling: Information Transfer and Training for the Federated States of Micronesia



Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
John Jensen

Funding: \$10,300

Water shortages are a persistent concern for residents of atoll islands. Normally, water demand is 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 developed an accurate and practical saltwater intrusion and groundwater evaluation model for atoll islands in the FSM. During 2008 and 2009, the developers of the model presented initial demonstrations to a limited number of available water resource managers and government officials on Yap and Pohnpei. Use of the model to predict the amount of fresh groundwater during average seasonal climatic conditions as well as periods of intense drought for the atolls of the FSM was carried out during the summer of 2010, and results of this analysis, along with additional training on atoll island geology and hydrology, were presented to FSM officials on Pohnpei in October 2010. During this year's Advisory Council meeting on October 5, 2010, on Pohnpei, council members specifically requested further training and presentation of results to be given next year on Chuuk, which contains 11 of the 32 atolls in the FSM. (Item III.5, Education and Professional Training, FSM Critical Water Resources Research, Education And Training Needs: Continue Atoll Groundwater Modeling workshops in all FSM States with atoll islands.)

This is an information transfer project in which end-users will be trained by WERI instructors on the derivation of the model, the operation of the model, the application of the model to estimate the responses of atoll island aquifers in the Caroline Islands to expected types of seasonal and inter-annual changes in rainfall, and finally results of the model when applied to specific FSM atoll islands. Application of the model thus also meets an additional identified need to continue the development of appropriate groundwater management plans for low and high islands throughout the FSM (Item II.4, Water Quantity Projects).

The objective is to train users of the model so that they can independently operate it and interpret the results. Training will be tailored for application of the model to the atolls of Chuuk. Such use may include making forecasts of the effects of selected changes in rainfall on atoll islands affected by significant natural events, such as ENSO-driven droughts, tropical storms, or wash-over events. A second objective is to establish an ongoing technical support relationship between the authors and 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 Federated States of Micronesia.



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 class calculate stream flow of a local river

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.



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.



Students in WERI computer/GIS 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 Coordinator, **Dr. Shahram Khosrowpanah**, 'phone: 671-735-2685, e-mail: khosrow@uguam.uog.edu



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