INTRODUCTION TO RESEARCH ACTIVITIES & TEACHING PROGRAMS

by

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

February 2014

INTRODUCTION TO RESEARCH ACTIVITIES AND TEACHING PROGRAMS

Prepared by

Shahram Khosrowpanah
Director

February 2014

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

WERI Faculty collecting field observations of the Geus River while setting up monitoring stations to assess annual turbidity and stream levels. (South of Guam)

WERI Hydrogeologist Dr. John Jenson, Graduate Research Assistant Vivianna Bendixson, and USGS hydrogeologist Todd Presley collecting field data at a USGS Groundwater Observation Well.

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 39th 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-2013 WERI faculty were involved as Principal Investigators and/or advisors on 23 research and training projects with a combined budget of approximately $1,011,762. Of this, $166,575 was awarded through the Water Resources Research, Institute Program administered by USGS under 104-B, while $378,000 was received as a special appropriation from the Guam Legislature. The remainder came from Federal and Private 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:

Dr. Shahram Khosrowpanah,
khosrow@uguam.uog.edu
Director, WERI, University of Guam
UOG Station, Mangilao, Guam 96923
Phone: 1-671-735-2694,
Fax:1-671-734-8890

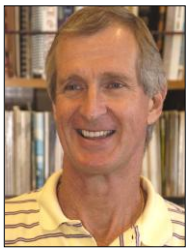
WERI FACULTY, STAFF & STUDENTS

DIRECTOR

Dr. Shahram Khosrowpanah
Prof. Civil Engineering

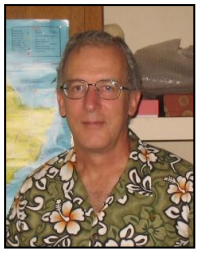
FACULTY:

Dr. John Jenson
Prof. Hydrogeology



Dr. Gary Denton
Prof. Environmental Toxicology

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:

April Hachero
Graduate RA

Maria Kottermair
Graduate RA

Bill Whitman
Graduate RA

Leena Muller
Graduate RA

Kaylyn Bautista
Graduate RA

Nathan Von Oort
Graduate RA

Vivianna Bendixson
Graduate RA

ACTIVE RESEARCH PROJECTS

PROJECTS FUNDED BY:
USGS 104B WATER INSTITUTE PROGRAM
(Initiated March 1,2014)

GUAM:

Estimating the Natural Limits of the Northern Guam Lens Aquifer: A First Step Toward Sustainable Management.

Prediction of Flow Duration Curves at Ungaged Stream Sites in Guam.

Expanding 'Guam Water Kids' with Five Modules to Prepare HS Students for Service-Learning Opportunities Beneficial to Freshwater Resources.

One-Day Field Course for Water Resource Professionals and Island Educators, with Educational Webpage on the Northern Guam Aquifer.

COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI):

Impact of Stormwater Discharges and WWII on the Mercury Status of Fish from the Southern Section of Saipan Lagoon.

Measurement of Groundwater Salinity for Selected Production Wells, Island of Saipan, CNMI.

Optimizing Saipan's Water System Operation.

Develop a GIS Model for Analysis of Groundwater Quality Data in Saipan.

FEDERATED STATES OF MICRONESIA (FSM):

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

Evaluating Rainfall Variability and Drought Thresholds for Atolls and High Islands of the FSM.

Develop Community Based Watershed Management Programs to Improve Water Quality of Community Water Systems in Pohnpei, FSM.

Pilot Study to Improve the Wastewater Treatment System in Yap.

ON-GOING PROJECTS
FUNDED BY: OTHER SOURCES

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) through GUAM BUREAU OF STATISTICS AND PLANS

a. **Development of a GIS Assessment Tool for Determining Cumulative and Secondary Impacts from Increase Development on Guam**
b. **Development of a Digital Watershed Atlas for Northern Guam**
c. **Assessment of Turbidity in the Geus River Watershed in Southern Guam**

US GEOLOGICAL SURVEY (USGS) through GUAM BUREAU OF STATISTICS AND PLANS

Update the Watershed Boundary Dataset (WBD) and National Hydrography Dataset (NHD) of Guam

GUAM WATERWORKS AUTHORITY (GWA)

A Study on Influence of Seawater on Biological Wastewater Treatment on Guam, CNMI, and FSM

US GEOLOGICAL SURVEY (USGS)

Pacific Islands Climate Center

NATIONAL SCIENCE FOUNDATION

Holocene Hydrological Variability across the Western Pacific Warm Pool

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center (2014-2015)

DIRECT LOCAL FUNDING FROM THE GUAM LEGISLATURE SUPPORTS:

A. COMPREHENSIVE WATER MONITORING PROGRAM (CWMP)

Stream-flow, Sediment Discharge, Rainfall and Groundwater Characteristics Data Collections in Guam

B. GUAM HYDROLOGIC SURVEY (GHS)

Hydrological Database for Northern Guam

Estimating the Natural Limits of the Northern Guam Lens Aquifer: A First Step Toward Sustainable Management

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Mark Lander & John Jenson

The Northern Guam Lens Aquifer (NGLA) provides 80% of Guam's drinking water. The anticipated addition of US Marine Corps activities will require additional production, while ongoing economic growth will increase demand as well. Policy-makers and water managers want to know what volumes of water can be sustainably withdrawn from various parts of the aquifer, and how increased withdrawal will affect salinity. The extent to which quantity and quality might be optimized, however, is ultimately constrained by the *natural limits* on aquifer recharge, storage, and water quality imposed by climatic and geologic conditions. This study is therefore directed at estimating the *maximum natural capacity* (superseding the obsolete concept of *sustainable yield*) of the NGLA to provide a baseline against which to evaluate future proposals for holistic sustainable management approaches.

The objectives of the respective phases of this project are:

(1) Data acquisition and literature review of published and emerging research regarding spatial and temporal distributions and trends of rainfall and salinity in the NGLA by WERI, USGS and others;
(2) Study of meteorological and geological phenomena that might control or influence the observed rates and amounts of rainfall, infiltration, storage, flow, and salinity; and
(3) Analyses of spatial and time-series data on rainfall, groundwater levels, specific conductivity, chloride concentrations, and production rates from existing wells within the NGLA; and
(4) Application of a groundwater model to estimate the maximum production that could be attained from an optimum set of strategically spaced shallow-draft vertical wells producing at specified maximum acceptable values of salinity, under specified natural conditions (*e.g.*, long-term average rainfall, vs. historic wet and drought conditions)
(5) Development of a production function that estimates the relationships between quantity and quality that might be produced by an ideal production system (i.e., one that would produce maximum quantity for a given quality or maximum quality for a given quantity).

Prediction of Flow Duration Curves at Ungaged Stream Sites in Guam

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Leroy Heitz & Shahram Khosrowpanah

In order to properly manage a region's water resources, it is important for water managers to know the time variability of flow in the streams of that region. Not only what are the highest flows, such as what would be available from a flood frequency study, but also how the flows vary day to day, season to season, and year to year.

Guam is no different than other areas requiring water resources investigations. In order to properly carry out good water resources management, it is necessary to be able to define the variability of flow available in Guam's streams. This is normally done by direct analyses of streamflow data for the stream in question or by applying some sort of inferential techniques from a gaged to an ungaged stream or from a gaged location on a stream to an ungaged location on that same stream. Of course, the most reliable means is to use actual stream flow data measured at the point of interest. The problem in Guam, as in most locations, is that stream flow information is not available for all possible sites where information is required. What is needed is a better means of predicting the variability of flow at ungaged locations that are likely to become candidate sites for water resources investigations.

The goal of this project will be the development of a means of predicting flow duration curves at ungaged sites in Guam. All of the major streams in Southern Guam 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 Guam available at WERI. Various statistical and analytical methods will be applied to the existing streamflow data along with the physical characteristics of the reaches in order to predict the streamflow variability in each stream reach.

Expanding 'Guam Water Kids' with Five Modules to Prepare HS Students for Service-Learning Opportunities Beneficial to Freshwater Resources

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Ann Card

The use of "Guam Water Kids," localized teaching materials about the importance of protecting and preserving fresh water resources, can be extended to high schools students through the Guam Department of Education (GDOE) service-learning project. Beginning in 2014, some 9,000 high school students will be required to perform 75 hours of service learning each to qualify for graduation. The superintendent's service-learning representative, Dr. Eloise Sanchez, has shared an urgent need to provide materials to assist teachers in preparing their students to participate in community service and has approved participation of "Guam Water Kids" as a community partner. The objectives of this proposal are to fill this need by:

- Providing Service-Learning Modules — Five appropriate learning modules about fresh water resources for use in the service-learning program and delivered through each high school's appointed facilitator. Teachers will use these educational modules to prepare their students to (1) participate in service projects that are beneficial to fresh water resources and (2) make "Guam Water Kids" presentations to middle school students, youth groups and other community organizations.
- Aligning to Common Core State Standards —Follow the STEM (Science, Technology, Engineering and Math) format and align the service-learning modules to the nationwide Common Core State Standards as GDOE as completes its full implementation in 2014. Existing "Guam Water Kids" Lesson Plans to be updated from old standards in use to these new, nationally recognized standards.
- Supporting with "Guam Water Kids" Website — Expand the teacher support section of www.guamwaterkids.com to introduce the new service-learning modules and deliver corresponding content/resource materials. Annotate website throughout with Common Core State Standards references. Perform an update to the existing self-paced slide shows for use with tablets and smart boards to increase technology in learning opportunities.
- Surveying participating educators to evaluate the use and effectiveness of "Guam Water Kids" service-learning modules. Include face-to-face interviews. Preserve contact information. Analyze and report results.

A Poster Created by Students in the 'Guam Water Kids' Program.

One-Day Field Course for Water Resource Professionals and Island Educators, 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 course will be modeled after, and build upon, a similar course offered the previous year to senior executives in local and federal government agencies on Guam. This program has been extremely well received in its first two offerings, so is being repeated to extend it to more.

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.

Executive/Professional Officials examining physical features of Barrigada Limestone at the Dededo Quarry, while on the one-day field course.

Impact of Stormwater Discharges and WWII on the Mercury Status of Fish from the Southern Section of Saipan Lagoon

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Gary Denton

On July 15, 1944, several thousand US troops stormed the southern beaches of Saipan Lagoon to liberate Saipan from the hands of the Japanese who took control of the island shortly after WWI. Japanese defenses positioned along the coast were heavily shelled prior to the US invasion, as were US troops in the lagoon during the assault. While this historic battle unquestionably marked the turning point of WWII, it left behind a legacy of chronic environmental mercury contamination that still exists to this day. The first hint of a potential mercury problem in this area emerged in 2007 when an independent research team reported frequent and occasionally high mercury detections in stormwater discharged into the upper section of the southern half of the lagoon (Environ Inc. 2007). These findings were especially noteworthy because mercury is rarely encountered in urban runoff (USEPA 1983). At about the same time, WERI researchers noted unusual mercury distribution patterns in sediments throughout the southern half of the lagoon (both upper and lower sections) that suggested inputs washed into the lagoon from land-based sources were superimposed upon a scattering of mercury contamination emanating from within the lagoon itself (Denton *et al.* in press). Since mercury was used extensively in WWII (as mercury switches in projectiles and rockets, and as the primary explosive, mercury fulminate, in primers and detonators of artillery shells and percussion caps of bullets) it was postulated that pockets of mercury contamination associated with exploding WWII ordnance and lost ammunition had been created along the coastal belt and in the lagoon.

The full impact of this contamination on fisheries within the southern half of Saipan Lagoon has only partially been addressed and is the subject upon which this proposal is predicated.

In 2010, WERI examined mercury levels in fish from approximately the same stretch of coastline as that visited earlier by the Environet team. The study focused on two fish types with restricted foraging ranges: snapper (*Lethrinus* spp.) and soldier fish (*Myripristis* spp.). The results of the investigation revealed a marked and irrefutable southerly increase in mercury concentrations in both fish types.

The project described herein therefore proposes to extend the fish sampling survey from its previous southern endpoint, adjacent to Chalan Monsignor Guerrero Road, to Agingan Point at the southern end of the lagoon – a distance of approximately four km. The survey will focus on the same two fish types as before and divide the sampling area into ~500 m shoreline blocks, or zones, that extend the same distance offshore, where possible. The assistance of local personnel and other government agencies in procuring samples will be obtained where necessary. The primary objectives of the study are to: a) identify the impact of mercury enriched stormwater discharges in the study area on mercury levels in the edible tissue of two resident fish types; b) evaluate potential health risks associated with unrestricted consumption of fish from within the impacted area; c) provide additional data that will assist with the identification and delineation of areas of contaminant enrichment within Saipan Lagoon, and d) enhance ongoing marine water quality monitoring, management and mitigation strategies for Saipan's coastal waters.

Measurement of Groundwater Salinity for Selected Production Wells, Island of Saipan, CNMI

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Elena Alexandrova, Heidi Yelin, Zachary Frey, & Max Simian

Groundwater resources of Saipan, Northern Marianas Islands, provide a majority of the public drinking supply. Fresh water pumped from the basal lens is replenished continuously by rainfall. Precipitation percolates through the unsaturated limestone host unit to reach the upper levels of the fresh water aquifer. The aquifer supplies potable water at several well fields. Some of these fields have historically shown elevated salinity (measured as chloride ion) as a result of high pumping rates that exceed the recharge rates of the reservoir, very deep pump placement, and proximity to the transition zone between the fresh and saltwater layers. This water quality problem has been addressed by past researchers (Van der Brug, 1985, Carruth, 2003); however, current information has not been compiled in recent years. While the USEPA recommended concentration for chlorides is 250 mg/L (EPA, 1986) measurements from some wells have exceeded 2,000 mg/L. Monitoring for chlorides is required and performed by CUC on a quarterly basis, for all wells.

Recent changes in island population (a significant decrease) and an increase in utilities costs have also resulted in lower water consumption over the last five years.

The project will be conducted in two parts. The first task is compilation of historical salinity data from selected wells. The data source is the CUC Water Quality Laboratory records. A period of 2009 through 2013 is considered for this data compilation activity.

The second task consists of frequent, scheduled collection of groundwater data (salinity measurements by conductivity and chloride argentometric quantification) of selected wells throughout 2014. This work will produce a current record of salinity variation in correlation with pumping rates and precipitation. Monthly pumping rate records for the selected wells will also be collected from CUC Water operations.

Production Well in Saipan

Optimizing Saipan's Water System Operation

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Brian Bearden & Shahram Khosrowpanah

A stated goal of the CNMI government is to provide 24-hour water to all residents served by the Commonwealth Utilities Corporation (CUC). In response, for the past several years the Saipan water delivery system has undergone significant changes. In 2006, the EPA acknowledged that the lack of safe drinking water was among the top environmental challenges facing the CNMI, particularly Saipan (Erediano, 2006). As the result, In March of 2009, the Commonwealth Utilities Corporation (CUC) entered into a stipulated order (STO) for preliminary relief under an agreement with the Government of the United States. The order provided for a long list of compliance items that CUC must complete in order to satisfy the stipulated order. One major item that CUC must prepare is a Master Plan for their water supply and waste water systems. Finally, in 2013 an updated master plan "Drinking Water Mater Plan-Saipan, Commonwealth of the Northern Mariana Island" was completed. Through field visits, the master plan did an assessment of the current state of the water infrastructure and provided recommendations for improvement. Reducing system leakage (non-revenue water), monitoring pressure changes throughout the system, and monitoring water usage were on the high priority list that was recommended to CUC for improvement. According to the master plan, non-revenue accounts for nearly 70 percent of the water production on Saipan. Assessing various strategies for reducing non-revenue water and providing 24-hour water was identified as one of critical research needs for CNMI at the CNMI research advisory meeting of October 17, 2013.
In order to reduce the non-revenue water rate and improve the system operation it is necessary to have a good knowledge of the pressure changes in the water system and how this changes with the hourly water use.

The specific objectives of this project will be to:

1. Determine the pressure change throughout the CUC's water distribution system using pressure loggers that will be installed at selected fire hydrants.
2. Continue to improve Diurnal demand pattern (changes of water demand during the day and month) that was developed in FY2013.
3. Examine the physical components of the entire water distribution system
4. Determine water system operation that assists CUC provides 24-hour water service to all its customers.

Develop a GIS Model for Analysis of Groundwater Quality Data in Saipan

Funded by:
US Geological Survey, Water Institute Program

Principal Investigators:
Yuming Wen & Brian Bearden

Water quantity and quality is essential to sustainable development and quality of life in tropical islands. The Commonwealth of the Northern Mariana Islands (CNMI), composed of a chain of 14 tropical islands in the western pacific, is facing problems with water resources and quality. The water quantity and quality is affected not only by natural forces such as tropical storms/typhoons, droughts, climate change and sea level rise, but also by anthropogenic activities. Human activities have contributed a lot to the increase of pollutants into water bodies. The increase of impervious surfaces is related to human induced activities, affects water quantity in CNMI due to aquifer recharge and degrades the quality of water including drinking water. The US Census data of 2000 and 2010 indicate that most of population (about 90% for both census years) lived on Saipan. Therefore, environmental concerns, and water quantity and quality issues should be paid specific attention on Saipan. In order to improve water quality and protect the environment in the inhabited islands, it is important to evaluate water quality of the aquifers in Saipan, locate drinking wells with quality deficiency, and monitor trends of water quality from drinking water wells.

The main objectives of this project are listed as follows.

1. Processing groundwater quality data in a way so that they can be further processed and linked to a GIS format;
2. Analyzing groundwater quality data geographically and over time;
3. Identifying drinking water wells that have deficient water quality or that may develop deficient water quality.
4. Establishing a GIS-based model for visualization of groundwater quality data, and analysis of groundwater quality geographically and over time.

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 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 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.

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 2014, 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) (Taborosi and Martin, 2009; Taborosi and Collazo, 2010), which will be used as test cases. (Items II.4, II.8 and II.15 of Water Quantity Projects, and Items III.2, III.3 of Education and Professional Training, FSM Critical Water Resources Research, October 10, 2013**)**.

Evaluating Rainfall Variability and Drought Thresholds for Atolls and High Islands of the FSM

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Mark Lander & Shahram Khosrowpanah

All states of the FSM are vulnerable to damaging drought conditions, despite high average annual rainfall amounts (e.g.,Yap Island = 120 inches, Chuuk Airport = 135 inches, Kolonia, Pohnpei = 185 inches, and Kosrae Airport = 205 inches). In the first few months of the calendar year that follows a strong El Niño, the rainfall across all of Micronesia tends to be well below normal. Sharply reduced rainfall can quickly become a life-threatening emergency as reservoirs and rain catchment systems run dry, and agricultural plants are damaged. This is especially true on atolls where the water lenses are thin and rain catchment is a prominent source of drinking water. Micronesia-wide severe droughts in 1983, 1992 and 1998 required the deployment of U.S. military assets to the islands of the FSM to help transport and generate drinking water supplies. Recently, a more localized severe drought occurred in the northern atolls of the Republic of the Marshall Islands. This drought was so severe over the first few months of 2013 that on 14 June, U.S. President Obama declared a disaster for the RMI, authorizing additional U.S. Government funding for relief and reconstruction. Another recent local severe drought occurred on the atoll of Kapingamarngi (Pohnpei State) where rainfall during the six-month period beginning in September 2010 through February 2011 was only 7.12 inches, or 7% of the normal 48.37 inches. These dry conditions at Kapingamarangi and at other islands close to the equator (e.g., Tarawa and Nauru) are thought to have occurred because of a La Niña-related westward extension of cold sea surface temperatures along the equator. Small personal distillation units from government and non-government sources and reliable water shipments by the FSM and Pohnpei State governments averted a likely disaster.

The proposed project will compile and evaluate historical and current climate data from all FSM existing sources to include the first-order weather office station data and all secondary stations. The project P.I. has a good working relationship with all FSM weather office managers and access to nearly all data from secondary stations. The data will be analyzed to determine the state-by-state main and outer island character of rainfall, including the typical response to El Niño and the nature (e.g., severity and frequency) of the more localized extremes.

The objectives of this project are to:

(1) compile as much of the FSM climate record as possible from the first order stations and the growing network of outer island stations;
(2) analyze the climate records to provide a detailed picture of El Niño-related drought, and the nature of more localized droughts;
(3) establish impact thresholds during periods of reduced rainfall; and,
(4) develop an outreach itinerary for group discussion of drought during FSM visits.

Develop Community Based Watershed Management Programs to Improve Water Quality of Community Water Systems in Pohnpei, FSM

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Eugene Joseph & Francisca Obispo

Water is essential and part of our daily life. The steep, tropical watersheds of Pohnpei, Federated States of Micronesia can provide ample water for distribution and usage by everyone, as long as upstream forests are properly managed. Water shortages are often caused by deforestation and water quality is often compromised by harmful farming techniques. Example of harmful or unsafe farming techniques is raising livestock especially pigs near the river bank, washing the pig waste into the rivers and causing bacteria or polluting the waters around Pohnpei. Water quality is one of the main issues around the island and it's due of rapid growth of population, people build their houses close to the rivers and do their farming right on the river banks.

Over the years, Conservation Society of Pohnpei (CSP) has incorporated projects that can help with water quality issues in the communities. CSP has started with community outreach awareness program to help the communities to understand what has been happening to our rivers. After the outreaches CSP has started a water quality project by removing and relocating pig pens from the rivers in Mand Madolenihmw and Nanpil River in Nett. With the help of Integrated Water Resource Management program in 2011, CSP and partners were able to conduct a source of pollution survey in Nett watershed as a pilot site. Result of this survey shows the sources of pollution that are impacting the rivers in Nett.

The goal of this project is to aid communities adjacent to the Watershed Forest Reserve (WFR) areas to implement their Conservation Action Plan (CAP), develop adaptive management plans, improve Watershed management through public and private partnerships, develop sustainable alternative sources of income and finally to promote conservation law enforcement. This project would contribute to the enhanced integrated management and sustainability of Pohnpei's watershed steering committee network. In addition, this project would also improve the practice of managing the watershed to improve our waters and conservation throughout Micronesia.

The objectives of the project are:

- To develop community-based sustainable watershed management plan using The Nature Conservancy's (TNC) Conservation Action Plan (CAP) tools
- Rehabilitate, monitor, enforce and protect watershed sites through existing community-based Forest Ranger program;
- Implement biophysical monitoring and keep records of monitoring data to help steer management decisions on improving watershed and water quality in Pohnpei

Pilot Study to Improve the Wastewater Treatment System in Yap

Funded by:
US Geological Survey, Water Institute Program

Principal Investigator:
Joseph 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 reason for this can often be attributed to a lack of functional technology due to inadequate funding for both capital investments and ongoing O&M.

On the island of Yap, in the Federated States of Micronesia (FSM), there is a centralized sewage treatment plant (STP) that is designed to provide only a primary level of treatment. Though the plant is well functioning, according to its design, the treatment level is clearly inadequate, resulting in the discharge of nearly raw sewage via a short outfall to the shallow ocean bay.

An upgrade of the existing STP to level capable of providing sufficient treatment power for removal of most dissolved organic contaminants, would require a major capital investment and be met with higher O&M costs as well. However, the possibility exists of fitting an attached-growth medium to the existing unit to serve as a biocarrier, which would allow for retention of beneficial biomass, thus providing the potential for enhanced treatment efficiency.

The objective of the proposed project is to conduct a pilot test by placing biocarrier net material attached to frames in the flow channel of the existing STP. System performance would be evaluated by quantifying removals of organic compounds across the biocarrier test zone over time.

Yap Sewer Plant Sign

Interior of the Yap Sewer Plant

Development of a GIS Assessment Tool for Determining Cumulative and Secondary Impacts from Increase Development on Guam

Funded by:
US Dept. of Commerce, National Oceanic and Atmospheric Administration (NOAA), Guam Coastal Management Program (GCMP)

Principal Investigator:
Joseph Rouse, Mark Lander, & Shahram Khosrowpanah

Due to the anticipated growth in the local economy, increasing tourist numbers and the military buildup, there is tremendous pressure on local government agencies to move quickly to approve development projects without carefully considering CSIs to the environment and to the community. The Guam Coastal Management Program (GCMP) is planning to develop a CSI Policy that creates a mechanism to assess such impacts, determine the extent of the impacts to natural resources and requires developers to assess CSIs of proposed developments. The purpose of this project is to develop a management tool that will determine the extended impact due to proposed development on our environment and incorporate it into the local policy. The results will assist the GCMP in developing and determine CSI policies.

Aerial View of Northern Guam

For this year, the northern part of the island is selected for developing the CSI management tool. The northern half of Guam is 1) home to 85% of the island's population, 2) subject to ongoing military buildup, 3) the focal point of Guam's vital tourism industry, 4) contains many of the island's pristine coral reefs and unique coastal habitats, 5) a karst plateau where drainage into the coastal zone is entirely by subterranean pathways and difficult to delineate, and 6) the aquifer source of drinking water for more than 80% of the residents and virtually all tourists. Local population growth currently stands at over 5% per year, tourism industry continues to expand, and the transfer of military facilities and personnel from Okinawa to Guam is on schedule. The pressure on coastal, marine, groundwater, and land resources that Northern Guam is experiencing is unprecedented. This project will focus on impacts from activities related to the quality of groundwater, coastal waters and coral reefs.

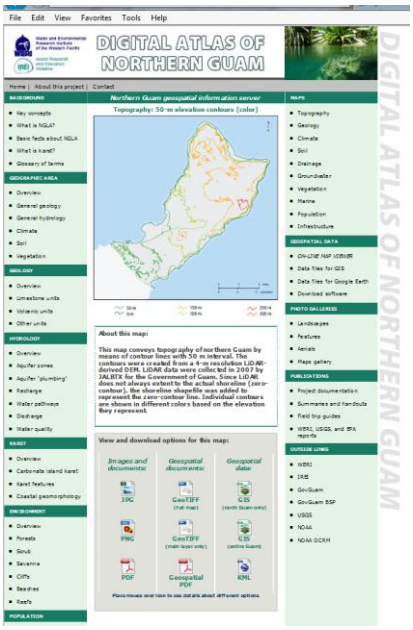
Development of a Digital Watershed Atlas for Northern Guam

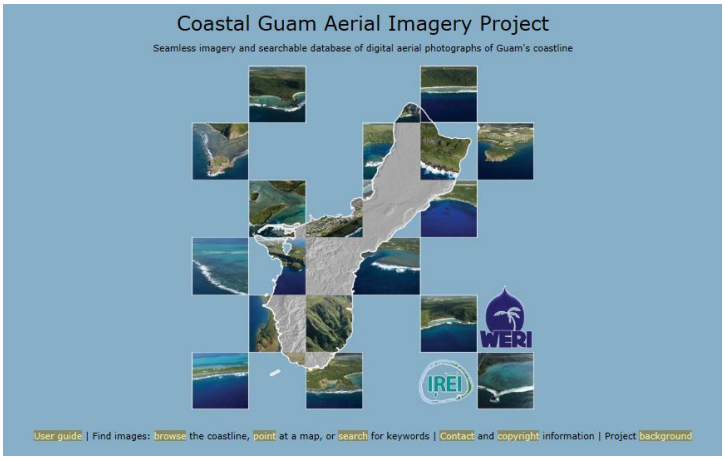
Funded by:
US Dept. of Commerce, National Oceanic and Atmospheric Administration (NOAA), Guam Coastal Management Program (GCMP)

Principal Investigator:
Shahram Khosrowpanah & Danko Taborosi

Sustainable utilization of natural resources requires an effective management plan. An effective management plan requires accurate baseline information. Baseline information often exists but is often not readily available to those who need it. It is, therefore, important that what is considered baseline information be stored and formatted in such a way that it can be readily available to anyone involved in resource management and studies. In addition, such information should be standardized and widely compatible; equipped with metadata regarding sources, techniques, and restrictions; and easily updatable.

After creating a successful and frequently accessed and utilized web-based digital atlas known as "Natural Resources Atlas of Southern Guam", which covers southern Guam and is (available at ***south.hydroguam.net***, researchers at WERI have now created a sister resource that covers the northern half of the island. It is entitled "Digital Atlas of Northern Guam" and is available at ***north.hydroguam.net***. Both sites rely on geographical information system (GIS) technology to disseminate geospatial data on various aspects of natural and man-made features of the area. Presently we are in process to finalized the web-site.





Screenshots of http://www.hydroguam.net

Assessment of Turbidity in the Geus River Watershed in Southern Guam

Funded by:
US Dept. of Commerce, National Oceanic and Atmospheric Administration (NOAA), Guam Coastal Management Program (GCMP)

Principal Investigator:
Joseph Rouse, Mark Lander, & Shahram Khosrowpanah

The programmatic implementation of the Guam Coastal Nonpoint Pollution Control Program (GCNPCP), in accordance with the requirements of Section 6217 of the Coastal Zone Act Reauthorization Amendment (CZARA) of 1990, requires the development of a multi-year watershed restoration strategy. According to the guidance of Section 6217, the Watershed Restoration Action Strategies should include watershed assessment and identification of opportunities to reduce nonpoint sources pollution.

For this project, the Geus and Manell (GM) watersheds were selected for a study of turbidity levels. These two watersheds are among the most pristine on Guam. The two watersheds are comprised of dense forest, some savanna, some wetlands at the lower reaches, and a small amount of badlands along the surrounding ridges. The village of Merizo is situated on the coastal plain, with considerable coastal development including the island's primary coastal road and the Cocos Island boat dock and other marine facilities. A few new homes are being built in the Pigua subdivision, located on a ridge to the west of the lower reaches of the Geus river. As the military continues to build more housing and other infrastructure on Guam and in Apra Harbor, there have been some efforts to offset environmental damage. The overall objective of this project is to establish baseline information on turbidity for the GM watersheds. The specific goals are: 1) to collect available information about the watershed's current condition from previous studies as well as field visitations, 2) to perform a watershed assessment of the existing condition in order to determine what degraded or impaired areas may exist in the watershed and why, 3) to set up equipment to monitor rainfall, streamflow and turbidity in the GM watersheds, and 4) to generate baseline information on watershed turbidity.

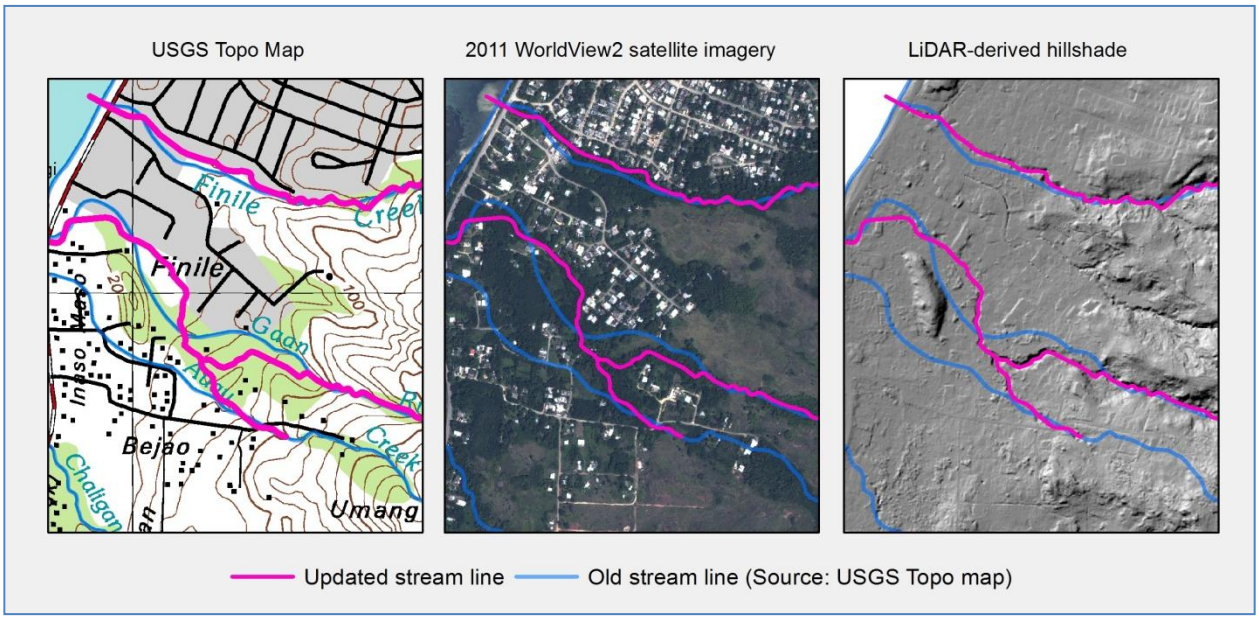
Installation of data loggers in the Geus River

Updating the Watershed Boundary Dataset (WBD) and the National Hydrography Dataset (NHD) of Guam

Funded by:
US Geological Survey, Guam Bureau of Statistics and Plans

Principal Investigator:
Maria Kottermair

The National Map provides the nation with access to basic geographic information describing the landscape of the United States and its territories. The National Hydrography Dataset (NHD) and the Watershed Boundary Dataset (WBD) are part of the National Map. This on-going project involves updating the NHD and WBD for Guam using a geographic information system (GIS). The update process is based primarily on high-resolution LiDAR-derived surface raster layers and, for secondary reference, the most recent satellite imagery, 2011 WorldView2 imagery by Digital Globe. A semi-automated approach was chosen to ensure a very accurate and cartographically better result (than choosing a fully manual or automated approach). The approach consists of digitizing main rivers and streams on-screen and then running the ArcHydro model, an extension of the ArcMap program, to derive a high-resolution stream network and watershed boundaries. The resulting vector data will then be formatted to meet the U.S. Geological Survey's National Hydrography database standards, which also includes identifying characteristics of the rivers and stream (e.g., perennial, intermittent or ephemeral etc.). The last step in the update process is incorporating the updated data into The National Map and geo.data.gov.



A Study on Influence of Seawater on Biological Treatment on Guam, CNMI, and FSM

Funded by:
Guam Waterworks Authority (GWA)

Principal Investigator:
Joseph Rouse

Management of fresh water resources has increasingly become an issue of concern in water-stressed islands of the western Pacific. With projected increases in Guam's population, the sustainable yield of the Northern Guam Lens Aquifer, which serves as a potable water source for over 80% of the residents and virtually all the tourists on Guam, may be surpassed in the near future. Accordingly, there is an urgent need to develop strategies for sustainable water use.

One option to conserve freshwater involves the use of seawater for toilet flushing, which would reduce the demand for potable water by over 100 L/capita/day, amounting to 30% of domestic demands. The use of seawater for flushing is a known practice (Leung et al. 2012); however, its influence on the biochemistry of wastewater treatment is yet a relatively new field of study with very few publications in the literature.

A key feature unique to seawater-based biological wastewater treatment, is the abundance of sulfate in seawater, which has the potential to serve as an electron acceptor, versus more commonly used dissolved oxygen or nitrate. Thus, as a first step, a waste stream consisting of seawater carrying organic contaminants could be treated effectively under anaerobic conditions. During this step, most of the organic compounds will be oxidized (eliminated) and some of the sulfate reduced to sulfide. In the second step, the sulfide can then serve as an electron donor for reduction of nitrate and formation of nitrogen gas by autotrophic denitrification (van Loosdrecht 2012), versus more commonly observed heterotrophic denitrification. The third step would be ordinary aerobic nitrification of ammonium to nitrate, with return of the nitrate-rich wastewater to the second step (as internal recycle) for denitrification. Overall, this approach has been shown to have the potential to reduce excess sludge production by 90%, energy requirements by 35%, and greenhouse gas emissions by 36% as compared to a conventional treatment system for biological nutrient removal (Lu et al. 2011).

The objectives of this study will be to evaluate the influence of seawater on biological wastewater treatment processes and determine optimal conditions for design and operation of seawater-based systems. Attention will be given to monitoring key parameters (COD, NH_4^+, NO_3^-, etc.) that will allow for determination of treatment efficiencies and rates. These objectives will be met by conducting continuous-flow treatment under various operational conditions using moving-bed unit processes. A porous biocarrier for immobilization and retention of biomass will be employed.

Pacific Islands Climate Center

Funded by:
US Geological Survey

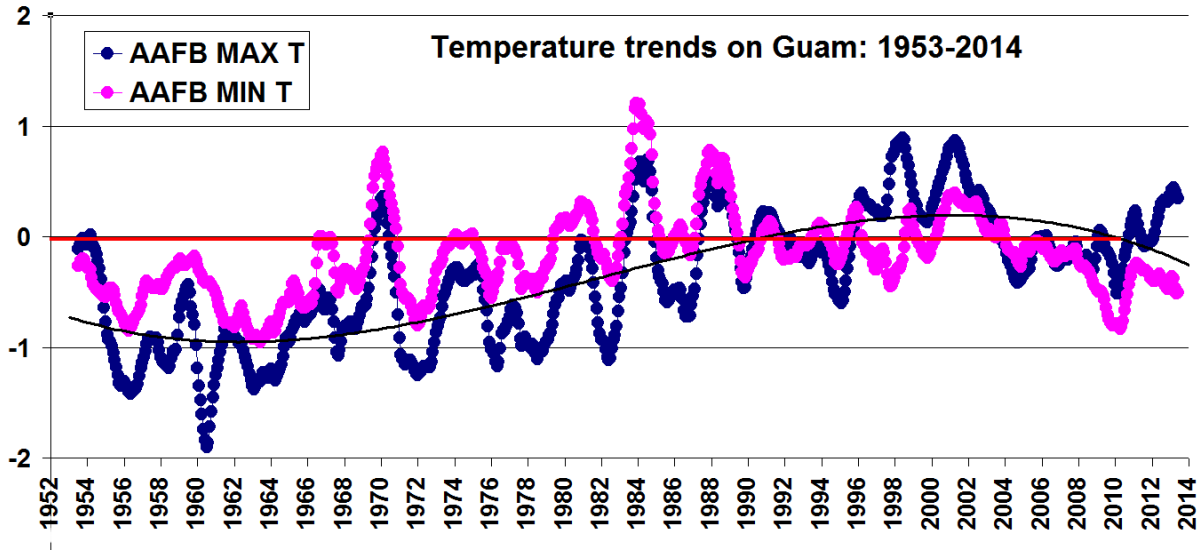
Principal Investigator:
Mark Lander & John Jenson

In the year 2011, the US Department of Interior announced the formation of the Pacific Islands Climate Science Center (PICSC). The PICSC is a consortium led by the University of Hawai'i at Mānoa, the University of Hawai'i at Hilo, and the University of Guam. Together with two other new regional climate science centers, the Pacific Islands Climate Science Center is part of a network of eight regional centers established by the Department of the Interior. The centers serve to provide land managers in federal, state and local agencies access to the best science available regarding climate change and other landscape-scale stressors impacting the nation's natural and cultural resources.

The PICSC addresses regional climate change challenges such as:

(1) Coral Reef Health
(2) Fish and Wildlife Response to Climate Change
(3) Invasive Species
(4) Marine and Coastal Resilience
(5) Protection of Trust Species
(6) Sea-level Rise and Coastal Erosion
(7) Wildlife Disease

The UOG is now in its second year of PICSC-sponsored ongoing efforts to understand the regional climate system, and to provide outreach, education activities and expert advice for local and regional climate, climate variability and climate change.



Holocene Hydrological Variability across the Western Pacific Warm Pool

Funded by:
National Science Foundation (NSF)

Principal Investigator:
John Jenson

This is a collaborative project with climate scientists at the University of Texas-Austin. The Western Pacific Warm Pool (WPWP) plays a major role in the global climate system and has important direct effects on climate within the Indo-Pacific region and areas adjacent to the Pacific Basin. This projects seeks to determine spatial and temporal changes in precipitation over the Holocene (last 10,000 years) across the WPWP by examining the prehistoric climate records at sites with varying sensitivity to El Niño-Southern Oscillation (ENSO) dynamics and monsoon dynamics. The central objective is to determine if the tropical Pacific played an active or passive role in driving the changes in the global hydrological cycle over the Holocene. The Holocene provides a natural climate experiment that would help quantify the links between external forcing and mean state tropical Pacific climate change. This collaborative project consists of routine field sample collection and laboratory analyses to generate hydrologic records using speleothem proxies from four sites in the WPWP: Guam, the Solomon Islands, Vanuatu, and the Philippines. The origin of the project dates to 2005, when the principal investigators collected speleothems in Guam, the Solomon Islands, and Vanuatu for exploratory analysis. Additional visits to Guam in 2008 and 2009 and the Philippines in 2008 formed the scientific basis for this research. Sample collection on Guam has now been ongoing since August 2008, and is providing new insights into the dynamics of not only inter-annual climate patterns, but also into the relationships between rainfall and groundwater infiltration and recharge on Guam and islands with similar aquifers. Moreover, the work in Guam is especially unique in that it provides the only ongoing sampling program at a tropical cave, which is providing an informative case study that can be used as a prototype for other tropical cave studies of past climate.

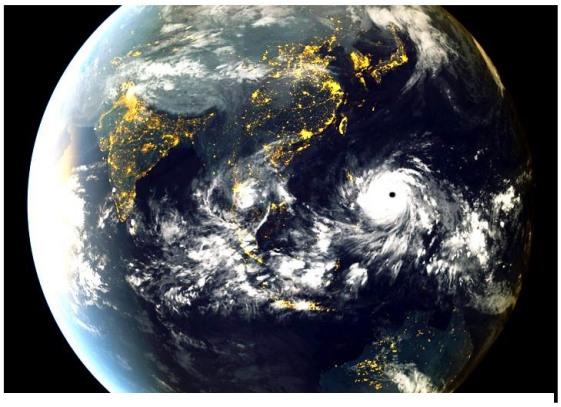
Staff Hydrologist John Jocson collecting samples from a research cave (northern Guam)

Pacific ENSO Application Center

Funded by:
National Oceanic and Atmospheric Administration (NOAA),
National Weather Service (NWS), and
Pacific ENSO Applications Climate (PEAC) Center

Principal Investigator:
Mark Lander

The Pacific ENSO Applications Climate Center (PEAC) was formally established in 1994 and funded by the National Oceanic and Atmospheric Administration (NOAA). It was among the first areas of the world to develop such a center. This Center was a collaborative effort between the University of Guam, the Pacific Basin Development Council, and the University of Hawaii. The goals of the PEAC Center are to tailor products of global El Niño/Southern Oscillation (ENSO) prediction models to the Pacific region, and to interpret and disseminate regional forecasts to public policy officials in the Pacific islands. To achieve these goals the activities of the Center revolve around two components: research and outreach. The research component includes: 1) a study of the regional climatology; 2) development and publication of regional synoptic climatology; 3) development of rainfall and sea level forecast models; and, 4) evaluation of and feedback on the performance of climate models from other agencies and institutions. The outreach program includes: 1) providing tailored ENSO advisories; 2) publishing a quarterly bulletin which includes information on El Nino and climate predictions for the region; and, 3) presenting on-island workshops to interpret the predictions for decision makers, and to offer suggestions for local water resources management.



Super Typhoon Haiyan South West Guam 2013

20 ft. Waves – Pago Bay, Guam

Comprehensive Water Resources Monitoring Program

Funded by:
Government of Guam

Principal Investigators:
Shahram Khosrowpanah

The United States Geological Survey (USGS) has monitored our island's water resources since 1951. Unfortunately, during the 1990s they were forced to downsize this program because matching support from the Government of Guam was discontinued. This resulted in the abandonment of all deep monitoring wells needed to monitor saltwater intrusion in the north, and most of the stream gages in the south by the mid-1990s. In 1995, the USGS closed its field office at Naval Station, but continued to run a limited monitoring program (out of its Saipan and Honolulu offices).

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

A well-designed long-term CWMP can save communities millions of dollars, and even human lives, by providing critical information for water-supply, culvert and bridge design, delineating flood-hazard areas, and tracking effects of climate change. The USGS started a water-resource monitoring program in Guam in 1951 with installation of stream gages at Pago, Lonfit, and Tolaeyuus and a rain gage near Fena dam. At the same time, measurements of discharge from Almagosa Springs and water levels in Fena Reservoir started. Since 1951 about 22 continuous streamflow, 8 rain, and 16 groundwater monitoring stations have been operated, providing reliable information on the water resources and hydrologic hazards of Guam.

Locations of USGS Monitoring Stations on Guam

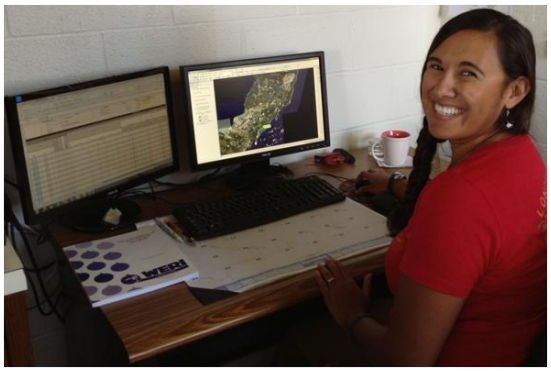
Hydrological Database for Northern Guam

Funded by:
Guam Hydrologic Survey (GHS)

Principal Investigators:
John Jenson, Mark Lander, & Shahram Khosrowpanah

The Northern Guam Lens Aquifer supplies 80% of the island's drinking water. Anticipated growth in demand, including a possible surge to support expansion of military activities during the coming decade has elicited interest and support from both the federal and local governments for acquiring tools to support timely development and sustainable management of the aquifer.

The *Northern Guam Lens Aquifer Database*, is a comprehensive centralized database containing information on custodianship, function, operational status, and the geographical, hydrological, engineering, and geological attributes of each well installed in northern Guam for which records could be found. The database is integrated with current ArcGIS® geospatial information visualization tools. Developed in support of the 2010-2013 *Guam Groundwater Availability Study* led by the USGS's Pacific Islands Water Science Center, with funding by the US Marine Corps, and in conjunction with the 2010 NavFacPac Exploratory Drilling Program on northern Guam, its integration into WERI's Guam Hydrologic Survey Program will keep it up to date and make it permanently and readily accessible to professional and scientific users. The database is also the foundational component for WERI's topographic map of the basement rock beneath the aquifer. In preparing the database, over 4,000 pages of documents were digitally saved and organized into individual electronic folders for each of the 525 wells documented so far. These include 20 exploratory wells, 115 observation/monitoring wells, 212 drinking water wells, 39 agricultural/industrial wells, and 104 stormwater management wells. Each well folder is electronically linked to its corresponding record in a Microsoft Excel® spreadsheet, which contains key engineering and hydrogeological data. The project goal is to consolidate Guam's hydrological data gathered over the years by local and federal government agencies and consultants.



Graduate Research Assistant, Vivianna Bendixson, working on the Northern Guam Lens Aquifer database.

PROJECTS
COMPLETED: FY2013

FUNDED BY:
US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM
(Completed, February 2014)

GUAM:

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

Water Resources of Guam: An Online One-Stop Information Center for Public and Professional Users.

CNMI:

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

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.

OTHER FUNDED PROJECTS

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center (2012-2013)

GUAM BUREAU OF STATISTICS AND PLANS (NOAA)

Degradation/Restoration Assessment of the Piti-Asan Watershed

GUAM WATERWORKS AUTHORITY (GWA) & US ENVIRONMENTAL PROTECTION AGENCY (USEPA)

Water Treatment Assessments and Groundwater under the Direct Influence of Surface Water Determinations (GWUDIS) for GWA Wells Located in the Northern Aquifer of Guam

USGS

Pacific Islands Climate Center (2012-2013)

NATIONAL SCIENCE FOUNDATION

Holocene Hydrological Variability across the Western Pacific Warm Pool (1st year) on-going

DIRECT LOCAL FUNDING

1. GUAM HYDROLOGIC SURVEY
Spatio-temporal Analysis of Groundwater Quality in Guam

2. WATER RESOURCES MONITORING PROGRAM
Stream-flow, Sediment Discharge, Rainfall and Groundwater Characteristics Data Collections in Guam (2012-2013)

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 on a WERI hydrology Field Trip, after Examining Karst Features in and around Pagat Cave

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@uguam.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

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@uguam.uog.edu**

RECENT PUBLICATIONS BY WERI FACULTY AND ASSOCIATE INVESTIGATORS

(2002-2013)

WERI TECHNICAL REPORTS

2013

Bell, Tomoko, John W. Jenson, Mark A. Lander, Richard H. Randall, Judson W. Partin, Benjamin F. Hardt, and Jay L. Banner, (2011). Coral and Speleothem in situ Monitoring and Geochemical Analysis: Guam, Mariana Islands, USA, WERI Technical Report No. 136: Mangilao, Water & Environmental Research Institute of the Western Pacific, University of Guam, Mangilao, Guam, 70 pp.

Bendixson, V.M. (2013). The Northern Guam Lens Aquifer Database. *WERI Technical Report No. 141*. Mangilao, Water & Environmental Research Istitute of the Western Pacific, University of Guam: 45.

Heitz, L.F., and Khosrowpanah, S. (2013). Improving the Weno, Chuuk Water Distribution System using Hydraulic modeling and Geographic Information System (GIS), *WERI Technical Report, No. 140, 50 pp.*

Schaible, B.C. and G.R.W. Denton (2013). Utility of the Brown Alga, *Padina boryana,* as a Biomonitor for Polychlorinated Biphenyls (PCBs) in Tropical Marine Waters: A Preliminary Assessment. *WERI Technical Report*. 34 pp.

Simard, C.A., Jenson, J.W. and Lander, M.A. (2013a). Analysis of Salinity in the Northern Guam Lens Aquifer. *WERI Technical Report No. 143*. Mangilao, Water & Environmental Research Institute of the Western Pacific, University of Guam**:** 65.

Vann, D.T., Bendixson, V.M., Roff, D.F., Habana, N.C., Simard, C.A., Schumann, R.M. and Jenson, J.W. (2013). Topography of the Basment Rock beneath the Northern Guam Lens Aquifer and Its Implications for Groundwater Exploration and Development. *WERI Technical Report No. 142*. Mangilao, Water & Environmental Research Institute of the Western Pacific, University of Guam**:** 44.

2012

Heitz, L.F., and Khosrowpanah, S. (2012). Predicting Hydropower Potential on Ungaged Streams in Kosrae, the Federated States of Micronesia (FSM), *WERI Technical Report, No. 137, 28 pp.*

Khosrowpanah, S., Lander, M., Golabi, M., and Manibusan, S. (2012). A GIS-Based Watershed Management for the Piti-Asan Watersheds, *WERI Technical Report, No. 139: 76pp.*

2011

Baily, R.T. and Jenson, J.W. (2011). Groundwater Resources Analyses of Atoll Islands in the Federated States of Micronesia Using and Algebraic Model. *WERI Technical Report*, No. 134: 29 pp.

Bell, T., Endo, T., Jenson, J.W., Bell, R., and Lander, M.A. (2011). Pneumatic Underwater Drill for Extracting Coral Cores, *WERI Technical Report*, No. 135: 18 pp.

Bell, T., Jenson, J.W., Lander, M.A., Randall, R.H., Partin, J.W., Hardt, B.F., and Banner, J.L. (2011). Coral and Speleothem *in situ* Monitoring and Geochemical Analysis: Guam, Mariana Islands, USA, *WERI Technical Report*, No. 136: 70 pp.

Heitz, L.F. and Khosrowpanah, S. (2011). Development of Geographic Information System for the Commonwealth Utility Corporation, Saipan Water Distribution System. *WERI Technical Report*, No. 132: 17 pp.

Kottermair, M., Golabi, M., Khosrowpanah, S. and Wen, Y. (2011). Spatio-Temporal Dynamics of Badlands in Southern Guam: A Case Study of Selected Sites, *WERI Technical Report*, No. 133: 90 pp.

Luo, Q. C. and Khosrowpanah, S. (2011). Continuing Calibration and Application of LUOM in the Southern Guam . *WERI Technical Report*, No. 131: 69 pp.

Schaible, B. and Denton, G.R.W. (2011). Use of the Seaweed, *Padina*, as a Biomonitor of PCBs in Tropical Marine Waters. *WERI Technical Report*, No. 134. 36 pp.

2010

Denton, G.R.W., Trianni, M.S. and Tenorio, M. (2010). Impact of Land-Based Sources of Pollution on Coastal Water Quality of Saipan, Commonwealth of the Northern Mariana Islands (CNMI): Arsenic, Mercury and PCBs in Popular Table Fish from Saipan Lagoon. *WERI Technical Report* No. 130: 98 pp.

Heitz, L.F. and Khosrowpanah, S. (2010). Prediction of Flow Duration Curves for Use in Hydropower Analysis at Ungaged Sites in Pohnpei, FSM. *WERI Technical Report* No. 129: 24 pp.

Khosrowpanah, S., Wen, Y. and Kottermair, M. (2010). Spatial Distribution of Badlands in the Ugum Watershed: Characterization and Temporal Analysis. *WERI Technical Report* No. 126: 29 pp.

Luo, Q.C. and Khosrowpanah, S. (2010). Calibration and Application of LUOM in Southern Guam Watersheds with and without Flow Data. *WERI Technical Report* No. 128: 87 pp.

2009

Habana, N., Heitz, L.F., Olsen, A.E. and Jenson, J.W. (2009). Vadose Flow Synthesis for the Northern Guam Lens Aquifer. *WERI Technical Report* No. 127: 231 pp.

Wen, Y., Khosrowpanah, S. and Heitz, L.F. (2009). Land Cover Assessment for Southern Guam. in Guam. *WERI Technical Report* No. 125: 33 pp.

Wen, Y., Khosrowpanah, S. and Heitz, L.F. (2009). Watershed Land Cover Change in Guam. *WERI Technical Report* No. 124: 38 pp.

2008

Denton, G.R.W., Bearden, B.G., Houk, P., Starmer J.A. and Wood H.R. (2008). Heavy Metals in Biotic Representatives from the Intertidal Zone and Nearshore Waters of Tanapag Lagoon, Saipan, Commonwealth of the Northern Mariana Islands (CNMI). *WERI Technical Report* No. 123: 50 pp.

Bailey, R.T., Jenson, J.W. and Olsen, A.E. (2008). An Atoll Freshwater Lens Algebraic Model for Groundwater management in the Caroline Islands. *WERI Technical Report* No. 120: 35 pp.

Bailey, R.T., Jenson, J.W. Rubinstein, D. and Olsen, A.E. (2008). Groundwater Resources of Atoll Islands: Observations, Modeling and Management. *WERI Technical Report* No. 119: 83 pp.

Heitz, L.F., Khosrowpanah, S. and Iglecias, M. (2008). Development of Junction Water Demands for the Saipan Water Distribution System Numerical Model. *WERI Technical Report* No. 122: 37 pp.

Hoffman, S.M., Jenson, J.W., Moran, D.C., Denton, G.R.W., Wood, H.R. and Vacher, H.L. (2008). Background Fluorescence in Guam's Coastal Waters. *WERI Technical Report* No. 118: 39 pp.

2007

Keel, T.M., Mylroie, J.E. and Jenson, J.W. (2007). A Preliminary Report on the Sabana *Technical Report* No. 121: 48 pp.

Wuerch, H.V., Cruz, B.C. and Olsen A.E. (2008). Analysis of the Dynamic Response of the Northern Guam Lens Aquifer to Sea level Change and Recharge. *WERI* Watershed/Talakhaya Springs System Rota (LUTA), CNMI. *WERI Technical Report* No. 114: 26 pp.

Khosrowpanah, S., Heitz, L.F. Wen Y. and Park, M. (2007). Developing a GIS-Based Soil Erosion Potential Model of the UGUM Watershed. *WERI Technical Report* No. 117: 95 pp.

MacCracken, R., Jenson, J.W., Heitz, L.F., Rubinstein, D.H. and Mylroie, J. (2007). Water Resource Analysis of Fais Island, Federated States of Micronesia. *WERI Technical Report* No.111: 41 pp.

2006

Denton, G.R.W., Kelly, W.C., III, Wood, H.R. and Wen, Y. (2006) Impact of Metal Enriched Leachate from Ordot Dump on the Heavy Metal Status of Biotic and Abotic Components in Pago Bay. *WERI Technical Report* No. 113: 68 pp.

Keel, T.M., Mylroie, J.E., and Jenson, J.W. (2006). The Caves and Karst of ROTA Island, Commonwealth of the Northern Mariana Islands. *WERI Technical Report* No. 107: 183 pp.

Krishnapillai, M.V., Scheidth, T. and Fillmed, C. (2006). Qualitative Examination of Groundwater from Yap and Neighboring Islands. *WERI Technical Report* No. 115: 27 pp.

Taboroši, D. (2006). Karst Inventory of Guam, Mariana Islands. *WERI Technical Report* No. 112: 214 pp.

2005

Denton, G.R.W., Sian-Denton, C.M., Concepcion, L.P. and Wood, H.R. (2005). Nutrient Status of Tumon Bay in relation to Intertidal Blooms of the Filamentous Green Alga, *Enteromorpha clathrata*. *WERI Technical Report* No. 110: 60 pp.

Denton, G.R.W., Wood, H.R., Wen, Y., Golabi, M. and Iyekar, C. (2005). Mobilization of Aqueous Contaminants Leached from Ordot Landfill in Surface and Subsurface Flows. *WERI Technical Report* No. 108: 83 pp.

Khosrowpanah, S. and Jocson, J.M.U. (2005). Environment Assessment for Ugum Watershed. *WERI Technical Report* No. 109: 53 pp.

2004

Keel T.M. and Jenson, J.W. (2004). Preliminary Report on the Caves and Karst of ROTA (LUTA), CNMI. *WERI Technical Report* No. 105: 113 pp.

Lander, M.A. (2004). Rainfall Climatology for Saipan: Distribution, Return-Periods, El Nino, Tropical Cyclones, and Long-Term Variations. *WERI Technical Report* No. 103: 59 pp.

Lander, M.A. and Khosrowpanah, S. (2004). Rainfall Climatology for Pohnpei Island, Federal State of Micronesia. *WERI Technical Report* No. 100: 58 pp.

McDonald, M.Q. and Jenson, J.W. (2003). Chloride History and Trends of Water Production Wells in the Northern Guam Lens Aquifer. *WERI Technical Report* No. 98: 70 pp.

Moran, D. and Jenson, J.W. (2004). Dye Trace of Groundwater Flow from Guam International Airport and Harmon Sink to Agana Bay and Tumon Bay Guam. *WERI Technical Report* No. 97: 38 pp.

Stafford, K. and Jenson, J.W. (2004). Karst Geology of Aguijan and Tinian, CNMI. *WERI Technical Report* No. 106: 239 pp.

Taboroši, D., Jenson, J.W. and Mylroie, J.E. (2004). Karst Features of Guam Mariana Island. *WERI Technical Report* No.104: 28 pp.

2003

Khosrowpanah, S. and Heitz, L.F. (2003). Slow Sand Filter Conceptual Design for the Federal States of Micronesia FSM. *WERI Technical Report* No. 101: 23 pp.

Lander M.A. and Guard, C.P. (2003). Creation of a 50-Year Rainfall Database, Annual Rainfall Climatology, and Annual Rainfall Distribution Map for Guam. *WERI Technical Report* No. 102: 31 pp.

Stafford, K., Mylroie, J.E. and Jenson, J.W. (2003). Karst Geology and Hydrology of Tinian and Rota (Luta), CNMI. *WERI Technical Report* No. 96: 29 pp.

2002

McDonald M.Q. (2002). Nitrate-Nitrogen Concentrations in the Northern Guam Lens and Potential Nitrogen Sources. *WERI Technical Report* No. 95: 41 pp.

Scheman, N.D., Khosrowpanah, S., Golabi, M. and Heitz, L.F. (2002). Identification of Erosion Process and Sources of Exposed Patches in the Lasa Fua Watershed of Southern Guam. *WERI Technical Report* No. 99: 77 pp.

JOURNAL ARTICLES

2013

Bailey, R.T., Jenson, J.W., Taboroši, D., (2013). Estimating the freshwater-lens thickness of atoll islands in the Federated States of Micronesia. Hydrogeology Journal, 21(2): 441-457.

Bailey, R.T. and Jenson, J.W. (2013). "Effects of Marine Overwash for Atoll Aquifers: Environmental and Human Factors." *Groundwater (on-line)*.

Denton, G.R.W. and S. Namazi (2013). Indoor Radon Levels and Lung Cancer Incidenceon Guam. *Procedia Environmental Sciences,* 18: 157-166.

Denton, G.R.W., C. Kautz and J.A. Starmer (2013). Influence of Stormwater Discharges, Inappropriate Waste Disposal Practices and World War II on the Distribution and Abundance of Heavy Metals in Saipan Lagoon, Saipan, CNMI. *Marine Pollution Bulletin* (in press)

Habana, N.C., Heitz, L.F., Olsen, A.E., Jenson, J.W., and Salvacion, J.L., (2013). Vadocharge: Groundwater recharge model for and uplifted island karst aquifer, Guam, USA. International Journal of Environmental Engineering Science and Technology Research, Vol. 1, No. 8, August 2013, pp: 141-164.

Habana, N.C., J.L. Salvacion, J.W. Jenson, and J.D. Rouse. (2013). VADOCHARGE-N: a Vadose Flow and N-Transport Simulation Model for the Northern Guam Lens Aquifer. International Journal of Environmental Engineering Science and Technology Research, Vol. 1, No. 11, November 2013, pp: 268-287.

Morrison, R.J., G.R.W. Denton, U. Bale Tamata and J.Grignon J. (2013). Anthropogenic Biogeochemical Impacts on Coral Reefs in the Pacific Islands - An Overview. Deep-Sea Research II, in press

M.A. Lander and C.P. Guard, (2013). Regional Climates: Oceania [in "State of the Climate in 2012"]. Bull. Amer. Meteor. Soc., 94, S270-S272 (In Press).

Rotzoll, K., Gingerich, S.B., Jenson, J.W., and El-Kadi, A.I., (2013). Estimating hydraulic properties from tidal attenuation in the Northern Guam Lens Aquifer, Territory of Guam, USA: Hydrogeology Journal, v. 21, p. 643-654.

Rouse, D. J., (2013). Sustainability of Wastewater Treatment and Excess Sludge Handeling Practicies in the Federated States of Micronesia. Journal of Sustainability 2013, 5, 4183-4104.

Sidike, A., Zhao, S. and Wen, Y, (2013). Estimating soil salinity in Pingluo County of China using QuickBird data and soil reflectance spectra, to be published in *International Journal of Applied Earth Observation and Geoinformation 26 (2014) 156–175*.

Stafford, K.W., Taboroši, D. and Jenson, J.W. (2013). Caves and Karst Hydrology of the Mariana Islands. *Coastal Karst Landforms*. Lace, M.J. and Mylroie, J.E. Dordrecht, Springer. **5:** 277-298. [book chapter]

Taborosi, D., Jenson, J.W., and Mylroie, J.E., (2013). Field observations of coastal discharge from an uplifted carbonate island aquifer, northern Guam, Mariana Islands: A descriptive geomorphic and hydrogeologic perspective, Journal of Coastal Research, v. 29, no. 4, p. 926-943.

2012

Desai, C.S., Sane, S., and Jenson, J.W., (2012). Constitutive modeling including creep and rate-dependent behavior, and testing of glacial tills for prediction of motion of glaciers: *International Journal of Geomechanics, V. 11, no. 6, pp. 465-476.*

Gong, J., Yue, Y., Zhu, J., Wen, Y., Li, Y., Zhou, J., Wang, D., and Yu, C. (2012). Impacts of Wenchuan Earthquake on the Chaping River Channel Change, *International Journal of Remote Sensing*, 3: 3907-3929.

Lander, M., (2012). Current Conditions and Local U.S. Affiliated Pacific Island Weather and Climate Summaries and Forecasts. *Pacific ENS Newsletter.* NOAA National Weather Services, 1st Quarter 2012; Vol.18 No.1 (February), 2nd Quarter 2012; Vol.18 No.2, (May), 3rd Quarter 2012; Vol.18 No.3 (July).

Morrison, R. J., Denton, G.R.W., Bale-Tamata, U. and Grignon, J. (2012). Anthropogenic Biogeochemical Impacts on Coral Reefs in the Pacific islands – An Overview. *Deep-Sea Research II Special Issue* (in press).

Partin, J.W., Jenson, J.W., Banner, J.L., Quinn, T.M., Taylor, F.W., Sinclair, D., Lander, M.A., Bell, T., Miklavič, B., Jocson, J.M.U., Hardt, B., and Taboroši, D. (2012). Relationship Between Rainfall Variability, Cave Dripwater and Stalagmite Geochemistry in Guam, USA. *Earth and Planetary Science Letters v. 13, no. 3, pp. 1-17.*

Schroeder, T.A., M.D. Chowdhury, M.A. Lander, C.P.Guard, C. Felkley and D. Gifford (2012). The Role of the Pacific ENSO Applications Climate Center in Reducing Vulnerability to Climate Hazards: Experience from the U.S-Affiliated Pacific Islands, *Bull. Amer. Meteor. Soc.*,

Sinclair, D., Banner, J.L., Taylor, F.W., Partin, J.W., Jenson, J.W., Mylroie, J.E., Goddard, E., Quinn, T.M., Jocson, J.M.U., and Miklavič, B. (2012). Magnesium and Strontium Systematics in Tropical Speleothems from the Western Pacific: *Chemical Geology, v. 294-295, pp. 1-17.*

Sinclair, D., Banner, J.L., Taylor, F.W., Partin, J.W., Jenson, J.W., Mylroie, J.E., Goddard, E., Quinn, T.M., and Jocson, J.M.U. (2012). Magnesium and Strontium Systematics in West Pacific Speleothems *Quatenary Science Reviews* (in press).

2011

Guard, C.P. and Lander, M.A. (2011). Regional Climates, Northwest Pacific, Micronesia [in "State of the Climate in 2010"]. Bulletin American Meteorological Society, 92 (7): S224-S227.

Denton, G.R.W. (2011). Good Fish Bad Fish: The Mercury Dilemma. *Journal of Micronesian Fishing.* Spring 2011 Issue.

Denton, G.R.W. Trianni, M.S., Bearden, B.G., Houk, P.C. and Starmer J.A. (2011). Tracking Down an Unusual Source of Mercury Enrichment in Fish from Saipan Lagoon, Saipan, Commonwealth of the Northern Mariana Islands. *Progress in Environmental Sciences and Technology*, Vol. III: 983-997.

Denton, G.R.W., Trianni, M.S., Bearden, B.G., Houk, P.C. and Starmer J.A. (2011). Impact of a Medical Waste Incinerator on Mercury Levels in Lagoon Fish from a Small Tropical Island in the Western Pacific. *Journal of Toxicology and Environmental Health Part A*, 74: 823–827,

Desai, C.S., Sane, S. and Jenson, J.W. (2011, in press). Constitutive modeling including creep and rate-dependent behavior, and testing of glacial tills for prediction of motion of glaciers. *International Journal of Geomechanics, Special issue: Material and Computer Modeling*. Desai, C.S., Zaman, M.M. and Singh, D.N. **11** 465-476.

Wen, Y. (2011). Impacts of Human Activities on Groundwater Quality in Guam, Mariana Islands. *International Journal of Environmental Cultural, Economic and Social Sustainability*, 7: 243-256.

Wen , Y., Khosrowpanah, S. and Heitz, L. (2011). Land Cover Change of Watersheds in Southern Guam from 1973-2001. *Environmental Monitoring and Assessment*, 179: 521-529.

2010

Bailey, R.T., Jenson, J.W. and Olsen A.E. (2010). Estimating the Groundwater Resources of Atoll Islands, Water, 2: 1-27.

Denton, G.R.W. and Sian-Denton, C.M (2010). Groundwater Monitoring on Guam: Management Responses to Recent Water Quality Violations, Journal of Groundwater Monitoring and Remediation, Spring 2010, pp. 127-133.

2009

Bailey, R.T., Jenson, J.W. and Olsen, A.E. (2009). Numerical Modeling of Atoll Island Hydrogeology. *Groundwater*, 47: 184-196.

Denton, G.R.W. and Morrison, R.J. (2009). Impact of a Rudimentary Landfill on the Trace Metal Status of Pago Bay, Guam. *Marine Pollution Bulletin*, 58: 150-162.

Denton, G.R.W., Morrison, R.J., Bearden, B.G., Houk, P., Starmer, J.A. and Wood, H.R. (2009). Impact of a Coastal Dump in a Tropical Lagoon on Trace Metal Levels in Surrounding Marine Biota: A Case Study from Saipan, Northern Mariana Islands (CNMI). *Marine Pollution Bulletin*, 58: 424-455.

Denton, G.R.W., Siegrist, H.G., and Jano-Edwards, J.P. (2009). Metal Deficiencies and Imbalances in Wetland Plants from a Manganese-Enriched Wetland in Southern Guam: A Preliminary Investigation. *Progress in Environmental Sciences and Technology*, Vol. II Part B: 1853-1858.

Denton, G.R.W., Siegrist, H.G., and Jano-Edwards, J.P. (2009). Trace Elements in Pandanus (*Pandanus tectorius*) from a Manganese-Enriched Wetland in Southern Guam: A Possible Lytico-Bodig Connection? *Journal of Toxicology and Environmental Health, Part A*, 72: 1-3.

Guard, C.P. and Lander, M.A (2009). Regional Climates, Northwest Pacific, Micronesia. Bulletin of the American Meteorological Society, 90 (7): S168-S170.

Lander, M.A., Ward, B.D., Diamond, H.J. (2009). Unusually Quiet West Pacific Typhoon Season Ends with a Dolphin Kick. Bulletin of the American Meteorological Society, 90 (7), S95.

Wilson, R., Pyatt, B. and Denton, G.R.W. (2009). An Evaluation of the Bioavailability and Bioaccumulation of Selected Metals Occurring in a Wetland Area on the Volcanic Island of Guam, Western Pacific Ocean. *Journal of Environmental Sciences*, 21: 1-5.

2008

Denton, G.R.W., Golabi, M.H.,Wood, H.R., Iyekar, C., Concepcion, L.P. and Wen, Y. (2008). Impact of Ordot Dump on Water Quality of the Lonfit River Basin in Central Guam. 2. Aqueous Chemical and Biological Contaminants. *Micronesica*, 40 (1/2): 149-167.

Sane, S.M., Desai, C.S., Jenson, J.W., Contractor, D.S., Carlson, A.E. and Clark, P.U. (2008). Disturbed State Constitutive Modeling of Two Pleistocene Tills. *Quaternary Science Reviews*, 10.1016/j.quascirev.2007.10.003, 27: 267-283.

Taboroši, D., Jenson, J.W. and Stafford, K. (2008). Artefatosmilitares E Uso De Cavernas Durante a Segunda Guerra Mundial Nas Ilhas Marianas, Pacifico Oeaste [in Portuguese; English Title: Artifacts and Wartime Use of Caves in the Mariana Islands]. In: L.E.P. Travassos and L.A.V. Figueiredo (Editors), *Antopoespeleologia: imaginário, religião eoutras relações humanas com as cavernas*. Brazilian Speleological Society, Minas Gerais, Brazil. (in press)

2007

Carlson, A.E., Jenson, J.W., and Clark P.U. (2007). Modeling the Subglacial Hydrology of the James Lobe of the Laurentide Ice Sheet: *Quaternary Science Reviews*. doi: 10.1016/j.quascirev.2007.02.002.

Denton, G.R.W and Sian-Denton, C.M. (2007). Unsightly Algal Blooms in Tumon Bay, Guam's Premier Tourist Location: Possible Connection to Hotel Landscaping Activities (2007). *Journal Interdisciplinary Environmental Review*, IX (1): 94-106.

Golabi, M.H., Denton, G.R.W., Wood, H.R., Wen, Y. and Iyekar, C. (2007). Impact of Ordot Dump on Water Quality of the Lonfit River Basin in Central Guam. 1. Soil Characterization of Nutrient Retention. *Micronesica*, 39: 41-45.

Lander, M.A. (2007). Current Conditions and Local U.S. Affiliated Pacific Island Weather and Climate Summaries and Forecasts. *Pacific ENSO Newsletter*. NOAA National Weather Service.

Taboroši, D., Jenson, J.W., Stafford, K.W. and Matsuzawa, R. (2007). World War II Artifacts and Wartime Use of Caves in the Mariana Islands, Western Pacific. *Journal of the Speleological Society of Japan*, 32: 42-53.

Vuki, M., Limtiaco, J., Aube, T., Emmanuel, J., Denton, G.R.W. and Wood, H.R. (2007). Arsenic Speciation Study in Some Spring Waters of Guam, Western Pacific Ocean. 379: 176-179

2006

Denton, G.R.W., Concepcion, L.P., Wood, H.R. and Morrison R.J. (2006). Trace Metals in Marine Organisms from Four Harbours in Guam. *Marine Pollution Bulletin*, 52: 1784-1804

Denton, G.R.W., Bearden, B. Concepcion, L.P., Wood, H.R. and Morrison R.J. (2006). Contaminant Assessment of Surface Sediments from Tanapag Lagoon, Saipan, Commonwealth of the Northern Mariana Islands. *Marine Pollution Bulletin,* 52: 703-710.

Denton, G.R.W., Concepcion, L.P., Wood, H.R. and Morrison R.J. (2006). Polychlorinated Biphenyls (PCBs) in Sediments from Four Harbours in Guam. *Marine Pollution Bulletin,* 52: 711-718.

Denton, G.R.W., Concepcion, L.P., Wood, H.R. and Morrison R.J. (2006). Polycyclic Aromatic Hydrocarbons (PAHs) in Small Island Coastal Environments: A Case Study from Harbours in Guam, Micronesia. *Marine Pollution Bulletin,* 52: 1090-1098.

Denton, G.R.W., Concepcion, L.P., Wood, H.R. and Morrison R.J. (2006). Polychlorinated Biphenyls (PCBs) in Marine Organisms from Four Harbours in Guam. *Marine Pollution Bulletin* 52: 214-238.

Jenson, J.W., Keel, T.M., Mylroie, J.E., Mylroie, J.R., Stafford, K.W, Taboroši, D. and Wexel, C. (2006). Karst of the Mariana Islands: The Interaction of Tectonics, Glacio-eustasy and Fresh-water/Sea-water Mixing in Island Carbonates: *GSA Special Paper 404, Geological Society of America,* p. 129-138.

Lander, M.A. (2006). Current Conditions and Local U.S. Affiliated Pacific Island Weather and Climate Summaries and Forecasts. *Pacific ENSO Newsletter*. NOAA National Weather Service.

Lander, M.A., Velden, C., Harper, B., Wells, F., Beven, J.L. II, Zehr, R. Olander, T. Mayfield, M., Guard, C., Edson, R., Avila, L., Burton, A., Turk, M., Kikuchin, A., Christian, A., Caroff, P. and McCrone P. (2006). The Dvorak Tropical Cyclone Intensity Estimation Technique: A Satellite-Based Method that Has Endured for over 30 Years. *Bulletin of the American Meteorological Society,* 87**:** 1195-1210.

2005

Denton, G.R.W., Concepcion, L.P., Wood, H.R. and Morrison R.J. (2005). Trace Metals in Sediments of Four Harbours in Guam. *Marine Pollution Bulletin,* 50: 1133-1141.

Stafford, K.E., Mylroie, J.E., Taborosi, D. and Jenson, J.W. (2005). Eogenetic Karst Development on a Small, Tectonically Active Carbonate Island: Aguijan, CNMI, Mariana Islands, *Transactions of the British Cave Association,* 31: 101-108.

Stafford, K.W, Mylroie, J.E., Taboroši, D., Jenson, J.W. and Mylroie, J.R. (2005). Karst Development on Tinian, CNMI: Controls on Dissolution in Relation to the Carbonate Island Karst Model. *Journal of Cave and Karst Studies,* 67: 14-27.

Taboroši, D., Jenson, J.W. and Mylroie, J.E. (2005). Karst Features of Guam. *Micronesica,* 38: 17-46.

2004

Carlson, A.E., Jenson, J.W., and Clark P.U. (2004). Field Observations from the Tiskilwa Till, II and Sky Pilot Till, MB of the Laurentide Ice Sheet: *Geographie Physique et Quaternaire*, 58: 229-239.

Taboroši, D., Jenson, J.W. and Mylroie, J.E. (2004). Karren Features in Carbonate Island Karst: Guam, Mariana Islands: *Zeitschrift fur Geomoprhologie*, 48: 369-389.

2003

Gamble, D. W., Taboroši, D., Mylroie, J.E., Jenson, J.W., Carew, J. L., Jocson, J. M. U., Mylroie, J. R., and Vann, D. T. (2003). The Use of Water Temperature to Characterize Groundwater Discharge of a Coastal Fracture on Guam, U.S.A. *Journal of Coastal Research,* 19: 462-471.

Keel, T. M., Stafford, K.W., Mylroie, J.E., Jenson, J.W. and Mylroie, J.R. (2003). The Carbonate Island Karst Model as Applied to Rota (Luta), Tinian, and Aguijan Islands, Commonwealth of the Northern Marian Islands. *Journal of Cave and Karst Studies*, 65: 186.

Khosrowpanah, S. and Heitz L.F. (2003). Water Resources Management: A Challenging Issue for Tropical Islands in the Western Pacific. *Journal of Water Resources, American Water Resources Association,* 5: 25-30, May 2003.

Lander M.A., Duval, P., Beven, J., Clark, D., Lulofs, H., Marra, J., Mojica, R. and Waters K. (2003). Service Assessment: Super Typhoon Pongsona (December 8, 2002). *U.S. Dept. Commerce, NOAA/National Weather Service.* 32 pp. plus appendices.

Lander, M.A., Guard, C.P. and Chiu, A.N. (2003). Meteorological Assessment: Super Typhoon Pongsona (December 8, 2002). *US Dept of Commerce, NOAA/National Weather Service.* 54 pp.

Stafford, K.W., Keel, T. M., Mylroie, J.E., Jenson, J.W. and Mylroie, J. R. (2003). Eogenetic Karst Development in the Mariana Islands: Aquijan, Rota, and Tinian: *Journal of Cave and Karst Studies,* 65: 188.

Stafford, K.W., Taboroši, D., Keel, T.M., Mylroie, J.E., Mylroie, J.R. and Jenson, J.W. (2003). 2002-2003 Joint Research Expeditions to the Mariana Islands: Aguijan, Rota, and Tinian: Journal of Cave and Karst Studies, 65: 179-180.

Stafford, K.W., Mylroie, J.E., Mylroie, J. R. and Jenson, J.W. (2003). Tinian, CNMI: A Carbonate Island Karst Model Evaluation (Abstract). *Geological Society of America*, 35: 3.

Taboroši, D., Jenson J.W. and Mylroie, J.E. (2003). Zones of Enhanced Dissolution and Associated Cave Morphology in an Uplifted Carbonate Island Karst Aquifer, Northern Guam, Mariana Islands. *Speleogenesis and Evolution of Karst Aquifers*, http://www.speleogenesis.info/archive/publication.php?Type=publication&PubID=3255, 1: 16.

2002

Mylroie, J.E. and Jenson, J.W. (2002). Karst Flow Systems in Young Carbonate Islands. *Karst Waters Institute Special Publication 7*. Karst Waters Institute, Charles Town, West Virginia, p. 107-110.

Jenson, J.W., Mylroie, J.E., Mylroie, J.R. and Wexel, C. (2002). Revisiting the Carbonate Island Karst Model (Abstract). *Geological Society of America*, 34: 226.

Jocson, J.M.U., Jenson, J.W. and Contractor, D.N. (2002). Recharge and Aquifer Response: Northern Guam Lens Aquifer, Guam, Mariana Islands, *Journal of Hydrology*, 260: 231-254.

Taboroši, D. and Jenson, J.W. (2002). World War II Artifacts and Wartime use of Caves in Guam, Mariana Islands. *Cave Archaeology and Palaeontology Archive CAPRA 4*, available at http://www.shef.ac.uk/~capra.

CONFERENCE PROCEEDINGS, PRESENTATIONS AND ABSTRACTS

2014

Mccutcheon, A., Raymundo, L., Prouty, N., Jenson, J., Lander, M. and Randall, R. (2014). Coral Growth Calibration of the Sr/Ca Proxy for SST Reconstruction in Guam. *17th Biennial Ocean Sciences Meeting*. Honolulu, Association for the Sciences of Limnology and Oceanography (ASLO), The Oceanography Society (TOS), and the American Geophysical Union (AGU).

2013

Denton, G.R.W. and S. Namazi, (2013). Indoor Radon Levels and Lung Cancer Incidence on Guam. *Proceedings 2013 International Symposium of Environmental Science and Technology*, Dalian, China June 4-7. Pp. 121-130

Denton, G.R.W. (2013). Retrospective Analysis of Water Quality Data of Chemicals of Concern in Guam's Groundwater: Energing Trends and Future Concerns. *USEPA Pacific Islands Environment Conference*, Hyatt Regency, Guam, June 26-28, 2013.

Jenson, J.W., Taboroŝi, D., Rotzoll, K., Mylroie, J.E., and Gingerich, S.B. (2013). Symposium Program and Abstracts: A hypothesis for carbonate island karst aquifer evolution from analysis of field observations in northern Guam, Mariana Islands. *International Symposium on Hierarchial Flow Systems*. Mádl-Szőnyi, J., Erőss, A., Mindszenenty, A. and Tóth, A.

Khosrowpanah, S., Heitz, L.F., (2013).L. Heitz, (2013). Improving the Weno, Chuuk Water Distribution System Using Hydraulic Modeling and Geographic Information Systems. Proceeding of 2013 International Specialty Conference on Water for Mega Cities: Challenges and Solutions, American Water Resources Association (AWRA) and Beijing Hydraulic Engineering Society, Beijing, China, September 16-18, 2013.

Mccann, S., Mylroie, J.E., Jenson, J.W. and Lander, M.A. (2013). Meteorological Conditions Affecting Speleothem Paleoclimate Record in a Tropical Cave, Guam, Mariana Islands. *National Speleological Society Convention*. Shippensburg University, PA.

Moore, M., Hardt, B., Banner, J. and Jenson, J. (2013). Program & Abstracts: Evaluation of speleothem oxygen isotope fractionation from a tropical cave on the island of Guam. *Fall Meeting, American Geophysical Union*. San Francisco.

Rouse, J. (2013). Assessment of Wastewater Treatment Facilities and Excess Sludge Handling Practices in the FSM. 35th Annual Conference of the Hawaii Water Environment Association. Honolulu, Hawaii; Febrauary 4-6, 2013.

Rouse, J. (2013). Assessment of Wastewater Treatment Facilities and Excess Sludge Handling Practices in the FSM: Sustainability of Wastewater Treatment Practices. 9th International Conference on Environmental, Cultural, Economic & Social Sustainability. Hiroshima, Japan; January 23-25, 2013.

Simard, C.A., Jenson, J.W., Lander, M.A., (2013). in review. Analysis of Salinity in the Northern Guam Lens Aquifer. In: Savarese, M., Glumac, B. (Eds.), 16th Symposium on the Geology of the Bahamas and Similar Regions, Gerace Research Center, San Salvador Island, Bahamas.

Simard, C.A., Jenson, J.W. and Lander, M.A. (2013b). Analysis of Salinity in the Northern Guam Lens Aquifer. *UCOWR-NIWR Conference*. Lake Tahoe, NV.

2012

Denton, G.R.W. and J.A. Starmer. (2012). Formerly Used Defense Sites (FUDS) on Saipan: Evaluation of Potential Ecological and Human Health Risks Associated with Heavy Metal Enrichment in Adjacent Soils and Sediments, APASEEM General Meeting, November 13-14, 2012, American Memorial Park Auditorium, Saipan.

Jenson, J., Roff, D., Bendixson, V., Hylton, T. and Simard, C. (2012). New Insights and Questions from Exploratory Drilling in the Northern Guam Lens Aquifer. *16th Symposium of the Geolgy of the Bahamas and other Carbonate Regions*. Gerace Research Center, San Salvador Island, Bahamas.

Jenson, J.W. (2012). Guam's Aquifer and the Myth of Sustainable Yield: How to Make Sure There is Enough Water for Everyone. *Island Sustainability Conference*. Hyatt Regency Guam.

Khosrowpanah, S., and Heitz, L.F., (2012). Safe Drinking Water: Challenging issue for Tropical Islands in the Western Pacific. I*n Proceedings of XII International Symposium on Environmental Geotechnology, Energy and Global Sustainable Development*, Los Angeles, California, pp 345-353

Lindzey, K.M., Partin, J.W., Quinn, T.M., Jenson, J.W., Shen, C.-C., Banner, J.L., K., L. and Hardt, B.F. (2012). Decadal-Scale Rainfall Variability in Guam over the Common Era. *American Geophysical Union Fall Meeting, Abstracts*. San Francisco.

Miklavič, B., Mylroie, J.E., Jenson, J.W., Randall, R.H., Banner, J.W., and Partin, J.W., (2012). Evidence of the sea-level change since MIS 5e on Guam, tropical West Pacific, in Onac, B.P., Fornos, J.J. (Eds.), Sea Level Changes into MIS 5: from observations to predictions, *Studia Universitatis Babeş-Boylai, Geologia* (Special Issue 2012), Cluj University Press Cluj-Napoca, Romania, p. 30-32.

Miklavič, B., Mylroie, J.E., Jenson, J.W., Randall, R.H., Banner, J.L., Partin, J.W. (2012). Evidence of the Sea-level Change Since MIS 5e on Guam, *Tropical West Pacific, NSF Workshop: Sea Level Changes Into MIS 5: From Observations to Predictions*, April 10-14, 2012, Palma de Mallorca, Mallorca, Spain.

Miklavič, B., Mylroie, J.E., Jenson, J.W., Randall, R.H., N.Z., L. and Taboroši, D. (2012). Denudation of eogenetic limestone during the last glacial cycle in a tropical environment. *20th International Karstological School "Classical Karst": Karst forms and processes*. Karst Research Institute, Postojna, Slovenia.

Mylroie, J.E., Jenson, J.W., Miklavič, B. and Taboroši, D. (2012). Surface and Vadose Implications in Karstification of Eogenetic Carbonates. *GSA Annual Meeting*. Charlotte, North Carolina.

Simard, C., Jenson, J. and Lander, M.A. (2012, in review). Analysis of Salinity in the Northern Guam Lens Aquifer. *16th Symposium on the Geology of the Bahamas and Similar Carbonate Regions*. Gerace Research Center, San Salvador Island, Bahamas.

2011

Bailey, R.T.a.J., J.W. (2011). Analysis of Groundwater Resources on Atolls in the Federated States of Micronesia. *Water Resources Sustainability Issues on Tropical Islands*. Water Resources Research Center, University of Hawaii at Manoa, Honolulu, HI, National Institutes for Water Resources.

Denton, G.R.W. and Sian-Denton, C.M. (2011). A Retrospective Analysis of Water Quality Data for Chemicals of Concern in Guam's Groundwater: Emerging Trends and Future Concerns, Abstract, *Water Resources Sustainability Issues on Tropical Islands*, 14-16 November, Ala Moana Hotel, Honolulu, HI.

Denton, G.R.W. Trianni, M.S., Bearden, B.G., Houk, P.C. and Starmer J.A (2011). Tracking Down an Unusual Source of Mercury Enrichment in Fish from Saipan Lagoon, Saipan, Commonwealth of the Northern Mariana Islands. *Proceedings 2011 International Symposium on Environmental Science & Technology*, Dongguan, Guangzhou, China, June 1-4, 2011.

Denton, G.R.W. (2011). Mother Nature Sustains Water Quality of Pago Watershed Despite Years of Heavy metal Insult from Ordot Dump. Abstract only. *2nd Regional Conference on Island Sustainability*, Hyatt Regency, Guam, April 19-20, 2011.

Jenson, J.W., Lander, M.A., Randall, R.H. (2011). Vadose Flow in the Northern Guam Lens Aquifer, *Water Resources Sustainability Issues on Tropical Islands*, Abstract, *Water Resources Sustainability Issues on Tropical Islands*, 14-16 November, Ala Moana Hotel, Honolulu, HI.

Jenson, J.W., Lander, M.A. and Randall, R.H. (2011b). Vadose Flow in a Tropical Island Karst Aquifer, Guam, Mariana Islands. *Carbonate Geochemistry: Reactions and Processes in Aquifers and Reservoirs*. Billings, Montana, USA, Karst Waters Institute.

Khosrowpanah, S., (2011). The Impact of Guam's Population growth on Island Water Resources. Water Resources Sustainability Issues on Tropical Islands Conference, Abstract, *Water Resources Sustainability Issues on Tropical Islands*, 14-16 November, Ala Moana Hotel, Honolulu, HI..

Miklavič, B., Jenson, J.W., Banner, J.L., Mylroie, J.E., Partin, J.W., Zabukovec Logar, N., Hardt, B., Sinclair, D. and James, E. (2011). Diagenesis and trace-element geochemistry of cave drip-water and a stalagmite in MIS5e limestone, Guam, Mariana Islands. *6th International Conference: Climate Change - The Karst Record*. University of Birmingham, Birmingham, England, U.K.

Wen, Y. (2011). Application of Multi-temporal and Multi-source Data for Land Cover Change Detection in Guam, USA, *Proceedings of the 19th International Conference on GeoInformatics*, June 24-26, 2011, Shanghai, China.

Wen, Y. and Khosrowpanah, S. (2011). Application of LIDAR Data For Delineation of Inarajan Watershed In Guam, *USA, Proceedings of 1st International Workshop on Surveying and Geospatial Information Systems (SGIS2011),* May 21 – 22, 2011, Fuxin, Liaoning, China.

2010

Bailey, R.T., Jenson, J.W. and Olsen, A.E. (2010). An Algebraic Model to Predict the Freshwater Lens Thickness of an Atoll Island. In: *Proceedings of the 14th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, Gerace Research Center, 12-16 June, 2008, San Salvador Island, Bahamas (in press).

Bailey, R.T., Jenson, J.W. and Olsen, A.E. (2010). Numerical Modeling of Atoll Island Hydrogeology. In: *Proceedings of the 14th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, Gerace Research Center, 12-16 June, 2008, San Salvador Island, Bahamas (in press).

Denton, G.R.W. Trianni, M.S., Bearden, B.G., Houk, P.C. and Starmer J.A. (2010), Impact Determination of Unusual Mercury Source on Fisheries Resources in Saipan Lagoon, Saipan, Commonwealth of the Northern Mariana Islands: A Preliminary Assessment. *Proceedings Islands Environments and Resources International Symposium,* University of the Ryukyus, Okinawa, December 18, 2010

Hoffman, S.M. and Jenson, J.W. (2010. Variability of Background Fluorescence in Tropical Karst Aquifers. In: *Proceedings of the 14th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, Gerace Research Center, 12-16 June, 2008, San Salvador Island, Bahamas (in press).

Hoffman, S.M., Jenson, J.W., Denton, G.R.W., Moran, D.C. and Vacher, L.L. (2010). Background Fluorescence In: Guam's Coastal Waters American Water Resources Association (AWRA). *2010 International Specialty Conference & 8th Caribbean Islands Water Resources Congress on Tropical Hydrology and Sustainable Water Resources in a Changing Climate*, August 30 - September 1, 2010, San Juan, Puerto Rico.

K**hosrowpanah, S. and Heitz, L. (2010).** Predicting Hydropower Potential on Ungaged Streams in Pohnpei Island. Federated States of Micronesia (FSM). *Proceedings of 2010 Annual Water Conference,* Philadelphia, Pennsylvania, November 2010.

K**hosrowpanah, S., Y. Wen, and Taborosi, D. (2010)**. Development of Digital Atlas of Natural Resources of Southern Guam. *Proceedings of the 9th International Conference on Hydroinformatics,* September 7-10, 2010, Tianjin, China. pp. 1593-1598

Khosrowpanah, S. and Heitz, L.F. (2010). Watershed Management for Pohnpei Island, The Federated States of Micronesia. *Proceedings Islands Environments and Resources International Symposium,* University of the Ryukyus, Okinawa, December 18, 2010

Luo, Q.C. (2010). 2010 Drought in Southwest China and Daoism, *Proceedings of 4th International Workshop on Catchment-scale Hydrological Modeling and Data Assimilation*, Lhasa, China, 21-23 July 2010.

Luo, Q.C. (2010). An ordering scheme for stream networks with channel loops. *Proceedings of 9th International Conference on Hydroinformatics, HIC 2010, Tianjing, China,* Vol.2, Chemical Industrial Press, pp.1697-1704.

Luo, Q.C. and Khosrowpanah, S. (2010). Developing the LUOM in Southern Guam Watersheds, *Proceedings of 4th International Workshop on Catchment-scale Hydrological Modeling and Data Assimilation, Lhasa, China,* 21-23 July 2010.

Miklavič, B., Mylroie, J.E., Jenson, J.W., Randall, R.H., Banner, J.L., and Partin, J.W., (2010). Interglacial limestone and its geomorphic features on Guam: implications for relative sea level changend flank margin cave formation, *in* Gamble, D.W., ed., *15th Symposium of the Geolgy of the Bahamas and Other Carbonate Regions:* Gerace Research Center, San Salvador Island, Bahamas.

Taboroši, D., Zega, M., Jenson, J.W. (2010). Assessment of Coastal Erosion and Quantification of Land Loss on Western Pacific Atolls During the Last 50 years, *European Geosciences Union General Assembly*, Vienna, Austria, 2-7 May 2010.

Taboroši, D., Jenson, J.W., Sánchez, M., Zega, M. (2010). Availability, Usage, and Threats to Freshwater Resources on Low Carbonate Islands in Micronesia, *European Geosciences Union General Assembly*, Vienna, Austria, 2-7 May 2010.

Wen, Y. (2010). Spatio-temporal Analysis of Badland Extent in Southern Guam, Mariana Islands Using Tonal Analysis, *ASPRS 2010 Annual Conference Proceedings*, San Diego, California, USA, April 26 – 30, 2010.

Wen, Y. (2010). GIS-based Analysis of Groundwater Quality in Guam, USA, *Proceedings of 18th International Conference on Environmental Indicators & 2010 Annual Meeting of International Society of Environmental Indicators*, September 13 – 16, 2010, Hefei, China.

Wen, Y. (2010). Change Detection of Land Cover in Northern Guam. *Proceedings of the 6th International Symposium on Digital Earth*, Beijing, China, September 9 – 12, 2009.

2009

Denton, G.R.W., Siegrist, H.G., and Jano-Edwards, J.P. (2009). Metal Deficiencies and Imbalances in Wetland Plants from a Manganese-Enriched Wetland in Southern Guam: A Preliminary Investigation. In: Progress in Environmental Sciences and Technology, Vol. II. *Proceedings of the 2007 International Symposium on Environment Science and Technology*, Shanghai, China, June 2-5, 2009.

Denton G.R.W. and Sian-Denton, C. (2009). Management Responses to Groundwater Quality Violations on Guam: 1996-2007. *AWRA Second Summer Specialty Conference on Adaptive Management of Water Resources II*, June 29-July 1, 2009, at Snowbird, Utah.

Khosrowpanah, S. (2009). The Impact of Guam's Population growth on Island Water Resources. *Proceeding of the International Workshop on Sustainable City Region*, Bali, Indonesia, February 23-24, 2009, p. 137-142.

Luo, Q. (2009). Daoism and Environmental Sustainability – A Completely Different Way of Thinking. *Proceedings of International Workshop on Sustainable City Region*, Bali, Indonesia, February 23-24, 2009, p. 164-171.

Luo, Q. (2009). Statistical Implications of Global Warming for Water Yield - A Case Study. *Proceedings of the American Water Resources Association 2009 Spring Specialty Conference – Managing Water Resources and Development in a Changing Climate*, Anchorage, AK, May 4-6, 2009.

Taboroši, D., Jenson, J.W., Jocson, J.M.U., and Mylroie, J.E. (2009). Coastal Discharge Features from and Uplifted Coastal Island Aquifer: Northern Mariana Islands: *15th International Congress of Speleology*, p. 548-553.

Stafford, K., Jenson, J.W., and Mylroie, J.E. (2009). Eogenetic Karst of the Carbonate Islands of the Northern Marianas: *15th International Congress of Speleology*, p. 542-547.

Taboroši, D., Jenson, J. W., Jocson, J. M. U. and Mylroie, J.E., 2009. Coastal Discharge Features from an Uplifted Carbonate Island Aquifer: Northern Guam, Mariana Islands. *Proceedings, 15th International Congress of Speleology* (Kerrville, Texas, July 19-25)

2008

Bailey, R.T., Jenson, J.W. and Olsen, A.E. (2008). Numerical Modeling of Atoll Island Hydrogeology, *14th Symposium on the Geology of the Bahamas and other Carbonate Regions*, Gerace Research Centre, San Salvador, Bahamas.

Bailey, R.T., Jenson, J.W. and Olsen, A.E., (2008). An Algebraic Model to Predict the Freshwater Lens Thickness of an Atoll Island, *14th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, Gerace Research Center, San Salvador Island, Bahamas

Denton, G.R.W. and Sian-Denton, C.M. (2008). Chemical and Biological Integrity of Guam's Groundwater: 1996-2007. *American Water Works Association Annual Conference and Exposition 2008*, Georgia World Congress Center, Atlanta, Georgia. June 8-12, 2008.

Golabi, M.H. and Denton G.R.W. (2008). The Role of Soil Components Such as Charge Characteristics on the Mobility of Contaminants Leached Down Gradient of the Ordot Landfill Area in Central Guam. *2008 Joint Meeting of The Geological Society of America, Soil Science Society of America, American Society of Agronomy, Crop Science Society of America, Gulf Coast Association of Geological Societies with the Gulf Coast Section of SEPM* Houston, Texas. October 5-9, 2008

Hoffman, S.M., Jenson, J.W., Denton, G.R.W., Moran, D.C. and Vacher, H.L. (2008). Variability of Background Fluorescence in Tropical Karst Aquifers, *14th Symposium on the Geology of the Bahamas and other Carbonate Regions*, Gerace Research Center, San Salvador Island, Bahamas.

Khosrowpanah S., and Park, M. (2008). Identifying the Optimum Land Coverage Practices for Reducing Soil Erosion in Southern Guam's Watershed using a Newly Developed GIS Based Erosion Potential Model. *Annual Meeting of Association of American Geographers,* Boston, Massachusetts, April 15-19, 2008, p. 360

Lander M.A. (2008). A Comparison of Typhoon Best-track Data in the Western North Pacific: Irreconcilable Differences. *Proceedings of the American Meteorological Society 28th Conference on Hurricanes and Tropical Meteorology*, Orlando FL, May 2008. (http://ams.confex.com/ams/28Hurricanes/techprogram/paper_137395.htm)

Mylroie, J.E., Mylroie, J.R. and Jenson, J.W. (2008). Caves and Non-Caves of Fais Island, Federated States of Micronesia, *National Speleological Society Convention*, pp. 114. (Abstract)

Sinclair, D.J., Banner, J.L., Taylor, F.W., Quinn, T.M., Jenson, J.W. and Mylroie, J.E. (2008). Deglacial Climate Dynamics in the Western Pacific Ocean Measured in a Stalagmite from Guam, *Goldschmidt Conference*, Vancouver, B.C.

Wen, Y. (2008). Spatio-Temporal Analysis of Land Cover Change in the Coastal Zone of Southern Guam (Abstract). *Proceedings of the Ninth Biennial Pan Ocean Remote Sensing Conference-PORSEC 2008* '*Oceanic Manifestation of Global Changes*' December 2–6, 2008, Guangzhou, China.

Wen Y., and Khosrowpanah, S. (2008). Land Cover Classification Accuracy Assessment in Guam. Presented at 2008 Annual Meeting, *Annual Meeting of Association of American Geographers,* Boston, Massachusetts, April 15-19, 2008, p. 738.

2007

Denton, G.R.W., Olsen, M.C. and Wen, Y. (2007). Solid Waste Disposal in Guam: The Impact of an Unsanitary Landfill on the Metal Status of Adjacent Aquatic Community Representatives. *Proceedings of the 2007 International Symposium on Environment Science and Technology*, Beijing, China, November 13-16, 2007, p. 1169-1176.

Denton, G.R.W., Olsen, M.C. and Wen, Y. (2007) Solid Waste Disposal in Guam: The Impact of an Unsanitary Landfill on the Metal Status of Adjacent Aquatic Community Representatives. *13th International Interdisciplinary Conference on the Environment,* June 30-July 3, 2007, Portland, Maine.

Olsen, A.E., Habana, N., Heitz, L.F. and Jenson, J.W. (2007). A Transfer Function Model for Deep Karst Vadose Zones, *The ASA-CSSA-SSSA International Annual Meetings*, New Orleans, Louisiana.

Sian-Denton and Denton, G.R.W. (2007). Microbiological Contaminants in Guam's Groundwater Past and Present: Benefits of Sound Management Practices. *13th International Interdisciplinary Conference on the Environment,* June 30-July 3, 2007, Portland, Maine.

2006

Denton, G.R.W. and Sian-Denton, C.M. (2006). Unsightly Algal Blooms in Tumon Bay, Guam's Premier Tourist Location: Possible Connection to Hotel Landscaping Activities. *Proceedings 12th International Interdisciplinary Conference on the Environment.* Kona, Hawaii, June 22-24, 2006.

Desai, C.S., Sane, S., Jenson, J.W., Contractor, D.S., Carlson, A.E. and Clark, P.U., (2006). A Unified Constitutive Model for Subglacial Till, Part Ii: Laboratory Tests, Disturbed State Modeling, and Validation for Two Subglacial Tills, *American Geophysical Union, Fall Meeting*, San Francisco, p. C31A-1223.

Jenson, J.W., Desai, C.S., Clark, P.U., Contractor, D.S., Sane, S. and Carlson, A.E., (2006). A Unified Constitutive Model for Subglacial Till, Part I: The Disturbed State Concept, *American Geophysical Union, Fall Meeting*. AGU, San Francisco, p. C31A-1222.

Khosrowpanah, S. and Heitz, L.F. (2006). Sources to Tap: Virtual Management of a Water Delivery System. *Proceeding of 2006th UCOWR/NIWR Annual Conference,* Santa Fe, New Mexico, July 18-20, 2006.

Lander, M.A. and Guard C. (2006). The Urgent Need for a Re-analysis of Western North Pacific Tropical Cyclones. *Proceedings 27th AMS Annual Conference on Hurricanes and Tropical Meteorology,* Monterey, CA, April 2006.

Mylroie, J.E., Mylroie, J.R., Jenson, J.W. and MacCracken, R.S. (2006). Fresh-Water Lens Anisotropy and Flank Margin Cave Development, Fais Island, Federated States of Micronesia, *Proceedings 13th Symposium on the Geology of the Bahamas and other Carbonate Regions*, Gerace Research Center, San Salvador Island, Bahamas. (in press)

Reece, M.A., Mylroie, J.E., and Jenson, J.W. (2006). Notches in Carbonate Cliffs and Hillslopes: Origin and Implications. *Proceedings of the 12th Symposium on the Geology of the Bahamas and Other Carbonate Regions,* Gerace Research Center, San Salvador, Bahamas, p. 143-152.

Sian Denton, C.M. and Denton G.R.W. (2006). Impact of Economic Growth and Urban Development on the Chemical Integrity of Guam's Groundwater Resources. *Proceedings 12th International Interdisciplinary Conference on the Environment.* Kona, Hawaii, June 22-24, 2006.

Taborosi, D., Jenson, J.W. and Mylroie, J.E. (2006). Karst Environments of Guam, Mariana Islands. *Proceedings of the 12th Symposium on the Geology of the Bahamas and Other Carbonate Regions,* Gerace Research Center, San Salvador, Bahamas, p. 220-227.

2005

Khosrowpanah, S., Lander, M.A. and Heitz, L.F. (2005). Pohnpei-the Wettest Island on Earth? Tools for Managing Watersheds. *Proceedings of the Institutions for Sustainable Watershed Management, American Water Resources Association,* Honolulu, Hawaii, June 27-29, 2005.

Khosrowpanah, S., Lander, M.A. and Heitz, L.F. (2005). Pohnpei-the Wettest Island on Earth? Tools for Managing Watersheds. *Proceedings of the Institutions for Sustainable Watershed Management, American Water Resources Association,* Honolulu, Hawaii, June 27-29, 2005.

2004

Keel, T.M., Jenson, J.W., Mylroie, J.E., Mylroie, J.R., Stafford, K.W. and Camacho, R. (2004). The Caves of Rota, Commonwealth of the Northern Mariana Islands. *Proceedings of the 12th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, Gerace Research Center, San Salvador, Bahamas, p. 76-87.

Mylroie, J.E., Jenson, J.W., Mylroie, J.R. and Carew, J.L. (2004). Epikarst on Eogenetic Rocks. *Proceedings of the Epikarst Conference, Karst Waters Institute Special Publication*, 9: 132-134

Mylroie, J.E., Mylroie, J.R. and Jenson, J.W. (2004). Modeling Carbonate Island Karst. *Proceedings 11th Symposium on the Geology of the Bahamas and other Carbonate Regions,* Gerace Research Center, San Salvador Island, Bahamas, p.135-144

Reece, M.A., Mylroie, J.E. and Jenson, J.W. (2004). Notches in Carbonate Cliffs and Hillslopes: Origin and Implications. *12th Symposium on the Geology of the Bahamas and Other Carbonate Regions,* p. 25-26.

Stafford, K.W, Mylroie, J.E., Mylroie, J.R., Jenson, J.W. and Taboroši, D. (2004). Coves and Pocket Beaches: Littoral Erosion of Flank Margin Caves. *Geological Society of America Abstracts and Programs*, 36(5): 284

Stafford, K. W., Mylroie, J.E., Jenson, J.W., Mylroie, J.R., and Taboroši, D. (2004). Dissolution Controls Related to the Carbonate Island Karst Model on Tectonically Active, Carbonate Islands: Tinian and Aguijan, CNMI. *Proceedings of the 12th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, p. 205-219.

Stafford, K.W., Mylroie, J.,E., Jenson, J.W., Mylroie, J.R. and Taboroši, D. (2004). Dissolution Controls Related to the Carbonate Island Karst Model on Tectonically Active, Carbonate Islands: Tinian and Aguijan, CNMI. *Proceedings 12th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, p. 30-31.

Stafford, K.W., Taboroši, D., Keel, M., Mylroie, J.M., Mylroie, J.R. and Jenson, J.W. (2004). Joint Research Expeditions to Mariana Islands: Aguijan, Rota, and Tinian. *Proceedings of the National Speleological Society National Convention.*

Stafford, K.W., Mylroie, J.E., Jenson, J.W., Mylroie, J.R. and Taboroši, D. (2004). Dissolution Controls Related to the Carbonaet Isladn Karst Model on Tectonically Active, Carbonate Islands: Tinian and Aguijan, CNMI. *Proceedings of the 12th Symposium on the Geology of the Bahamas and Other Carbonate Regions,* p. 205-219.

Taboroši, D., Jenson, J.W. and Mylroie, J.E. (2004). Karst Features of Guam, Mariana Islands. *Proceedings12th Symposium on the Geology of the Bahamas and Other Carbonate Region*, p. 31.

Taboroši, D., Jenson, J.W. and Mylroie, J.E. (2004). Karst Environments of Guam, Mariana Islands. *Proceedings of the 12th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, p. 220-227.

Wen, Y. and Wang, Y. (2004). Validation of Spatial Diffusion Model for Simulation of Suburban Sprawl, *ASPRS Annual Conference Proceedings*, Denver, CO, May 23–28, 2004.

Wen, Y. and Wang, Y. (2004). Cell-based Dynamic Modeling of Urban Land Cover Change. *Proceedings 100th Annual Meeting of the Association of American Geographers (AAG),* Philadelphia, Pennsylvania, March 14-19, 2004.

2003

Heitz L.F. and Rumong, L. (2003). Water Water Everywhere but I Can't Take a Shower: Using Rainwater Catchment Systems for Emergency Backup Water

Supplies. *Proceeding of the 11th International Rainwater Catchment Systems Conference,* Mexico City, Mexico, September 2003.

Iyekar, C., Golabi, M. Denton, G.R.W. and Wood, H.R. (2003). Impact of Ordot Dump on Water Quality of Lonfit River Basin in Central Guam. *Proceedings 20th Pacific Science Congress,* Bangkok, Thailand, March 17-21, 2003.

Khosrowpanah, S. and Scheman, N. (2003). Badland Erosion rates and Sources in a Tropical Watershed. *Proceedings of 2003rd Annual Conference, Soil and Water Conservation Society,* Spokane, Washington, July 2003.

McDonald, M.Q. and Jenson, J.W. (2003). Historical Analysis of Chloride ion Concentrations in Production Wells in the Northern Guam Lens Aquifer, Guam, Mariana Islands. *Proceedings 2nd International Conference on Saltwater Intrusion and Coastal Aquifers: Monitoring, Modeling and Management*, March 30-April 2, 2003, Merida, Yucatan, Mexico.

Mylroie, J.E., Jenson, J.W., Mylroie, J.R. and Carew, J.L. (2003). Epikarst on Eogenetic Rocks. *Proceedings of the Epikarst Conference, Karst Waters Institute,* p. 17.

Stafford, K.W., Mylroie, J.E., Mylroie, J.R. and Jenson, J.W. (2003). Tinian, CNMI: A Carbonate Island Karst Model Evaluation (Abstract). *Geological Society of America Abstracts and Programs,* 35(1): 3.

Stafford, K.W., Mylroie, J.E., Taboroši, D., Mylroie, J.R., Keel, T.M. and Jenson, J.W. (2003). Structurally Controlled Eogenetic Karst: Mariana Islands. *Proceedings GSA Annual Meeting,* Seattle, WA, 34: 452.

Wen, Y. and Wang, Y. (2003). Coupling Spatial Diffusion and Fractals for Simulation of Suburban Sprawl. *Proceedings GeoInformatics 2003 International Conference,* Toronto, Canada.

Wen, Y. and Wang, Y. (2003). Spatial Diffusion Modeling for Simulation of Suburban Sprawl. *ASPRS 2003 Annual Conference Proceedings*, Anchorage, Alaska, May 5-9, 2003.

2002

Jenson, J.W., Mylroie, J.E., Mylroie, J.R. and Wexel, C. (2002). Revisiting the Carbonate Island Karst Model. *Geological Society of America, Abstracts with Programs*, 34(6): 226.

Lander, M.A. and Edson, R.T. (2002). Evaluation of Microwave Imagery in the Life Cycle of Tropical Cyclones. *Proceedings of the 25th AMS Conference on*

Hurricanes and Tropical Meteorology, May 2002, San Diego, California, p. 477-478

Khosrowpanah, S. (2002). Rainfall Erosivity Factors for Selected Islands in the Federated States of Micronesia. *Proceedings American Water Resources Association,* New Orleans, Louisiana, May 2002, p. 225-230.

Lander, M.A. Edson, R.T., Cantrell, C.E., Franklin, J.L., Chang, P.S. and Hawkins, J.D. (2002). Operational Use of Quickscat Over Tropical Cyclones. *Proceedings of the 25th AMS Conference on Hurricanes and Tropical Meteorology,* May 2002, San Diego, California, p. 41-42.

Lander, M.A. (2002). A Look at Global Tropical Cyclone Activity with Respect to the Atlantic Change-Point Year of 1995. *Proceedings of the 25th AMS Conference on Hurricanes and Tropical Meteorology,* May 2002, San Diego, California, p. 142-143.

Lander, M.A. and Ward, B.D., Jr. (2002). Distal and Sympathetic Surface Trough Development Induced by TUTT Cells: A Case Study. *Proceedings of the 25th AMS Conference on Hurricanes and Tropical Meteorology,* May 2002, San Diego, California, p 446-447.

Mylroie, J.E. and Jenson, J.W. (2002). Karst Flow Systems in Young Carbonate Islands. In: J.B. Martin, C.M. Wicks and I.D. Sasowsky (Editors), *Karst Frontiers: Florida and Related Environments*. *Karst Waters Institute Special Publication 7*. Karst Waters Institute, Charles Town, West Virginia, p. 107-110.

Mylroie, J.E., Mylroie, J.R. and Jenson, J.W. (2002). Modeling Carbonate Island Karst. In: R. Martin and B. Panuska (Editors), *11th ssymposium on the Geology of the Bahamas and Other Carbonate Regions*, Gerace Research Center, San Salvador Island, Bahamas, p. 135-144.

Taboroši, D. and Jenson, J.W. (2002). Fluviokarst on a Small Carbonate Island: Guam, Mariana Islands. *Geological Society of America Abstracts with Programs,* 34(6).

Wen, Y. and Wang, Y. (2002). Spatial Diffusion Modeling: A New Approach in Simulation of Urban Sprawl. *ACSM- ASPRS 2002 Annual Conference Proceedings,* Washington DC, April 19-22, 2002.