Water and Environmental Research Institute of the Western Pacific
Annual Technical Report
FY 2001

Introduction

The Water & Environmental Research Institute of the Western Pacific or WERI is one of 55 similar water research institutes established by U.S. Congressional legislation at each Land Grant University in the United States and in several territories. The institute is now in its 27th year of operation.

WERIs 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 regional island nations. WERI also runs a state of the technology water analytical laboratory and geographical information system facility.

WERI administers and carries out research, training, and 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 money on Guam, in the Commonwealth of the Northern Mariana Islands (CNMI) and in the Federated States of Micronesia (FSM). In the 2001-2002 period WERI faculty were involved as Principal Investigators on eighteen research and training projects. Funding sources include US Geological Survey, US Weather Service, NASA, local agencies such as Guam Environmental Protection Agency and Guam Bureau of Planning, and direct appropriations from the Guam legislature.

Currently WERI has a fulltime director who is also a UOG faculty member, five regular research faculty, one adjunct research faculty, a water analysis laboratory manager and technician, two office staff, as well as six graduate research students who were completing their MS degree in the Environmental Sciences program. During the 2001-2002 interval, WERI faculty and staff taught nine graduate courses and four undergraduate courses in the Environmental Science MS program and the undergraduate pre-engineering curriculums respectively. At the same time WERI faculty were first or second authors on eighteen refereed journal articles or conference proceedings, five technical reports, and fourteen professional presentations. Currently WERI faculty members serve as committee members on, or chairs of about fourteen MS research theses in the Environmental Sciences and Biology graduate programs.

NON USGS Funded Projects

NASA

Ground Based Radar Rainfall Estimation Project: Guam TRMM Validation

NATIONAL WEATHER SERVICE

Pacific ENSO Applications Center

GUAM WATERSHED PROJECTS GUAM Environmental Protection Agency

The Spatial Variability of contaminants from Septic Tanks in Northern Guam

Potential Impact of Current Landscaping Practices in the Tumon Basin on the Nutrient Status of Tumon Bay

Restoring the Northern Guam Watershed by identifying Groundwater Nitrate-Nitrogen Anomalies and their Sources

Contaminant and Restoration Assessment of Agana Swamp and Adjacent Waters

Harmon Sink Dye Trace to Establish The Hydraulic Connection With Discharge Points Along The Coast of Agana Bay

GUAM BUREAU OF PLANNING

Contaminant and Restoration Assessment of Agana Swamp and Adjacent Waters

GUAM DEPARTMENT OF EDUCATION

Identifying The Water Resources Required To Rehabilitate A Large Wetland In Piti, Guam

GUAM AIRPORT AUTHORITY

Hydrogeological Service for Drilling of Exploratory Wells

DIRECT LOCAL FUNDING

Guam Hydrologic Survey

Water Resources Monitoring Program

Research Program

The Water and Environmental Research Institute (WERI) Advisory Council is the body, which determines research goals and priorities for WERI in general and the USGS 104B program in particular. The Research Advisory Council (RAC) for Guam consists of representatives from all Guam governmental agencies involved with water resources development or regulation, members of U.S. Federal agencies, military organizations on Guam that deal with water resources issues and members of the university research community. The RAC for the Federated States of Micronesia and the Commonwealth of the Northern Mariana Islands consist of representatives from various government departments that deal with water resources, representatives from local colleges, private sector engineers, environmentalists, and planners.

WERI held RAC meetings in March and April 2000. Twenty three (23) people attended the Guam meeting, eighteen (18) people attended the CNMI meeting and nineteen (19) people attended the FSM meeting. The RAC groups examined the previous years research priorities and discussed changes to keep the listings up to date.

In late September, a Request for Proposals (RFP) was sent out by e-mail, FAX, and mail to the three regions: Guam, CNMI, and FSM. RFPs were sent to all regular members of the three RACs as well as to several agencies and institutions that had expressed interest during the previous year. A total of fifty (50) RFP e-mails, mailings or Faxes were issued together with a copy of a) 104-B proposal guidelines and submittal forms, and b) the list of critical water resource needs for their region.

Seven (7) proposals, three (3) for Guam, two (2) for the FSM, and two (2) for the CNMI were submitted. Review panels were selected for each of the regions. These panels were made up of researchers not submitting proposals or from others highly regarded in the water resources area of each of the regions. The submitted proposals were photocopied and mailed to the members of the appropriate review panels. Each panel member had the list of critical needs and a scoring procedure that had been agreed upon at earlier RAC meetings. They were advised to work independently. Following a three-week interval, reviews were returned to WERI and re-evaluated by the Director. No changes were made in the individual ratings by review panel members and average ratings were then calculated to select winners. All of the projects that were submitted were highly rated and were funded .

Information Mangement

Basic Information

Title:	Information Mangement
Project Number:	2001GU1301B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Not Applicable
Focus Category:	Climatological Processes, Hydrology, Management and Planning
Descriptors:	Water Resources Management, Climate Data,Rainfall Data
Principal Investigators:	Leroy F. Heitz

Publication

INFORMATION MANAGEMENT

WERI's mission involves maintaining and providing water resources related data to researchers, water resources managers, educators and the general population of the islands of the Western Pacific. This project was used to provide funding to maintain subscriptions to a wide variety of data sources dealing with meteorology, climatology and hydrologic data. These resources are maintained at WERI and made available to researchers, water managers, educators and the general public throughout the region. Communication and information exchange between experts in the area of water resources is vital to the improvements in the wise use of this resource. In the past WERI published a Directory of Water Resources Expertise in Guam and the Federated States of Micronesia. This publication was not only valuable to administrators and faculty at WERI but was also quite useful to those in government agencies and the public at large who were interested in contacting people with expertise in a particular field. Because of turnover in personnel in the region we felt that it was time to update and reprint this publication. We also added listings for those from the Commonwealth of the Northern Marianas Islands. The expertise data base has been developed and it is presently being added to WERI's Web page as a searchable data base.

Investigation of the Use of Locally Available Materials for Slow Sand Filtration In Kosrae State, Federated States of Micronesia

Basic Information

Title:	Investigation of the Use of Locally Available Materials for Slow Sand Filtration In Kosrae State, Federated States of Micronesia
Project Number:	2001GU1321B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Water Quality
Focus Category:	Treatment, Water Supply, Surface Water
Descriptors:	Streams, Water Quality Control, Slow Sand Filter
Principal Investigators:	Shahram Khosrowpanah, Leroy F. Heitz

Publication

1. Khosrowpanah S., L. Heitz, & C. Beausoliel, The Application of Slow Sand Filtration Technology for Kosrae State, FSM: A Pilot Project, University of Guam/WERI, Technical Report No. 91a, May 2001.
2. Khosrowpanah S., & L. Heitz, The application of Slow Sand Filtration Technology for Kosrae State, the Federated States of Micronesia: A Pilot Project, in Proceedings of 10th Pacific Science Inter-Congress, June 1-6, 2001, Tumon, Guam.

PROJECT SYNOPSIS REPORT

Title: Investigation of the Use of Locally Available Materials for Slow Sand Filtration In Kosrae State, Federated States of Micronesia

Problems and Research Objectives:

The lack of clean drinking water is a significant problem for residents of the high, volcanic islands of the Federated States of Micronesia (FSM). Residents of Kosrae State, the easternmost member of the FSM, are highly reliant on surface water resources. These waters however, are not treated, due to a lack of funding for conventional treatment methods. Consequently, untreated water is piped directly into people's homes bearing with it significant sediment and contamination. Study by the Hawaii Department of Health (1991) indicates that Kosrae has one of the highest incidences of water related diseases in the world. In order to reduce the incidence rate of water borne illnesses, water treatment is necessary. The treatment technology must be economical to build, and simple to operate and maintain given the adverse economic and environmental conditions of this remote island. For these reasons, slow sand filtration was selected as a potential water treatment technology. The objectives of this study were: 1) modify the existing pilot plant to gain better flow control to the test cylinders, 2) measure the level of turbidity and coliform removal, under various hydraulic loading rates, 3) evaluate different local sand size distributions, and 4) determine the economic and technical feasibility of using the local sources as opposed to previously tested commercially available sources.

Methodology:

This project was divided into four phases as described below:

Phase I. Modifications to Existing Pilot Plant. We used the existing pilot plant that was constructed for the previous study. This plant consists of four test cylinders that were constructed near the Tofol stream in Kosrae. Each plant includes a PVC pipe 13 feet long, 12-inch diameter with 5.5 feet of sand media sitting on 1.8 feet of gravel bed. To measure the head loss across the cylinder, each cylinder is equipped with three piezometers, sampling taps, and an outflow weir that prevents the creation of negative pressure across the filter media. For this study we used only two of the test cylinders. Two modifications were done with the pilot plant. One was using a variable volume flow rate peristaltic pumps, regulating the inflow to the each cylinder at approximately 230 ml/min. The other modification was installing a submersible sump pump that supplies water from the source stream next to the plant to an on-site storage tank. The solids were held in suspension using an aquarium pump circulating air through the tank. The peristaltic pumps fed directly from the tank to the test cylinders. These two changes guaranteed that a continuous flow from the stream with a constant rate was input to the test cylinders at all times.

The two filters that were used had a locally manufactured sand material that has been prepared according to typical SSF specifications.

Phase II. Testing the loading rate and different local sand size distributions
Originally we had planned to run the pilot plants with four different hydraulic loading rates such as 2.6, 3.9, 5.2, and 7.8 ml/sec. However, after our preliminary results, we decided to use only one loading rate which was 2.6 ml/sec. This decision was based on the level of turbidity of the inflow to the filters.

To determine the best sand size distribution for the filters that could give us a longer filter run between scrapping, we used local materials with Uniformity Coefficient (UC = d_{60}/d_{10}) of 2 and 2.2. The Uniformity Coefficient is a reflection of the degree of variation in particle sizes. A lower UC indicates more uniformity in particle sizes, which generally results in a higher porosity. A higher UC indicates greater variation in particle sizes and usually indicates reduced porosity.

Phase III. Monitoring and testing The testing, that was started in February and was continued until end of July of this year, included: 1) daily flow measurement to the filters to be sure that constant flow is being delivered to the filters, 2) daily inflow/outflow turbidity measurement to determine the filter's turbidity removal rate, 3) daily head loss measurement across the filter bed to determine the scrapping time for the filters, 4) daily inflow/outflow temperature measurement to determine the filter bed maturity, and 5) weekly coliform measurement of the inflow/outflow to the filters to determine the filter removal rates.

Phase IV. Evaluation. The pilot plant performance were evaluated base on the results of Phase III. The criteria for evaluating pilot plant performance were based on criteria such as:

1. The ability of the plant to remove coliform bacteria: We are seeking removal of at least 90 to 99% of coliform bacteria.
2. The ability to reduce the turbidity of feed waters to an acceptable level.
3. Fairly long filter run times.

The difference in performance of each filter's materials were carefully evaluated. A final set of design recommendations and criteria for the actual slow sand filter were developed from the pilot plant data.

Principal Findings and Significance:
The results of the first phase of the slow sand filtration pilot study for Kosrae that was completed last year showed that the bacteria and turbidity removal rate for local basalt media was the same as the commercial sand media. However, the locally manufactured sand media had a longer initial run compared to off island media before being scraped. This was due to a large uniformity coefficient of the local sand media (4.5) compare to commercial sand media (2.2). Another problem we encountered last year was lack of a system to regulate inflow to the filters.

The monitoring and testing of the pilot plant performance has been completed. The preliminary results indicate that in order to increase the time between the filter's scraping, a settling tank is required. The actual size of the settling tank will depend on the time required for the solid particles to settle. The results will be carefully evaluated to determine the optimum uniformity coefficient for local media. There is great interest in applying SSF technology to other islands in the FSM. This is especially true on Pohnpei Island where a recent cholera outbreak is being blamed partially on unsanitary conditions in rural surface water supplies.

Contaminant and Restoration Assessment of Agana Swamp, and Adjacent Waters

Basic Information

Title:	Contaminant and Restoration Assessment of Agana Swamp, and Adjacent Waters
Project Number:	2001GU1341B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Water Quality
Focus Category:	Toxic Substances, Sediments, Wetlands
Descriptors:	Risk Assessment, Watershed Management, Wetlands,Pollutants
Principal Investigators:	Gary Denton, Harold Wood

Publication

1. Concepcion, L. P. and G.R.W. Denton (2001). PCBs in Agana Swamp, Guam: Historic Overview & Current Research. In: The Integration of Natural and Social Sciences in the New Millennium. in Proceedings 10th Pacific Science Inter-Congress, Guam, June 1-6, 2001. P. 99.

PROJECT SYNOPSIS REPORT

Project Title: Contaminant and Restoration Assessment of Agana Swamp, and Adjacent Waters

Problem and Research Objectives

The Agana Swamp is an area of permanent wetland bordering the western shores of central Guam. It is lens fed and also receives surface runoff from the surrounding slopes of Sinajana, to the southwest, and Mongmong, to the northeast. Water is drained from the swamp into the coastal belt via the Agana River. The swamp contains a rich diversity of flora and fauna and is a popular fishing ground for many local people. It also lies adjacent to several high-yielding water wells.

In 1995, PCB contaminated soil was discovered in the vicinity of the Agana Power Plant located at the northern edge of the Agana Swamp. Preliminary studies carried out by the US Navy subsequently revealed relatively high levels of PCBs in fish taken from the swamp and adjacent river system. To data, however, there is no definitive link between PCBs in fish from the swamp and the high levels found at the power plant. Indeed, levels found in fish and sediment samples taken from sites close to the power plant were found to be lower than those taken further away at the headwaters of the Agana River. The discrepancy between the limited data sets therefore implies that the Agana Power Plant may not be the only major source of PCBs into this watershed.

The following study was deigned to determine the distribution and abundance of PCBs and other contaminants (chlorinated pesticides and heavy metals) in surface and subsurface soils from the Agana Swamp and adjacent waters. The study focused primarily on samples taken from the swamp perimeter thus complementing the earlier US Navy data for samples collected from accessible points within it. The objectives of the study were to delineate concentration gradients of the above contaminants within the study area, identify areas of enrichment, and locate primary point sources if they exist. Also, to provide urgently needed baseline data upon which sound watershed restoration strategies could be implemented as necessary.

Methodology

One hundred and twelve soil cores (30 x 5 cm) were collected at ~100-200 m intervals around the perimeter of the wetland (Fig. 1) using stainless steel corers fitted with pre-cleaned aluminum liners. Additionally, 18 cores were taken from the lower reaches of Agana River that exits the swamp and drains into Agana Bay (~1200 m length). A slide hammer was used to push the corers into the substrate at each site. Once charged with soil, the liners were removed from the corers and fitted with Teflon lined, plastic end-caps. They were then wrapped in aluminum foil and immediately chilled for transportation to the laboratory where they were stored at -20^{o}C. Horizontal surface sediment sweeps were also made at eight sub-tidal sites in Agana Bay, immediately adjacent to the Agana River mouth. The samples were collected in hand-held aluminum liners and prepared for transportation and storage in the same way as described above for the soil cores.

When required for analysis, the frozen cores were expelled from the aluminum liners using a heat-gun and gentle pressure from a Teflon rod. The extruded cores were rewrapped in aluminum foil, refrozen, and then cut into two equal lengths using a band saw. The upper and lower sections of each core were thus operationally defined as surface and subsurface samples respectively.

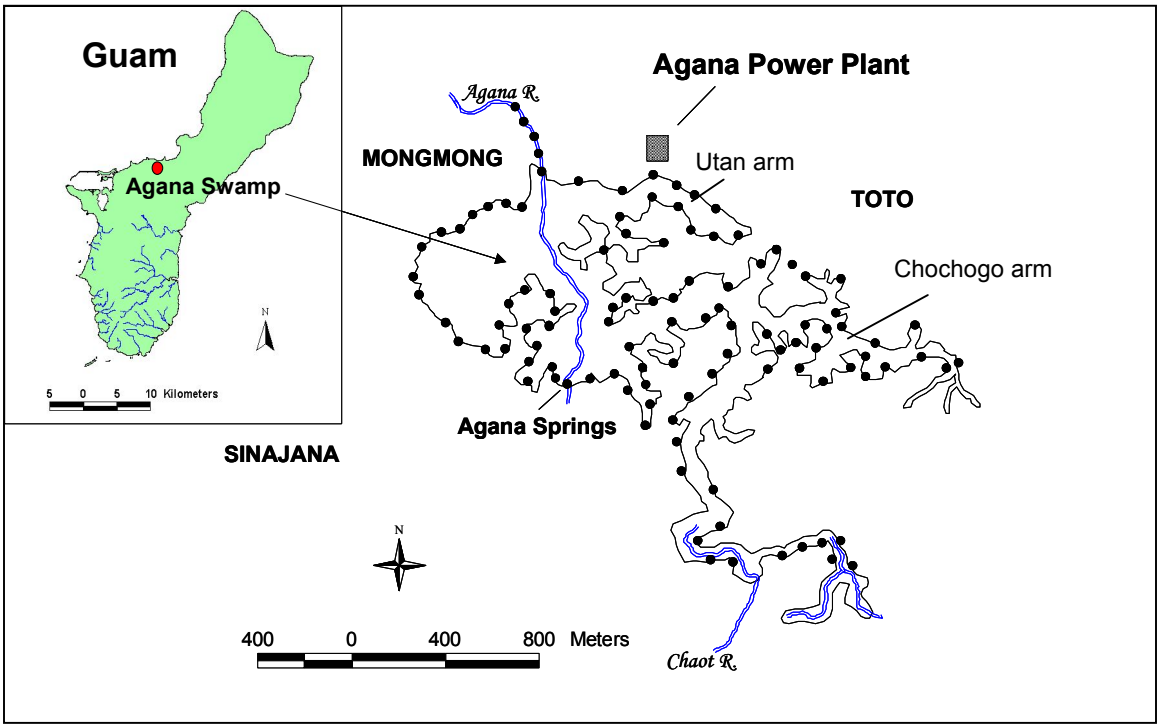

Figure 1. Map of Agana Swamp Showing Location of Perimeter Sampling Sites

Once thawed, each section was thoroughly homogenized in a glass bowl with a polyethylene spatula following the removal of large rocks, shells and other such bulky materials. Samples for heavy metal analyses were placed in acid cleaned polyethylene vials and dried to constant weight at 60^{o}C while those for PCB analyses were air dried in the dark in shallow aluminum pans. Residual amounts of sediment samples were stored in pre-cleaned glass jars at -20^{o}C for further analysis if necessary.

Upon drying, sediments were disaggregated in non-contaminating containers with a heavy Teflon rod. Those samples for metal analysis were sieved through a 1 mm nylon sieve and stored in polyethylene vials at room temperature until required for analysis. Those for PCB analysis were sieved through a 1 mm stainless steel screen into clean glass vials for storage at -20^{o}C.

Appropriate analytical methods for the above contaminants were adapted from the current SW-846 protocols developed by USEPA in addition to those recommended by the NOAA National Status and Trends Program. Appropriate quality control and quality assurance procedures, including full procedural blanks, matrix spikes, and certified reference materials, were built into the analytical procedures.

Principal Findings and Significance
The data summaries for PCBs and other chlorinated pesticides detected in the swamp samples analyzed are presented in Table 1 below. All data are expressed as ng/g dry wt. (ppb). The heavy metal analysis has yet to be completed.

PCBs:
It can be seen that while PCBs were detected in the majority of samples, relatively few samples yielded profiles that matched the commercial PCB mixture, Aroclor 1260. Moreover, no sample exceeded the 1000 ng/g remediation goal recently established by US EPA for PCBs in Agana Swamp.

Soil	Σ_{20}PCBs	Aroclor 1260	DDT	DDE	DDD	Chlordane
Surface (% Quantifiable)	<0.01 - 232 (96)	<0.01 - 511 (26)	<0.1 - 33 (6)	<0.07 - 9.7 (6)	<0.21 - 475 (6)	27 - 687 (3.6)
Subsurface (% Quantifiable)	<0.01 - 640 (86)	<0.01 - 854 (20)	<0.1 - 149 (7)	<0.04 - 52 (7)	<0.1 - 35 (7)	24 - 674 (3.6)

Table 1. PCBs and Chlorinated Pesticides (ng/g) in Agana Swamp Soil

The highest PCB concentrations were found in the Agana Springs area and along the northern perimeter of the swamp into the Utam arm (Fig. 1). The highest overall value (as Σ_{20}PCBs) was 640 ng/g in a subsurface sample collected near the Guam Mass Transit Authority depot. Interestingly, the corresponding surface sample from this site was only 4.3 ng/g suggesting that the overburden at this site had come from elsewhere. Σ_{20}PCB levels were less than 10 ng/g in ~90% of all other surface and subsurface samples taken from within the study area (Fig. 2).

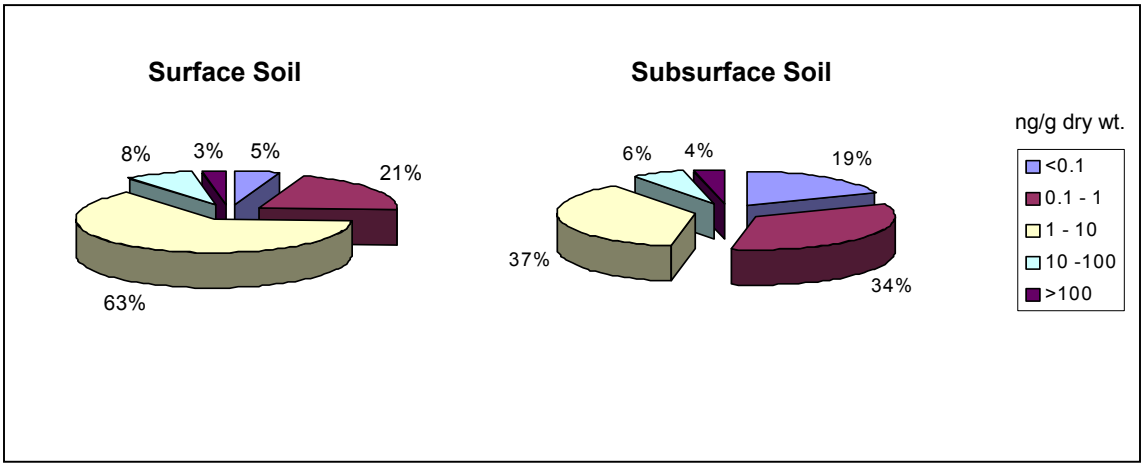

Figure 2. Σ_{20}PCB Concentration Ranges in Agana Swamp Soil

Σ_{20}PCB concentrations were higher in the surface fractions of about two thirds of the soil cores examined. The difference between the two fractions was less than one order of magnitude in the majority of these. Likewise, where Σ_{20}PCB levels were higher in the subsurface fractions, a dissimilarity factor of 10, or less, generally prevailed (Fig. 3).

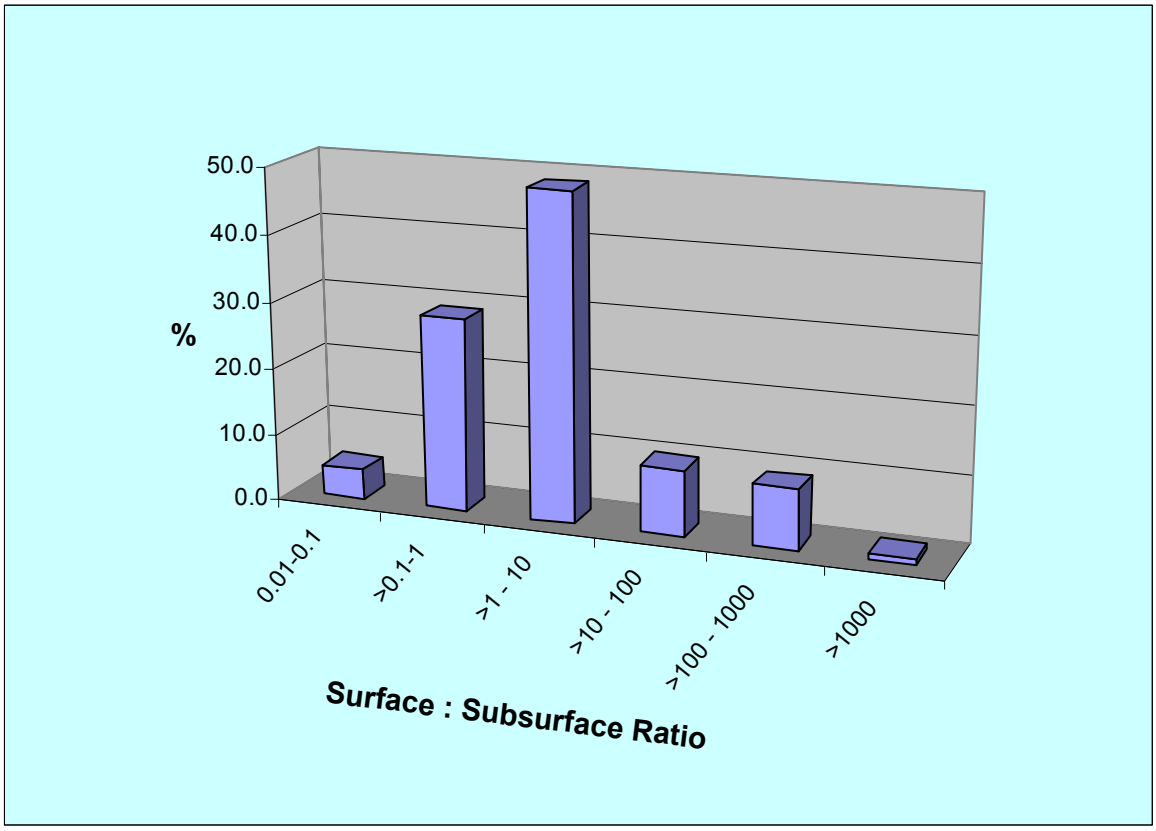

Figure 3. Depth Dependant Differences in PCB Abundance in Agana Swamp Soil

Chlorinated Pesticides:

Of the other chlorinated hydrocarbons looked at, only chlordane and the DDT analogues were occasionally detected (Table 1). In fact, chlordane was only found in a small block of samples adjacent to a commercial shopping center, along the northwestern perimeter of the swamp. In contrast, DDT and related compounds were detected all along the northern edge and into the *Utam* arm of the swamp. Two soil samples from the *Chochogo* arm of the swamp also tested positive for these compounds. The comparatively high concentrations of DDD in several of these samples probably reflect the anaerobic nature of the swamp environment.

Development of Monthly and Seasonal Rainfall Climatologies and Distribution Maps for Guam

Basic Information

Title:	Development of Monthly and Seasonal Rainfall Climatologies and Distribution Maps for Guam
Project Number:	2001GU1342B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Climate and Hydrologic Processes
Focus Category:	Hydrology, Drought, Climatological Processes
Descriptors:	Climate, Rainfall, Data Analysis, Atmospheric Processes, Remote Sensing
Principal Investigators:	Charles Guard, Mark Lander

Publication

PROJECT SYNOPSIS REPORT

Project Title: Development of Monthly and Seasonal Rainfall Climatologies and Distribution Maps for Guam

Problem and Research Objectives:
Guam is characterized by one of the highest levels of rainfall variability in the world, with the highest annual rainfall nearly three times the amount of the lowest rainfall. This makes the region extremely susceptible to significant droughts and floods. Much of this variability can be traced to inter-annual climate variability such as El Niño and La Niña events and to the occurrence of typhoon and monsoon events that affect the island. This climatic variability and the occurrence of tropical weather systems determine the character of the rain, which is a reflection of rainfall intensity, rainfall frequency, and rainfall duration.

Despite its small size, the island has a very complex annual rainfall distribution pattern. The high rainfall variability and complex distribution directly affect ground and surface water supplies, water quality, erosion, pollution from run-off, and local flooding. In order to adequately and credibly deal with these issues, users on Guam need an accurate and representative rainfall database, rainfall climatology, and a representative set of rainfall distribution maps, both for monthly and seasonal (rainy season, dry season) periods.

The study of rainfall distribution on Guam using new information sources (e.g., new databases, Doppler radar, etc.) was identified at the 1998 Guam-WERI Water Advisory Council meeting as one of the critical needs of the Island. The need was reiterated at the 1999 Guam-WERI Water Advisory Council meeting. Accurate rainfall databases and representative rainfall climatology are fundamental to an accurate analysis of rainfall distributions. Rainfall distribution charts are critical for water management, research, and the development of public water policy.

Methodology:
This study entailed updating a recently completed 50-year rainfall database for 150 locations on Guam. Where there were occasional missing months of data in an otherwise complete data set, rainfall was estimated by correlating it with nearby data. However, this was not done in the conventional sense, but correlations were determined based on the synoptic weather regimes (general atmospheric processes) producing the rain. This eliminated the past practice of clumping all rainfall types together without concern for the rainfall character. The complete database is now available to WERI and USGS scientists in a shared database.

Annual rainfall was divided into regimes (e.g., the El Niño year, El Niño + 1 year, La Niña year, and "normal" year groups) that best reflected the rainfall variability on Guam. This produced a climatology from which major portions of the variance in rainfall could be explained. From this climatology and the earlier developed annual rainfall distribution

map, we developed a set of monthly and "seasonal" rainfall distribution maps for Guam using the primary synoptic regimes.

Doppler radar data, microwave rainfall data, and other, more conventional meteorological satellite data was used to determine the rainfall patterns in data sparse areas, especially those in the immediate off-shore areas around Guam. The radar data was available upon request from the National Weather Service at Tiyan, Guam, and the satellite data was available half-hourly at WERI. In addition, microwave rainfall data was available via the internet and through our involvement with the Tropical Rainfall Measuring Mission (TRMM). Further, additional rain gauges managed by WERI for the TRMM experiment were used for fine-tuning rainfall rates and gradients.

Principal Findings and Significance:

Accurate and representative rainfall climatology and a corresponding set of rainfall distribution maps are fundamental to hydrologic studies of Guam. This project took a recently completed 50-year rainfall database developed for 150 locations on Guam (Figure 1) and the annual rainfall distribution map (Figure 2) developed by the PI under an earlier USGS proposal and derived accurate and representative monthly and seasonal rainfall climatologies and rainfall distribution maps. This process was the next logical step after developing the comprehensive database and annual rainfall distribution map. The resulting products will allow researchers, water managers, and land use planners to select a representative rainfall climatology segment on which to base critical environmental decisions. This is essential in an area with so much rainfall variability exists. To a large extent, this variability can be explained, but this knowledge has neither been conveyed in published rainfall climatology nor in existing monthly rainfall distribution maps. The results of this research have added credibility to regional hydrologic studies, and will give water resource managers and rainfall forecasters a much more accurate understanding of rainfall processes. The study also greatly benefits the Guam Hydrological Survey program and will ultimately benefit those making public water policy.

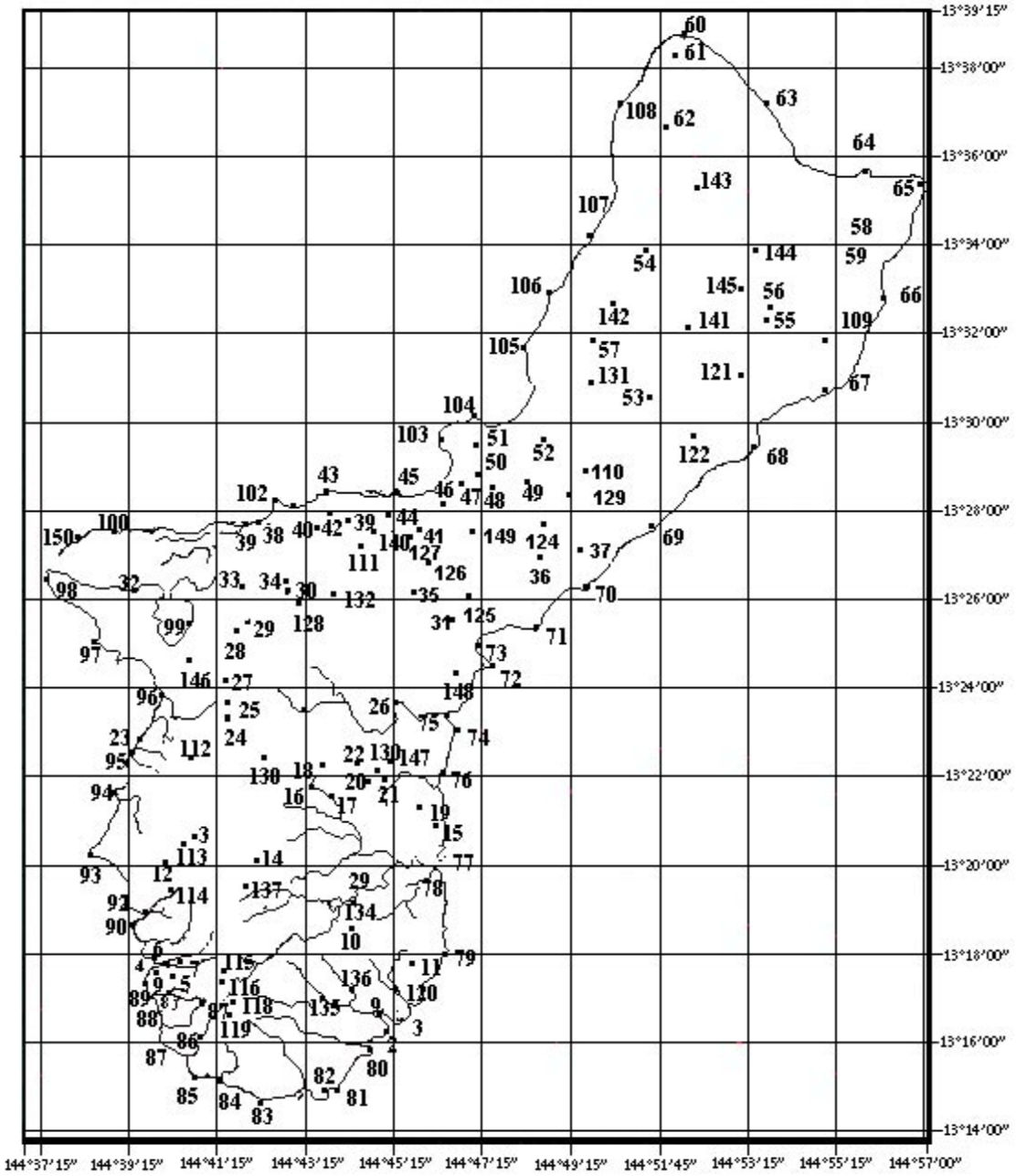

Figure 1. Locations of the 150 sites that make up the derived 1950-1999 rainfall database on which the newly developed annual rainfall distribution map for Guam is based.

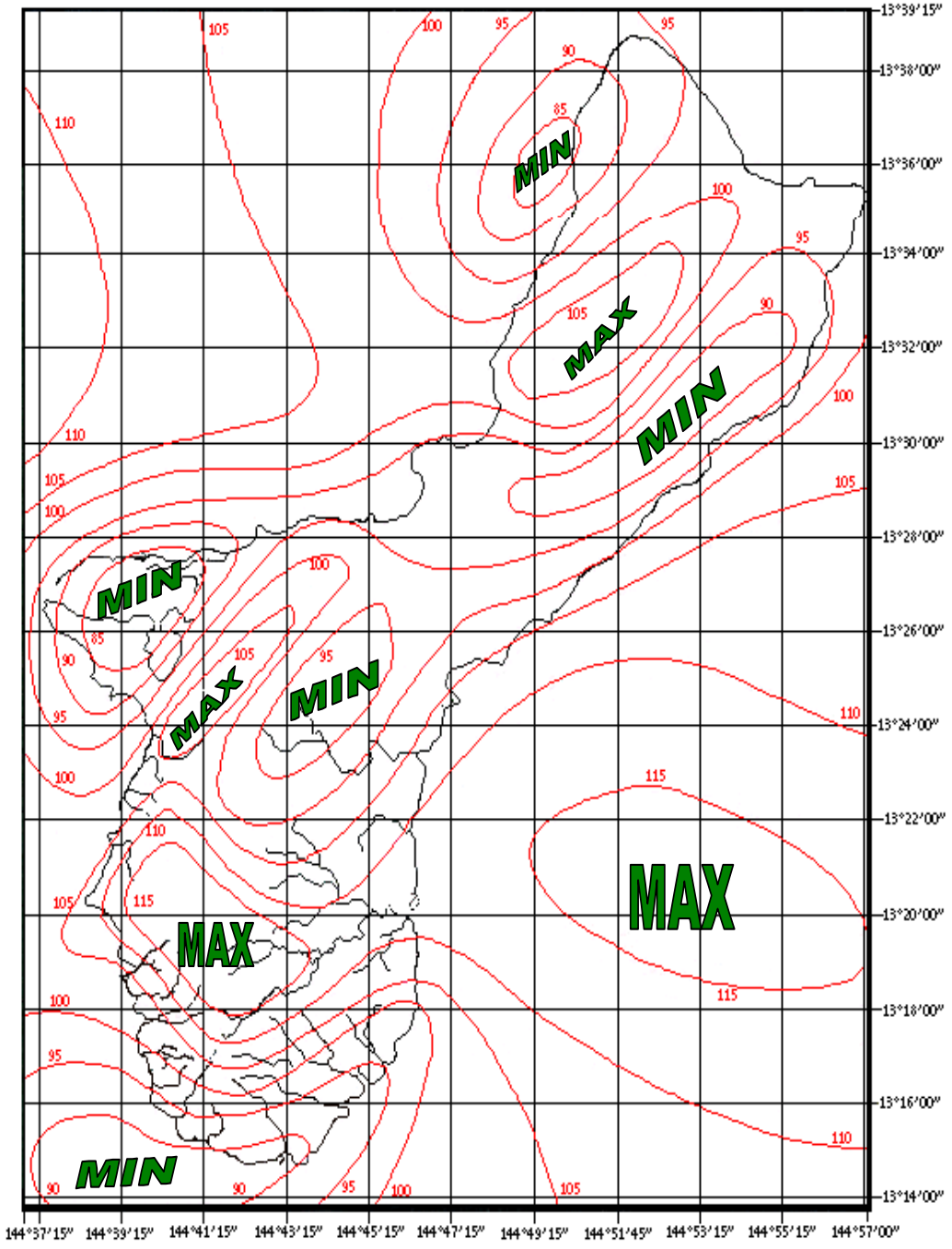

Figure 2. Newly developed annual rainfall distribution map for Guam. The analysis is based on the compositing of 50 individual annual analyses from 1950-1999. Rainfall is in inches.

Groundwater Infiltration and Recharge in the Northern Guam Lens Aquifer as a Function of Spatial and Temporal Distribution of Rainfall

Basic Information

Title:	Groundwater Infiltration and Recharge in the Northern Guam Lens Aquifer as a Function of Spatial and Temporal Distribution of Rainfall
Project Number:	2001GU1343B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Climate and Hydrologic Processes
Focus Category:	Groundwater, Hydrology, Climatological Processes
Descriptors:	Groundwater, Sustainable yield, Climate, Data Analysis, Rainfall, Remote sensing, Atmospheric processes
Principal Investigators:	Mark Lander, John W. Jenson

Publication

1. Lander, M.A., Jenson, J.W., Beausoliel, C., 2001, Responses of Well Water Levels on Northern Guam to Variations of Rainfall and Sea Level, WERI Technical Report No. 94, Water and Energy Research Institute of the Western Pacific, University of Guam.
2. Lander M.A. & C. Beausoliel Responses of well water levels on Northern Guam to variations of rainfall and sea level., in Proceedings of 10th Pacific Science Inter-Congress, June 1-6, 2001, Tumon, Guam.

PROJECT SYNOPSIS REPORT

Project Title:

Responses of well water levels on northern Guam to variations of rainfall and sea level.

Problem and Research Objectives

The island of Guam is blessed with an enormous amount of fresh water stored in the thick limestone mantle that covers almost all of the northern half of the island and some of the southern half of the island. The Northern Guam Lens Aquifer (NGLA) provides 80% of Guam's potable water production of 40 mgd for its 150,000 permanent residents and 1,000,000 tourists who visit the island annually. As limits to production are approached, understanding aquifer characteristics is imperative if the aquifer is to be managed properly to meet future demand and to preserve water quality.

The NGLA is composed primarily of two permeable limestone formations, the Pliocene-Pleistocene Mariana Limestone, and the Miocene-Pliocene Barrigada Limestone (Tracey, et al. 1964). The Mariana limestone was deposited as a shallow-water fringing and barrier reef, and is thickest along the rim of the uplifted northern plateau. The older Barrigada limestone is a deeper-water limestone of bank and off-reef detrital deposits. The Barrigada limestone dominates the interior of the plateau, and accounts for the greatest volume of the aquifer, especially in the phreatic zone and vadose zone of the island's interior. The basement beneath the limestone is a late Eocene-Oligocene submarine volcaniclasitc deposit with a permeability many orders of magnitude less than that of the overlying limestone.

The sustainable yield of the aquifer (which is divided into several independent sub-basins by the complex topography of the underlying basement rock – Figure 1), is not known with sufficient precision to give water managers strict guidelines on where to place wells, and how much should be pumped from each well site. Several areas of uncertainty militate against efforts to determine exactly how to proceed with expanded production in the NGLA. These include an imprecise knowledge of the rainfall distribution over the island – the complexities of which are only now being revealed by Guam's NEXARD weather radar, and new dense raingage networks (Guard 2000). Another uncertainty is the nature of the pathways taken by rainfall through the limestone matrix. Mylorie and Vacher (1999) have proposed a dual-porosity aquifer in which dissolution-widened fractures are typically superimposed on a high-porosity matrix. The conductivity associated with each component is high, though variable, and can be orders of magnitude different from the other. Regional and local conductivity studies show wide-ranging values from 1 - 6 km/day (e.g., Ayers and Clayshulte's (1984) study of tidal-signal attenuation in inland wells) to 1-100 m/day (e.g., local values derived from pumping tests). Contractor and Jenson (2000) modeled the observed properties of well-level variations, and concluded from a comparison of their model results to well-level time series that temporary storage of infiltrating water in the vadose zone is significant and infiltration rates are strongly dependent on the water content of the vadose zone of the NGLA. The optimization of vadose parameters in the model did not achieve appreciable error-reduction in the model's prediction of well level, suggesting that

temporal and spatial variations in vadose zone characteristics are insufficiently known and/or that other processes affecting the temporal and spatial distribution of recharge have yet to be discovered. They noted three plausible sources of error; 1) unknown spatial variability of the hydraulic conductivity in the aquifer, 2) unknown variations in evapotranspiration, and 3) large errors introduced, especially under wet conditions, by the dependency of infiltration and storage on precipitation rates on Guam. Continued modeling studies, along with statistical comparison with the historical record and field hydrographic studies were recommended. This paper is an ongoing attempt at the latter. The preliminary results of a study of the rain and tide on three well-level time series are presented.

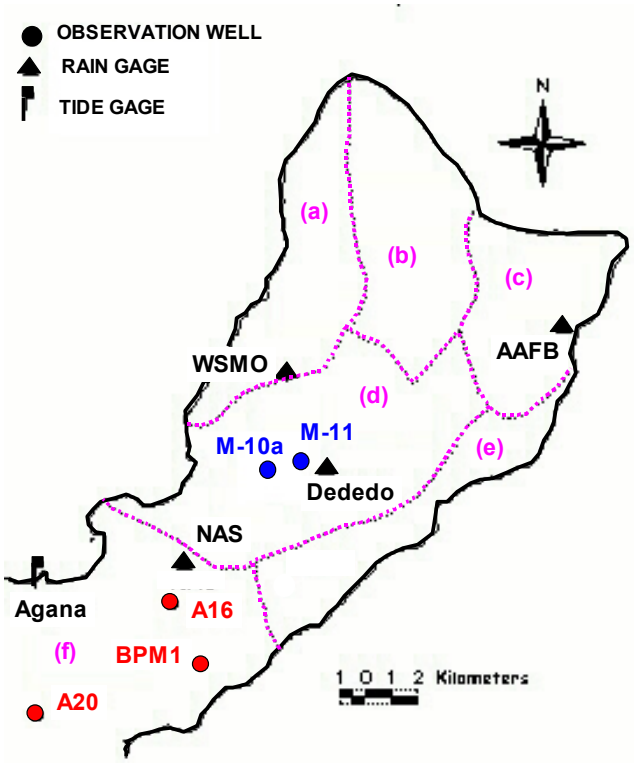

Figure 1. A map of northern Guam showing the locations of cited wells, rain gages, and the Agaña Boat Basin tide gage. The purple dotted lines indicate the boundaries of the sub-basins of the northern Guam lens aquifer: (a) Finagayan, (b) Agafa Gumas, (c) Andersen, (d) Yigo-Tumon, (e) Mangilao, and (f) Agaña.

Methodology

De-tiding the well time series

All well level time series of the NGLA exhibit statistically significant cross-correlations with the time series of the daily average tide (expressed in feet above mean sea level). The tidal signal is transferred rapidly into the aquifer, and cross-correlations are highest at zero time lag for all periods investigated (daily to monthly). At some wells, the variations of sea level account for upwards of 50% of the variance of the time series of daily and monthly average well levels. The correlation of wellheads with the daily and monthly mean sea level is a function of distance from shore.

In order to remove the signal of variations in sea level from the well-level time series, the linear cross correlation value is used. The cross correlation coefficients between the sea level and the level of a given well can be used in a linear regression to predict the value of one variable given the value of the other. The best prediction that a linear regression can yield is given by

$$(A_i)^* = (r) (s_A / s_B) (B_i)' + \overline{A} \qquad (1)$$

where: ( )* indicates the predicted value;
( )' indicates departure from the mean value;
subscript i indicates the i^{th} value of the time series;
s_A and s_B are the standard deviations of variables A and B respectively;
r is the cross-correlation coefficient between variables A and B; and,
the over-bar indicates the mean value of the indicated time series.

Using equation (1), the well level may be predicted from the sea-level time series. An adjusted well-level time series that is not correlated with the sea level may be obtained by subtracting the i^{th} term on the right-hand side of equation (1) from the i^{th} raw value of the well-level time series. In this manner, the well-level time series is "de-tided". Note: the well-level time series may be similarly adjusted to "de-rain" the time series, or to remove the component of any variable that has a non-zero cross-correlation with the well level. In this report, the sea level signal was always removed first in order to evaluate the relationship of the remaining "de-tided" time series to the rainfall. Maximum correlations of well level with rainfall tended to occur at a time lag of one of about 1 month with strong evidence that the well heads were also responding to long-term rainfall surpluses and deficits at a long time lag of approximately 18 months. Maximum correlations of well levels with sea level were simultaneous at all frequencies examined.

Using rainfall and tide to predict well levels

The "de-tided" well-level time series may be cross-correlated with any other time series (such as time series of rainfall) to form a multiple linear regression equation of the form:

$$(A_i)^* = (r_{A:B}) (s_A / s_B) (B_i)' + (r_{A:C}) (s_A / s_C) (C_i)' + \overline{A} \qquad (2)$$

where: ( )* indicates the predicted value;
( )' indicates departure from the mean value;
subscript i indicates the i^{th} value of the time series;
s_A, s_B, and s_C, are the standard deviations of variables A, B and C respectively;
$r_{A:B}$ is the cross-correlation coefficient between variables A and B;
$r_{A:C}$ is the cross-correlation coefficient between variable A (signal of B removed) and
variable C; and,
the overbar indicates the mean value of the time series.

Such an equation derived to predict the level in well BPM1 from the rain and tide

$$(BPM1_i)^* = 0.5281\ (TIDE_i)' + 0.02227\ (RAIN_i)' + 2.723 \qquad (3)$$

yields a predicted time series for BPM1 that explains 66% of the variance of the raw time series. An investigation of the analysis of the variance explained by the rain and the tide (and the inter-relationships among other variables, such as the wind and the tide) at several well sites occurs in a later section.

Integrated anomalies

All of the variables examined in this report (rainfall, the SOI, sea level, and well levels) were subjected to an analysis wherein the long-term annual or monthly mean of the variable is removed and the anomalies of each variable are added in sequence to create a time series of the running total. These running totals, or "integrated anomalies", sharply highlight any long-term deficits or surpluses. The running totals of all the variables show prominent long term deficits and surpluses that are clearly inter-related.

Residuals

One of the most important findings of this study was strong evidence that the wellheads were responding to long-term rainfall surpluses and deficits at a long time lag of approximately 18 months. This property of the behavior of the wellheads was most clearly revealed by analyzing the residuals of the observed wellhead minus the predicted value from the regression equations developed from the sea level and nearly simultaneous rainfall. The time series of the residuals had non-random long-term surpluses and deficits that were clearly related to similar long-term surpluses and deficits of rainfall. The surpluses and deficits in the time series of the residuals best matched those of the rainfall when the rainfall time series was moved forward by 18 months.

Principal Findings and Significance

As the number of tourists and the population of Guam rise, there is an ever-expanding need for potable water. The current rate of production from the NGLA supports 80% of Guam's commercial and residential water needs. The remaining 20% is derived from surface water sources in southern Guam, including the Fena Reservoir and the Ugum River pumping station. Estimates of the sustainable yield of the NGLA show that the current rate of production is nearing it in some sub-basins of the aquifer.

Variations in rainfall and sea level cause variations in well levels (Figure 2). The combined variations in sea level and rainfall in real time or near-real time account for up to 65% of the variance of water levels in the wells – the sea level accounting for the larger share of this variance near the coast, and the rain accounting for the larger share of the variance at well locations further inland. There is evidence that multi-year variations of rainfall appear in the well levels at time lags up to nearly two years. Heavy 24-hour

rainfalls of up to 3 inches may cause no immediate response of well levels if they occur at the end of prolonged dryness. Similar rain events cause immediate and large increases of well level if they occur during prolonged wet periods. Rapid increases in well levels in response to heavy short-term rain events decay to background levels within a period of about 10 days. The observed response of the wells to variations in the rainfall and sea level suggest a complicated mix of diffuse and open pathways through a non-homogeneous limestone medium.

A close scrutiny of the well response to the forcing of TIDE and RAIN may help to determine the amount of rainwater captured by the NGLA, and how it travels through the limestone matrix. The mix of time lags at which the wells respond to the RAIN suggest that both the diffuse and open pathways are working to move water through the NGLA independently, with each pathway having its own characteristic distribution and response time. Wells respond to widespread heavy rain events with a sharp spike within one day of an event, then return to pre-event levels after about 10 days. Multi-year surpluses or deficits of rainfall tend to be reflected in the well levels at a nearly 2-year time lag. This 2-year memory of the rain forcing suggests that substantial long-term vadose storage is occurring.

The optimization of vadose parameters in Contractor and Jenson's model (Contractor and Jenson 1999) did not achieve appreciable error-reduction in the model's prediction of well level, suggesting that temporal and spatial variations in vadose zone characteristics are insufficiently known and/or that other processes affecting the temporal and spatial distribution of recharge have yet to be discovered. They noted three plausible sources of error; 1) unknown spatial variability of the hydraulic conductivity in the aquifer, 2) unknown variations in evapotranspiration, and 3) large errors introduced, especially under wet conditions, by the dependency of infiltration and storage on precipitation rates on Guam. The integrated anomalies of the wells used in this report (A16, A20, M10a, M11, and BPM1) (Fig. 2), indicate that ***all*** of the wells in the NGLA are tracking the same long-term forcing, and that each of the wells (except A20) track this forcing in concert. The major surpluses and deficits of integrated well-level anomalies appear to lag by approximately 18 months similar surpluses and deficits in the integrated rainfall anomaly (Figs. 3 and 4) (at A20, the time lag of the response is approximately 6 months). This would suggest that spatial variations in the hydraulic conductivity of the aquifer do not appreciably alter NGLA response to long-term variations in forcing. Future work will examine more wells in the NGLA and extend the time series through the major 1997-98 El Niño episode which should help to address the implications of the well responses to target heavy rain events and to the long-term deficits and surpluses of rainfall.

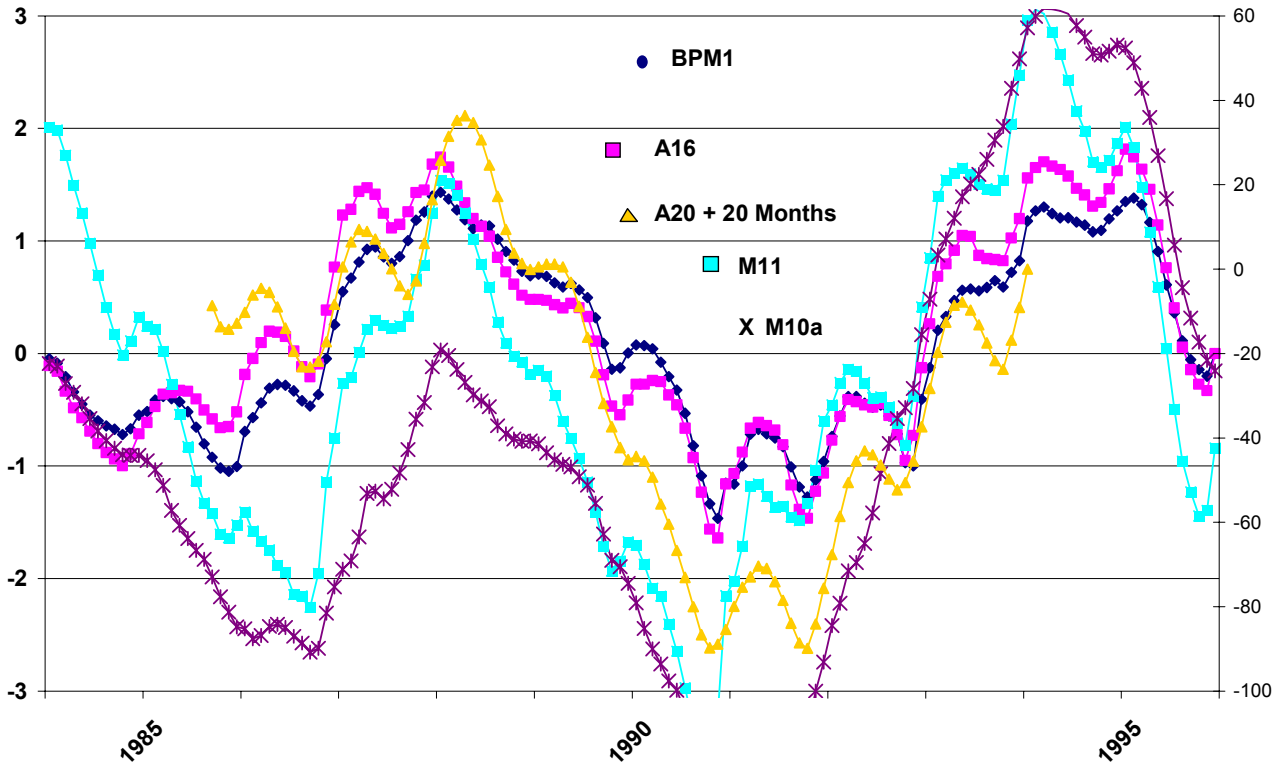

Figure 2. Integrated anomalies of the indicated wells reveal the same long-term trend at each site. All wells rise and fall in concert, except well A20 which exhibits the same rises and falls 20 months earlier (its integrated anomaly has been shifted to the right by 20 months on the chart.

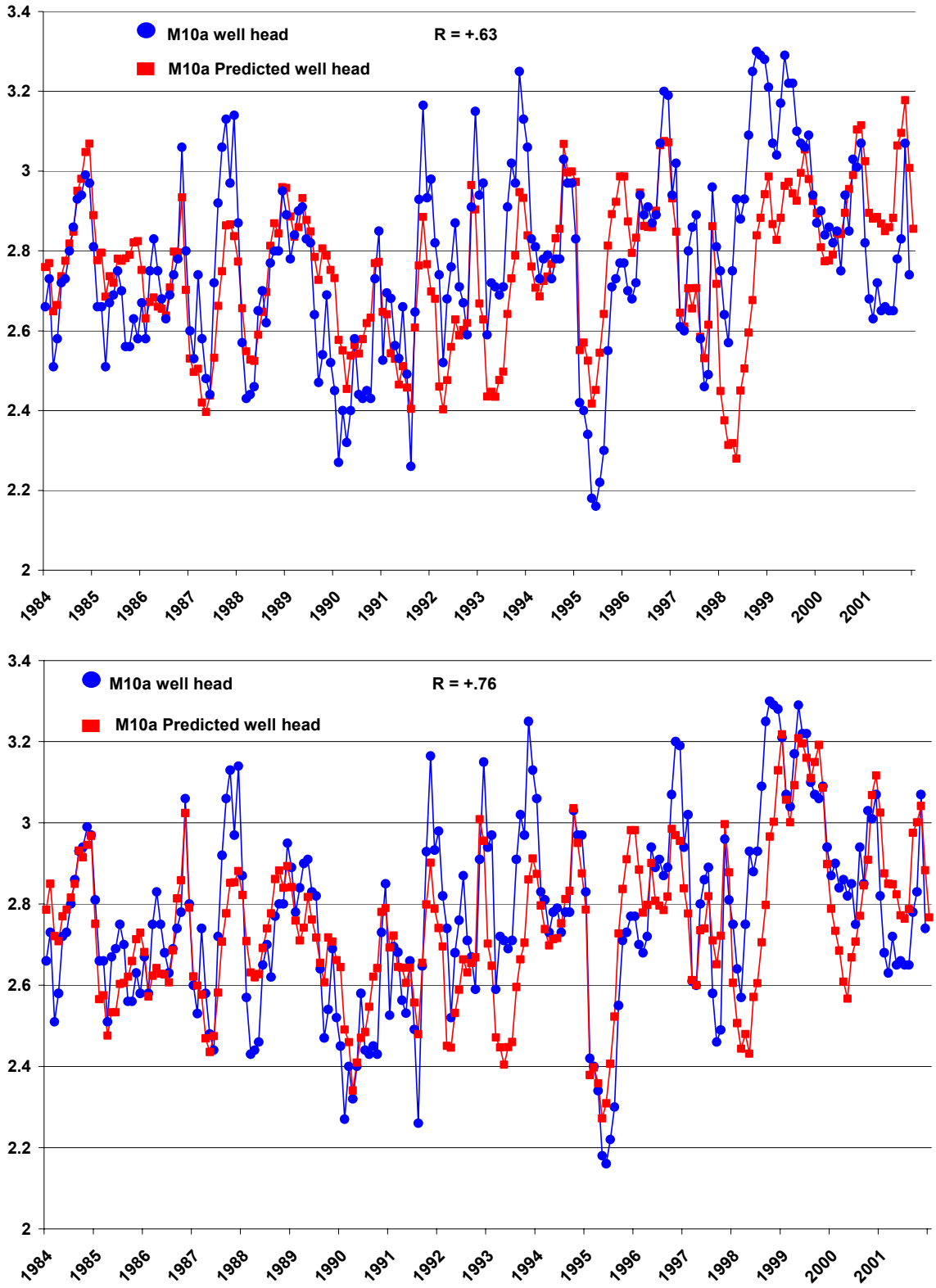

Figure 3. Prediction of the water levels of well M10a based on monthly sea level and rainfall. Top panel shows a prediction made using the sea level and rain anomalies with no time lags. Bottom panel includes a correction made for rainfall at an 18-month time lag. Note the improvement of the correlation coefficient from +.63 to +.76 when the time lag information is included. Blue time series are the observed water level in Well M10a and the red time series are the predictions made from multiple linear regression.

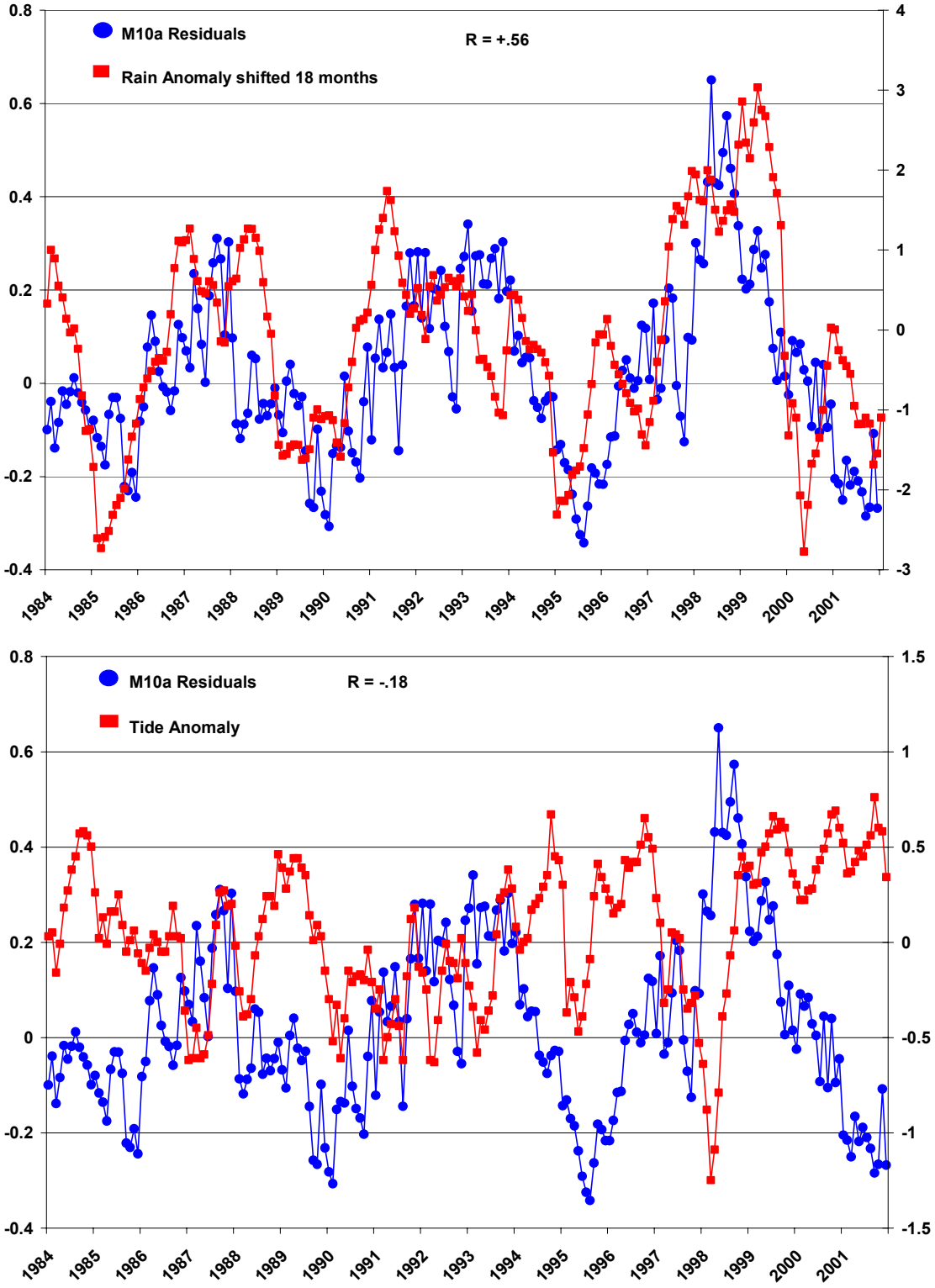

Figure 4. Residuals (observed – predicted) of the time series of the water level in Well M10a. Top panel shows residuals compared with a moving average of the monthly rainfall anomaly that has been shifted forward by 18 months. Bottom panel shows residuals compared with simultaneous sea level anomaly. Note that the non-random surpluses and deficits of the residuals are closely related to rainfall anomalies at an 18-month time lag, but not to sea level in any obvious manner. Residuals are in blue.

REFERENCES

Contractor, D.N., and J.W. Jenson, 2000: Simulated effect of vadose infiltration on water levels in the Northern Guam Lens Aquifer. *J. Hydrology,* **229**, 232-254.

Maddox, R.A., 1980: Mesoscale convective complexes. *Bull. Amer. Meteorological Soc.,* **61**, 1374-1387.

Mylorie, J.E., and H.L. Vacher, 1999: A conceptual view of island karst. In: Palmer, A.N. Palmer, M.V., and I.D. Sasowsky (eds), Karst Modeling Symposium, Charlottesville, VA pp. 48-58.

Tracey Jr., J.I., S.O., Schlanger, J.T. Stark, D.B. Doan, and H.G. May, 1964: General geology of Guam, vol. 403-A. U.S. Geological Survey Professional Paper, U.S. Government Printing Office, Washington D.C.

Trenberth, K.E., 1997: The definition of El Niño. *Bulletin of the American Meteorological Society.* **78**, 2771-2777.

Water Resources Training For The Commonwealth of the Northern Marianas Islands

Basic Information

Title:	Water Resources Training For The Commonwealth of the Northern Marianas Islands
Project Number:	2001GU1344B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Not Applicable
Focus Category:	Education, Water Supply, Management and Planning
Descriptors:	Operations and Maintenance, Education, Training,Water Resources
Principal Investigators:	Leroy F. Heitz, Gary Denton, John W. Jenson, Shahram Khosrowpanah, Mark Lander, Harold Wood

Publication

PROJECT SYNOPSIS REPORT

Title: Water Resources Training For The Commonwealth of The Northern Mariana's Islands

Problems and Research Objectives:

To have effective island water resources planning and management requires having a good understanding of the various components of the basic nature of an island's water resources. This is especially true for those making decisions and operating the island's water system. It is also important that water resources managers have an understanding of the technical vocabulary used in various engineering and environmental studies that are commonly carried out in the water resources area. In most cases, managers, supervisors and line employees have a good knowledge of what is going on in their specific field but in many cases their broad general background in water resources is lacking. In response to this need, a six weeks training program was designed for the Commonwealth of the Northern Mariana Islands (CNMI) agencies with the objectives of: 1) providing technical understanding of water resources related issues such as island's meteorology, hydrology, geology, surface and groundwater, and water quality, and 2) to facilitate a long-term development of a partnership between the institute and water resources professionals in the CNMI.

Methodology:

The method used to meet the objectives of the training program included formal lectures, laboratory sessions, and filed trips. Pertinent water resources issues as shown in the attached table were selected. Lectures were augmented with detailed handouts, overheads, slide presentations, practical demonstration, and field trips. The training was conducted from June 27 through August 24, 2002 in Saipan at the Saipan Commonwealth Utility Corporation training facility. Each of the six topics was presented in two days followed by a field trip. Fourteen (14) students from Division of Environmental Quality (DEQ), Commonwealth Utility Corporation (CUC), and Division of Coastal Resources Management (DCRM) participated in this training.

A certificate of completion was awarded to the students who successfully completed the training.

Principal Findings and Significance:

The significant accomplishments of this six weeks training was a better understanding of various water resources related issues such as:

1. Knowledge of how the geology of the islands dictates the movement of water above and under the ground.
2. An appreciation of the various tests that are used to help us assure that our surface and groundwater is safe for drinking.

3. An appreciation for the hydrologic cycle and the rainfall runoff process that regulates how much of the rain makes its way into useful runoff and groundwater.
4. An understanding of how water moves under the ground and the potential for contamination of that resource.
5. An understanding of how water is delivered from source to consumer through a water distribution system.
6. Learning about tropical island meteorology with emphasis on rainfall, the ultimate source of our waters.

Table 1. Topics for CNMI's Water Resources Training

SESSION/INSTRUCTOR	TOPICS
Water Quality (Session 1) Dr. Gary Denton	• Bacteriology • Indicator organisms • Health and aesthetic aspects (physical parameters)
Water Quality (Session 2) Dr. Gary Denton	• Health and aesthetic aspects (Chemical Parameters inorganic) • Health and aesthetic aspects (Chemical Parameters organic) • Chlorination
Water Quality (Lab Session) Mr. Harold Wood/Dr Gary Denton	• Bacteriology • Colorimetry, titration and field kits • Atomic absorption analysis (demo if available discussion if not) • Gas chromatograph analysis (demo if available discussion if not)
Geology (Session 1) Dr. Galt Siegrist	• Physical and historical geology of the C.N.M.I. Geologic materials of C.N.M.I.
Geology (Session 2) Dr. Galt Siegrist	• Environmental and resource geology of C.N.M.I. • Mineral and water resources • Geologic hazards • Geologic and topographic maps
Geology (Field Trip Session) Dr. Galt Siegrist	• Visit outcrops of geologic features discussed in class
Meteorology (Session 1) Dr. Mark Lander	• Western Pacific climatology • Rainfall distributions in CNMI • Areal distribution of rainfall on high islands
Meteorology (Session 2) Dr. Mark Lander	• Droughts and effects of ENSO • Predicting droughts • Typhoons and tropical storms
Meteorology (Laboratory Session) Dr. Mark lander	• Laboratory exercises • Typhoon plotting • Typhoon related flooding
Hydrogeology (Session 1) Dr. John Jenson Mr. Rob Carruth (Guest Instructor)	• Groundwater occurrence on high volcanic islands • Karst Aquifers • Specifics of CNMI aquifers • Well construction and testing

Table 1. Topics For CNMI's Water Resources Training (continued)

SESSION/INSTRUCTOR	TOPICS
Hydrogeology (Session 2) Dr. John Jenson Mr. Rob Carruth (Guest Instructor)	• Water production and well field management • Salt water intrusion • Groundwater protection strategies • Application of groundwater modeling to groundwater management
Hydrogeology (Lab Session) Dr. John Jenson Mr. Rob Carruth (Guest Instructor)	• Visit Saipan well fields • Visit karst features for examination of characteristics affecting groundwater yields and distribution
Hydrology (Session 1) Dr. Leroy Heitz	• Hydrologic cycle • Measurement units and calculations • Rainfall distribution and storm runoff design • Evaporation and evapotraspiration
Hydrology (Session 2) Dr. Leroy Heitz	• Water budgets • Streamflow measurement and data interpretation • Rain catchment system sizing
Hydrology (Field Trip Session) Dr. Leroy Heitz	• Visit stream gage site and make flow measurement • Visit sites using rooftop rain catchment systems • Computer analysis of rain catchment sites
Water Distribution Systems (Session 1) Dr. Shahram Khosrowpanah	• Hydraulics of pipe flow • Units of measure and calculation • Water budgets in piping systems • Equations for movement of water in piping systems • Losses in piping systems
Water Distribution Systems (Session 2) Dr. Shahram Khosrowpanah	• Water distribution systems components and functions (tanks, valves and piping) • Pumps • Water system demands • Modeling water distribution systems

Inventory and Evaluation of Karst Features Relating to Past and Present Groundwater Flow in Saipan, in Terms of the Carbonate Island Karst Model

Basic Information

Title:	Inventory and Evaluation of Karst Features Relating to Past and Present Groundwater Flow in Saipan, in Terms of the Carbonate Island Karst Model
Project Number:	2001GU2121B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Ground-water Flow and Transport
Focus Category:	Groundwater, Hydrology, Climatological Processes
Descriptors:	Carbonate Island Aquifers, Island Karst,Groundwater
Principal Investigators:	John W. Jenson

Publication

PROJECT SYNOPSIS REPORT

Project Title: Inventory of Karst Features Relating to Past and Present Groundwater Flow on Tinian, CNMI, in Terms of the Carbonate Island Karst Model

Problem and Research Objectives

This project consisted of a survey of the karst features that control the input, transport, and discharge of fresh water from the limestone units covering the island of Tinian. Specific work included mapping and cataloging of karst surface features, caves, and coastal discharge features. In addition to obtaining such data to support sustainable development of Tinian's aquifer, the project provides new data by which to develop a more accurate and complete conceptual model of carbonate island karst aquifers in general. Karst research begun on the relatively uncomplicated aquifers of Atlantic-Caribbean islands has recently been completed on Guam and extended to Saipan. This project extended the work to Tinian. Tinian is unique in that it is a composite island (i.e., a carbonate island with the volcanic core of the island exposed near the center) with relatively compact shape and simple topography. This makes it ideal for testing certain hypotheses regarding the evolution of island karst aquifers.

Methodology

The study employed the classical methods of geological field investigation, including surface traverse and mapping, mapping of caves, and photo-documentation of key features both above and underground. Previous maps of the general geology (Doan et al., 1960) showed numerous faults and fractures. The relationship of structural features to sinkholes and coastal discharge features is now being systematically examined.

Principal Findings and Significance

The project began with an exhaustive literature and data search, which assembled all of the historical scientific and engineering publications related to the island. Many such documents are archived at the University of Guam's Micronesian Area Research Center. Much unpublished data also resides in the field offices of the USGS and Commonwealth Utility Corporation on Saipan and Tinian, and is accessible to support the project. All such data will be catalogued and put into a database to support the maps and diagrams that will be produced from the field study. These are being used to identify clues regarding the specific pathways by which water moves into and through the aquifer. Generalizations regarding such relationships will be incorporated in the Carbonate Island Karst Model, a general conceptual model for karst aquifers on small carbonate islands.

The project is the next logical step toward to eventually completing a comprehensive survey of the island, as for Guam and Saipan. A technical report is currently being prepared from work done in Summer 2002. The results of additional field work in December 2002 and January 2003 will be incorporated in a final report that will be published in Summer 2003. The final report will contain the full set of maps and photographs from the survey, including sinkholes, caves, coastal springs, and other significant karst features. It will also document and explain the relationships between these and structural features mapped in the current study as well as by previous workers.

Information Transfer Program

WERIs mission involves a large information transfer-dissemination component. Key elements include written forms such as newsletters, brochures and pamphlets, a web site, technical reports, journal articles, newspaper columns, and book chapters and special conferences. The audience for the results of USGS sponsored research is widely varied geographically and by education level. Projects under information transfer this year-included design, layout and printing of five technical completion reports resulting from USGS funded research projects. Seventy five (75) hard copies of each report were printed and the reports were prepared in PDF file format and were published on WERIs Web page. A second project involved keeping WERIs Web page updated and optimized. A professional Web maintenance firm was contracted to provide maintenance to the WERI Web page on a regular basis. Because of Guams remote location it is difficult and quite costly for researchers to present their findings at technical conferences and symposiums. This project funded a portion of stateside travel expenses for any PI or his graduate student presenting a refereed professional paper summarizing all or a portion of current or past 104-B research.

Another area of information transfer involved the joint sponsorship of a special conference in the Federated States of Micronesia (FSM). The title of this conference was Sharing Experiences of the Recent Cholera Outbreak and Where Do We Go From Here? The conference was held at the Pwohmaria Beach Resort in Kolonia, Pohnpei, FSM on August 7-8, 2001. Cholera outbreaks have occurred repeatedly throughout the islands of the FSM. Outbreaks occurred in Chuuk State in 1983 and in Pohnpei State in April of 2000 causing 20 deaths. The cause, as reported by Pohnpeis cholera outbreak task force, was water and food contamination. This conference was a wonderful opportunity for key players in the medical and public health fields throughout FSM to gather, discuss and device plans to combat this most dreaded disease which as one presenter stated It is not a question of whether we will have another epidemic. It is a question of when and where it will happen.

Information Transfer

Basic Information

Title:	Information Transfer
Project Number:	2001GU1302B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Not Applicable
Focus Category:	Education, Management and Planning, None
Descriptors:	Water Resources, Education,Information Transfer
Principal Investigators:	Leroy F. Heitz

Publication

INFORMATION TRANSFER

WERI's mission involves a large information transfer-dissemination component. Key elements include written forms such as newsletters, brochures and pamphlets, a web site, technical reports, journal articles, newspaper columns, and book chapters. The audience for the results of USGS sponsored research is widely varied geographically and by education level. Projects included under information transfer this year included design, layout and printing of five technical completion reports resulting from USGS funded research projects. Seventy five (75) hard copies of each report will be printed and the reports were prepared in PDF file format and were published on WERI's Web page. It is very important that WERI's Web page be updated and optimized on a regular basis. A professional Web maintenance firm has been contracted to provide maintenance to the WERI Web page on a regular basis. Because of Guam's remote location it is difficult and quite costly for researchers to present their findings at technical conferences and symposiums. This project funded a portion of stateside travel expenses for any PI or his graduate student presenting a refereed professional paper summarizing all or a portion of current 104-B research.

Water Resources Symposium on the Outbreak of Cholera in Pohnpei State, FSM.

Basic Information

Title:	Water Resources Symposium on the Outbreak of Cholera in Pohnpei State, FSM.
Project Number:	2001GU1303B
Start Date:	3/1/2001
End Date:	2/28/2002
Funding Source:	104B
Congressional District:	N/A
Research Category:	Not Applicable
Focus Category:	Education, Water Quality, Management and Planning
Descriptors:	Health Effect, Environmental Sanitation, Education,Information Dissemination
Principal Investigators:	Shahram Khosrowpanah, Leroy F. Heitz

Publication

1. Heitz, Leroy F.,Sharing Experiences of the Recent Cholera Outbreak and Where Do We Go From Here, Proceeding of Cholera Conference held at Pwohmaria Beach Resort, Kolonia, Pohnpei, FSM WERI, University of Guam, (Web based Cd Rom).

PROJECT SYNOPSIS REPORT

Project Title: Water Resources Symposium on the Outbreak of Cholera in Pohnpei State, FSM

Problem and Research Objectives

Cholera outbreaks have occurred repeatedly throughout the islands of the Federated States of Micronesia (FSM). Outbreaks occurred in Chuuk State in 1983 and in Pohnpei State in April of 2000 causing 20 deaths. The cause, as reported by Pohnpei's cholera outbreak task force, was water and food contamination.

The University of Guam Water and Environmental Research Institute of the Western Pacific sponsored a conference titled "Sharing Experiences of the Recent Cholera Outbreak and Where Do We Go From Here?" This conference was held at the Pwohmaria Beach Resort in Kolonia, Pohnpei, FSM on August 7-8, 2001.

The primary goal of this conference was:

1) to create an awareness of cholera itself among the FSM community and,
2) to share information on the causes and best practice for outbreak preparedness and ultimately prevention.

Principal Findings and Significance

The keynote speaker for the conference was Dr. Philippe Calain , Medical officer for the Global Task Force on Cholera Control World Health Organization, Geneva, Switzerland. Dr. Calain was in Pohnpei during the recent Cholera outbreak. Various key members of the Pohnpei Task Force made presentations. These included representatives from the FSM Department of Health, Education and Social Affairs, The Pohnpei State Office of the Lieutenant Governor, Pohnpei State Hospital, Pohnpei State Department of Health Services, the Pohnpei Utility Corporation, and the FSM National Red Cross. Each gave presentations on their roles as members of the Pohnpei State Cholera Task Force. All commented on their perceived success of the preparedness and prevention plans that were adopted. Three representatives from the environmental protection and public health agencies from each of FSM states were also invited to attend the symposium. Each discussed their state's response to the Pohnpei epidemic and their plans if a similar cholera outbreak should strike their island. There were also presentations on the inter-state and inter-country economic impact and trading problems that resulted from various shipping bans that were imposed during the epidemic.

This conference was a wonderful opportunity for key players in the medical and public health fields throughout FSM to gather, discuss and device plans to combat this most dreaded disease which as one presenter stated "It is not a question of whether we will have another epidemic. It is a question of when and where it will happen."

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	0	0	0	3
Masters	4	0	1	0	5
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	7	0	1	0	8

Notable Awards and Achievements

Publications from Prior Projects

1. Heitz, L. F., Nathan C. Habana, and J. Raza, Designing Your Rainwater Catchment and Storage System for Rainwater Catchment Systems in Saipan CNMI, Water Information Bulletin No. 3, University of Guam Water and Energy Research Institute of the Western Pacific, May 2001
2. Heitz L. F., Rainwater Catchment System Design: A Delicate Balancing Act With Examples From Iloilo City, Philippines, 2nd East Asia Conference On Rainwater Utilization. Sponsored By Philippine Watershed Management Coalition In Cooperation With Central Philippine University, Iloilo, Philippines, November 7-9, 2001
3. Heitz, L.F. Rainwater Catchment System Design In The Western Pacific, in Proceedings of 10th Pacific Science Inter-Congress, June 1-6, 2001, Tumon, Guam.
4. Denton, G.R.W., B. Bearden, L.P. Concepcion, H.G. Siegrist, D.T. Vann, & H.R. Wood (2001). Contaminant Assessment of Surface Sediments from Tanapag Lagoon, Saipan. WERI Technical Report No. 93, 2001. 110 pp. plus appendices
5. Khosrowpanah S., L. Heitz, & C. Beausoliel, The Application of Slow Sand Filtration Technology for Kosrae State, FSM: A Pilot Project, University of Guam/WERI, Technical Report No. 91a, May 2001.
6. Khosrowpanah S., & L. Heitz, The application of Slow Sand Filtration Technology for Kosrae State, the Federated States of Micronesia: A Pilot Project, Proceedings of 10th Pacific Science Inter-Congress, June 1-6, 2001, Tumon, Guam.
7. Denton, G.R.W. (2001). Nutrient Sources and Pathways into Tumon Bay In: Whose Business is the Environment? in Proceedings and Resource Guide of the 20th Annual Pacific Islands EPA Conference, Hyatt Hotel, Guam, June 11-15, 2001.
8. Denton, G.R.W. and L.F. Heitz (2001). Potential Impact of Landscaping Activities on the Nutrient Status of Tumon Bay, Guam. In: The Integration of Natural and Social Sciences in the New Millennium. in Proceedings 10th Pacific Science Inter-Congress, Guam, June 1-6, 2001. P. 97.
9. Heitz, L.F. and G.R.W. Denton (2001). A Fully Automated Sequential Sampling Device for

Monitoring Contaminants in Urban Runoff. In: The Integration of Natural and Social Sciences in the New Millennium. in Proceedings 10th Pacific Science Inter-Congress, Guam, June 1-6, 2001. P. 96.

10. Lander, M.A., Jenson, J.W., Beausoliel, C., 2001, Responses of Well Water Levels on Northern Guam to Variations of Rainfall and Sea Level, WERI Technical Report No. 94, Water and Energy Research Institute of the Western Pacific, University of Guam.
11. Lander M.A. & C. Beausoliel Responses of well water levels on Northern Guam to variations of rainfall and sea level, Proceedings of 10th Pacific Science Inter-Congress, June 1-6, 2001, Tumon, Guam.
12. Khosrowpanah S., & L. Heitz, Rainfall Erosivity Factors for Selected Islands in the Federated States of Micronesia., University of Guam/WERI, Technical Report No. 92, June 2001.
13. Khosrowpanah S., L. Heitz, & C. Beausoliel Determination of Rainfall Erosivity Factors for Selected Island in the Federated States of Micronesia, in Proceedings of 10th Pacific Science Inter-Congress, June 1-6, 2001, Tumon, Guam.