



Summary Report: WRRC Fall 2008 Water Quality Conference

Motivation for this Conference

One of the missions of the Water Resources Research Center (WRRC) at the University of Hawaii is to periodically organize public conferences to discuss current water issues in Hawaii. WRRC organized a two-day conference at the Pagoda Hotel, Honolulu on October 30 -31, 2008. Approximately 120 people registered to attend. The title of the conference was "How Clean or Polluted are Hawaii's Drinking and Recreational Waters". The goal was to invite expert speakers to address the following four questions raised in many previous meetings:

1. How clean or polluted are Hawaii's recreational and drinking waters?
2. What are the best ways to analyze these waters to determine if they are safe for their designated uses?
3. Are the tests performed to meet water quality standards sufficient to ensure that these waters are safe?
4. If these water quality standards are not adequate, what actions should be taken?

The premise of the conference was that the best way to determine whether waters are safe is to analyze them for more relevant water quality parameters, and to interpret the data using a weight of evidence approach. Therefore, most of the invited speakers were scientists involved in analyzing water in Hawaii for various water quality parameters.

Three mainland experts were invited to the conference because of their special expertise and experience relevant to the major water quality problems identified for the state of Hawaii. Dr. Richard Whitman of the US Geological Survey (USGS) in Indiana was invited to address the problems related to inadequacy of current recreational water quality standards. Dr. Nicholas Ashbolt of the US Environmental Protection Agency (EPA) in Cincinnati, Ohio was invited to talk about current EPA plans to revise the recreational water quality standards. Dr. William Ambrose from Bates College in Maine was invited to integrate and interpret the results of the five scientists in Hawaii who have been analyzing the benthic and fish populations near the City and County of Honolulu's (CCH) four ocean sewage outfalls.

Conference Directives and Agenda

Three sessions entitled, The Clean Water Act, WRRC Ocean Biomonitoring Program, and Water Quality Standards, were organized to address water quality problems related to recreational water. One session entitled The Safe Drinking Water Act was organized to address problems related to drinking water. The invited speakers were provided the following directives in assessing these issues.

1. To initially assess the degree of pollution and relative safety of recreational and drinking waters by analyzing water quality data generated to meet water quality standards for drinking water (Safe Drinking Act) and for recreational water (Clean Water Act/Beach Act).
2. To further assess the degree of pollution and health risks of these same water sources based on other water quality monitoring data and the weight of evidence approach.
3. To summarize the results of water quality monitoring data and to identify problems and challenges in reliably determining whether these waters are safe for their designated uses.
4. To provide recommendations for future actions.

Session One: The Clean Water Act

The focus of this session was to discuss problems in Hawaii related to implementation of the Clean Water Act. This Act, established by EPA, sets national recreational water quality standards that each state must implement.

Speaking during this session were:

Dr. Roger Fujioka, (WRRC) provided monitoring data to show that EPA recreational water quality standards based on concentrations of *E. coli* and enterococci are not reliable in Hawaii as these same bacteria are found naturally in soil in this state and represent environmental rather than sewage sources. As a result, the elevated concentrations routinely measured in most streams do not represent sewage but rather soil contamination. Dr. Fujioka provided data that indicate that monitoring recreational waters using culture methods for alternative fecal microorganisms



the Pagoda Hotel

(*C. perfringens*, F+ coliphages), and molecular tests for human specific Bacteroides will provide more reliable data to determine when waters are contaminated with sewage.

Mr. Watson Okubo from the Hawaii State Department of Health (HDOH) explained that his department is charged with maintaining the quality of recreational waters under the Clean Water Act and the Beach Act. He provided monitoring data collected by HDOH that confirm the unreliability of using EPA water quality standards to determine when recreational waters are contaminated with sewage. Mr. Okubo pointed out that in order to address this problem HDOH has adopted a more reliable state water quality standard based on monitoring for *C. perfringens* to make public health decisions regarding closing and opening beaches.

Mr. Ross Tanimoto from the City and County of Honolulu provided CCH data showing that EPA water quality standards are unreliable for determining when recreational waters are contaminated with sewage. Mr. Tanimoto stated that a major problem facing CCH is that it must comply with regulations under the Clean Water Act and Beach Act despite acknowledgements from HDOH that the EPA standards are not reliable in Hawaii.

Ms. Lourdes Vazquez from the CCH Water Quality Lab described the toxicity test assay used to determine whether primary treated sewage to be discharged into the ocean is "toxic" based on laboratory testing of the fertilization rate of eggs by sperm of the Hawaiian collector urchin (*Tripneustes gratilla*). Ms. Vazquez reported that this test is not easy to perform, requires special skills, and is not a compliance test to meet recreational water quality standards. Rather, it is a test to detect toxic chemicals in sewage. Using this test Ms. Vazquez has determined that some of the primary treated sewage effluent disposed of through the outfall contains toxic components. She further determined that usually the toxic component is a surfactant or a compound having detergent properties. Surfactant in primary sewage interferes with the fertilization process, providing evidence that toxic chemicals in the sewage effluent are



T. Gratilla - Hawaiian collector urchin

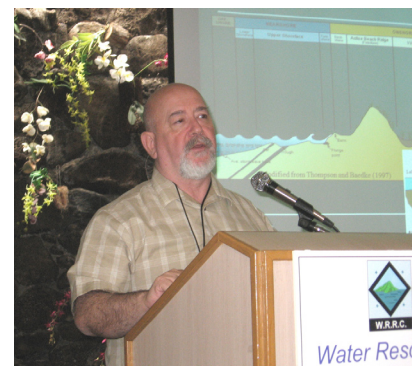
being discharged into the ocean. However, Ms. Vazquez made several important points; first, the test is not a standard toxicity assay and applies specifically to sewage in Hawaii; second, the cells of sperm and eggs of the sea urchin are especially fragile because they do not have protective covering like most other living cells. Moreover, these cells are designed to take part in the fertilization process or die within a few hours after release; and third, one cannot extrapolate from the toxicity assay results to predict toxicity effects in the ocean near the outfalls.

Reuben Wolf from the USGS Honolulu office, reported that significant changes in the quality of water in

Hawaii's streams can be reliably assessed by measuring changes in the populations of benthic macroinvertebrates living therein. This is an example of an alternative way of testing stream water quality by evaluating several benthic populations and using the weight of evidence approach to detect changes, rather than testing water samples in streams as required by the Clean Water Act.

Dr. Richard Whitman, Chief of the USGS Lake Michigan Ecological Research Station in Porter, IN, was one of three speakers invited from the mainland. Dr. Whitman provided monitoring data obtained from the temperate climate of the mid-western US, that show that the EPA prescribed fecal indicators such as *E. coli* and enterococci can also multiply in the environment (soil, plants, decaying vegetation) there. These results confirm the results obtained from tropical regions such as Hawaii, and provide strong evidence that the EPA water quality standards are not reliable for anywhere in the US.

Dr. Whitman related that water quality data obtained one day cannot be reliably applied to subsequent days. This shows that implementation of current water quality standards is flawed because beaches are opened and closed based on the previous day's monitoring data. Dr. Whitman pointed out the need to adopt water quality tests which can provide results in a few hours, or alternatively, to use predictive modeling, a method to predict the levels of fecal bacteria at a beach, and to close or open beaches based on the results of several rapid measurements.



Dr. Richard Whitman

Luncheon Presentations

Luncheon speakers were selected to inform the attendees about the goals and accomplishments of the two professional water organizations in Hawaii.

On Thursday Dr. Victor Moreland and Mr. John Katahira, were the speakers, representing the Hawaii Water Environment Association (HWEA). The speakers informed us that HWEA is Hawaii's branch of the national Water Environment Federation (WEF), and that both organizations focus on water issues regulated by the Clean Water Act. HWEA's stated goals are to; fill the professional needs of its members, support WEF to achieve its vision and fulfill its mission, work to enhance water quality and advance the profession, share expertise and resources with the public and policy makers, and form working relationships with other organizations that support similar objectives.

WRRC is part of the State Water Resources Research Institute (WRII).
This program, authorized by section 104 of the Water Resources Research Act of 1984,
is a Federal-State partnership under the aegis of the USGS
(808) 956-7847 voice (808) 956-5044 fax

Dr. Moreland and Mr. Katahira also described some of the educational activities that HWEA has participated in, including public meetings to clarify issues related to EPA's denial of the secondary treatment waivers for disposal of primary treated sewage via deep ocean outfalls.

On Friday Mr. Elson Gushiken and Mr. Woodie Muirhead were the luncheon speakers, representing the American Water Works Association (AWWA) Hawaii Section. Both the Hawaii Section and the national AWWA focus on water issues regulated by the Safe Drinking Water



Mr. Elson Gushiken

Act. The goals of AWWA were stated as being to promote public health, safety, and welfare through the improvement of the quality and quantity of water delivered to the public and the development and furtherance of understanding of the problems relating thereto. Mr. Gushiken and Mr. Muirhead described how the history of the AWWA closely parallels the history of advancements in drinking water treatment in the US, and they described some of the major contributions made by AWWA members.

Session 2: WRRC Ocean Outfall Biomonitoring

The focus of this session was to review the long-term monitoring data generated by WRRC to assess the environmental impact of discharging variously treated sewage effluents at the four CCH deep ocean outfalls. This is a timely topic because in 2008, EPA announced its decision to deny the Sand Island and Honouliuli sewage treatment plants the waivers from secondary treatment under which they currently operate. This decision is still pending. If the waivers are denied, the two treatment plants will be required to upgrade from primary to secondary treatment.

WRRC Director Dr. James Moncur described the WRRC biomonitoring as an innovative program designed to assess the environmental impact of sewage disposal by measuring changes in benthic populations near the four CCH outfalls. The scientific rationale for this program is that if the outfalls are significantly changing

the quality of the nearby water and sediments, the populations of benthic organisms and other aquatic species (e.g. fishes) near these outfalls will also change. The WRRC biomonitoring team consists of six independent expert scientists. Five of the scientists work in Hawaii and have monitored five different aquatic populations (benthic micromollusks, polychaete worms, and crustaceans; coral; and fish) near the outfalls over many years. The sixth scientist is an external expert, who works in another state and is charged with integrating the data submitted by the five scientists and to use the weight of evidence approach to assess the impact of the sewage outfalls on the environment.

Speaking during this session were:

Regina Kawamoto, an expert in Hawaiian micromollusk taxonomy, has been working with Dr. Alison Kay to monitor the micromollusk communities near the four CCH ocean outfalls. The results of micromollusk monitoring program indicate that these communities have not changed significantly over many years. Thus, the micromollusk data indicate that the outfalls have not substantially changed the quality of water or the sediments nearby.

Dr. Julie Brock, an expert in polychaete worm taxonomy, monitors worm communities near the four outfalls. The results of Dr. Brock's work indicate that the polychaete worm communities have not changed significantly over the many years of monitoring. This data indicate that the discharge from the outfalls has not significantly altered the water and sediment quality nearby.

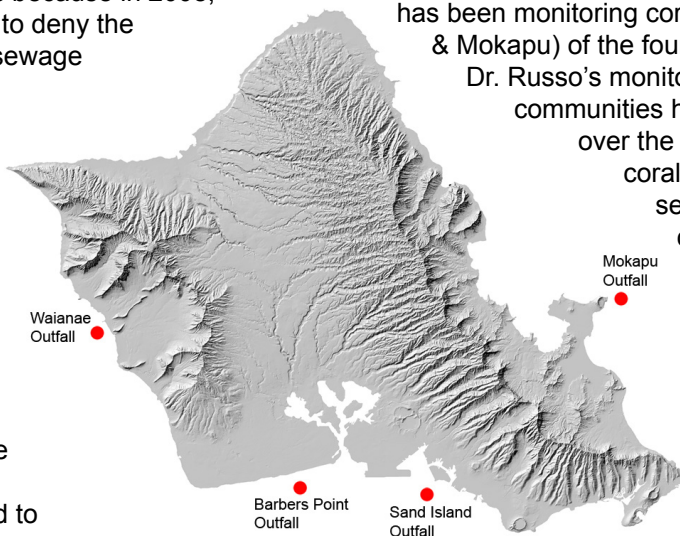
Dr. William Cooke, the biomonitoring team's crustacean expert, has been monitoring crustacean communities near the four outfalls over the 20-plus years of the project. The results of his monitoring indicate that the crustacean communities have not changed significantly during this time. Thus, his data indicate that the outfalls discharge is not having any substantial impact on the quality of water or the sediments nearby.

Dr. Anthony Russo, the team's coral taxonomy expert has been monitoring coral communities near two (Waianae & Mokapu) of the four CCH outfalls. The results of

Dr. Russo's monitoring indicate that the coral communities have not changed significantly over the many years of monitoring. The coral monitoring data indicate that the sewage outfalls have not substantially changed the quality of the surrounding water and sediment.

Dr. Richard Brock, an expert in fish and coral taxonomy monitors the fish communities near the outfalls as part of the WRRC effort. The results of the fish and coral monitoring indicate that rather than impairing fish and coral populations, the outfall pipes and diffusers serve as protective cover and sources of nutrients, resulting in

much larger fish populations and greater coral coverage than are seen in adjacent areas.



Locations of the CCH outfalls

Dr. William Ambrose, Professor of Biology at Bates College in Maine, serves on the project as an external statistical analyst and report writer. He is a recognized expert with extensive experience researching benthic communities in a wide range of environments around the world. Dr. Ambrose has reviewed and integrated the data collected by the five different monitoring programs in Hawaii and concluded that based on weight of evidence assessment, definitive and measurable changes in the populations near the ocean outfalls have not been detected. These results indicate that the outfalls have not altered the quality of the surrounding environment enough to cause a change in the marine communities.



Dr. William Ambrose

Session 3: Water Quality Standards

The focus of this session was on EPA's acknowledgement that the current recreational water quality standards may not be reliable, and on the agency's commitment to improving and modifying these standards.

Speaking during this session were:

Dr. Nicholas Ashbolt, (Senior Research Microbiologist with the EPA's National Exposure Research Laboratory in Cincinnati) discussed recent developments in EPA



Dr. Nicholas Ashbolt

activities stemming from the outcome of legal actions taken by environmental groups against the agency for failure to update water quality standards in a timely manner. EPA conducted a workshop in March of 2007 to obtain the recommendations of 43 invited experts. Then in August of 2007 EPA put together a "Critical Path Science Plan" for the development of new or revised recreational water quality criteria. Dr. Ashbolt

described several of the problems identified in establishing new water quality standards that EPA must resolve between 2007 and 2010, and the studies needed to address these problems. Some of the studies highlighted by Dr. Ashbolt include:

1. Conducting epidemiological studies at marine beaches affected by untreated sewage and sewage treatment plant discharges.
2. Conducting quantitative microbial risk assessment studies to estimate illness at a freshwater beach impacted by agricultural animal sources of fecal contamination.
3. Studying quantitative polymerase chain

reaction (QMRA - genetic ID method for microorganisms) signal performance for enterococci and comparing this to wastewater pathogens.

4. Designing and evaluating a monitoring approach that will take into account the spatial and temporal variability at beaches.
5. Evaluating multiple indicator/method combinations to develop quantifiable relationships.
6. Evaluating the suitability of individual combinations of indicators and methods for different Clean Water Act programs.
7. Pilot testing the "Virtual Beach" model for beach notification and advisories/closures.
8. Refining and validating existing water quality models for freshwater and marine beach notification, advisories/closures.
9. Developing technical protocols for site-specific application of predictive models to be used in making beach advisory decisions.
10. Comparing EPA's 1986 Bacteria Criteria recommendations to the National Epidemiological and Environmental Assessment of Recreational studies to better understand the relationship between fecal contamination and illness in these data sets.

Dr. Vijay Kannappan and Mr. Marcus Soderlund (researchers working in Dr. Fujioka's laboratory) pointed out that the current water quality standard is based on measuring a single fecal indicator, and the data obtained do not identify the type/source of the contamination. As a result, the actual risk to humans cannot be determined. Most scientists have recommended that new water quality tests should include microbial source tracking (MST) methods which provide data to identify the source of contamination. Both researchers recommended that a monitoring strategy for Hawaii should include two independent but complimentary measurements. The first measurement is culture based for *C. perfringens* and F+ coliphages because these are reliable indicators of sewage contamination in Hawaii, and the data obtained provides data on sewage concentrations and probable concentrations of viable human pathogens. The second measurement uses a molecular test - quantitative polymerase chain reaction, which also provides more reliable data about the source of fecal contamination in the sample. In recent experiments these methods were applied to detect human sewage contamination in a storm drain and also to monitor ambient beach water quality at many beaches on Oahu.

Dr. Hans Krock (Emeritus Professor of Ocean and Resources Engineering at the University of Hawaii at Manoa) presented his monitoring data for chemical pollutants near several ocean sewage outfalls. He pointed out that log-normal distributions of water quality data from sewage discharges near ocean outfalls are the most

reliable way to assess pollutant concentrations near ocean outfalls.

Dr. Victor Moreland, (WRRC researcher) presented an historical overview of how sewage treatment and disposal has progressed on the island of Oahu. He described the improvements in the ocean outfalls that led to approval of secondary treatment waivers for the Sand Island and Honouliuli treatment plants. Dr. Moreland described the quality of effluents from these two plants and discussed the recent EPA denial for continuation of the waivers. Dr. Moreland concluded that based on water quality monitoring data for the effluents being discharged at the Sand Island and Barbers Point outfalls, the quality of nearby water meets the criteria for the waiver requirements.

A panel discussion followed to receive questions from the audience related to issues of recreational waters and for the speakers to respond, and to identify recommendations and future action plans. The first topic of discussion was the monitoring data related to the waivers for the Sand Island and Honouliuli treatment plants. Dr. Fujioka led this discussion and pointed out that since all the speakers concluded that the monitoring evidence supported continuation of the waivers, it would be more fruitful to discuss what will happen if the waivers are denied and CCH is obliged to upgrade to secondary treatment at the plants.

Dr. Moreland said that upgrading to secondary treatment will improve effluent quality but will not likely affect rates of water quality violations (exceedances of enterococci concentrations) in ocean water samples near the swimming beaches. However, he noted there will be substantial increases in cost, energy requirements, the production of CO₂, and biosolids requiring disposal.

Dr. Krock volunteered that increasing the volume of biosolids will create problems in treatment because of elevated sulfite in the biosolids. He also pointed out that current UV treatment is expensive. He recommended that, if the waivers are denied, the outfall pipes should be extended into deeper water so sewage and sewage components will remain submerged and will not be likely to violate standards at depths where swimmers may be exposed.

Ross Tanimoto told the group that if secondary treatment is adopted at the plants and the waivers are not needed, CCH will obtain monitoring permits from HDOH rather than EPA. If this happens, CCH will need to negotiate with HDOH on the need for disinfection of secondary treated sewage, and on details of the mandatory monitoring programs, including the biomonitoring program being conducted by WRRC.

Dr. Ashbolt said that CCH should prioritize the risk to people and deal with the most likely sources of problems first. For example, fixing leaky sewer lines and preventing untreated sewage from contaminating coastal waters where people may be exposed should take priority. Ross Tanimoto agreed and stated that CCH is currently placing emphasis on upgrading the sewer lines. However, Mr. Tanimoto stated that addressing waiver requirements may be a matter independent of upgrading sewer lines.

The consensus recommended action plan was to continue granting the waivers because the monitoring data indicate no adverse impact to marine organisms near the outfalls, and no measurable risk to swimmers. However, if the waivers are denied, the City should consider extending the outfall pipes into deeper waters rather than implementing secondary treatment. The cost, energy requirements, increase in CO₂ that will contribute to global warming, and expected problems related to effective treatment of the increased volume of biosolids produced, make the secondary treatment option undesirable.

Dr. Fujioka then led the discussion to the second topic of unreliable water quality standards for Hawaii and problems related to interpreting violations of current water quality standards.



Dr. Roger Fujioka

Watson Okubo stated that monitoring recreational waters to meet current State of Hawaii and EPA standards does not provide data which can be related to health effects. HDOH is contributing to modifying and revising the existing water quality standards for Hawaii.

Dr. Ashbolt said that EPA standards based on epidemiological studies are not the only strategy to be used to make water quality assessments for recreational water uses and standards. Since epidemiological studies are slow and expensive, there is a need to use quantitative microbial risk assessments at many beaches to assess risk in the absence of epidemiological studies. For practical reasons, more predictive modeling studies should be conducted so beaches can be opened or closed in a timely manner. Dr. Ashbolt pointed out the importance of knowing the sources and associated health risks of the various identified pollutants in the watershed that can be expected to contribute to pollution at swimming beaches.

Dr. Richard Whitman agreed that water quality standards have to be modified. because taking one sample per week at a beach site is not a reliable way to assess pollution and risk to swimmers. Dr. Whitman supported Dr. Fujioka's assertion that using both culture and molecular tests is better way than the current protocol. Dr. Whitman also supported the conclusion made by Dr. Ashbolt that QMRA and predictive modeling studies should be made for individual beaches. Dr. Whitman pointed out that there are human risks due to non-human sources of contamination (birds, algae, domesticated animals, wild animal populations).

The consensus conclusion was that current recreational water quality standards are not reliable. EPA has been informed and has accepted this conclusion. EPA has developed an action plan called "Critical

Path Science Plan” which provides guidelines on how new and revised recreational water quality standards will be developed by 2010. The recommendations of this conference include developing recreational water quality standards that are applicable and reliable for Hawaii. The recommended monitoring strategy is to employ both culture data and molecular tests because the results provide more reliable data related to expected pathogens and more specific data related to human pathogens. Using this approach, interpretation can use the weight of evidence approach and can be better related to risk of human infection. Since EPA is charged with developing new water quality standards, the action plan is for scientists in Hawaii is to continue to communicate their findings to EPA. Moreover, scientists in Hawaii should collaborate with colleagues working in other states so that national and regional guidelines for water quality can be prepared.

Session 4: The Safe Drinking Water Act

The focus of this session was to address water quality monitoring problems in Hawaii related to implementation of the Safe Drinking Water Act.

Speaking during this session were:

Mr. Stuart Yamada, from the Hawaii Department of Health, presented a review of HDOH water quality monitoring data for drinking water sources, and stated that it is a HDOH mandate to test all drinking water sources for concentrations of 85 different contaminants, and to compare the results with standards established under the Safe Drinking Water Act. Another HDOH mandate is to send all customers a Consumer Confidence Report so that the public can be kept informed about the quality of their drinking water. Mr. Yamada stated that most of Hawaii’s drinking water sources meet the requirements of the Safe Drinking Water Act. However, some pollutants are detected in drinking water sources, but generally below health-risk levels.



Mr. Stuart Yamada

Mr. Erwin Kawata, from the Honolulu Board of Water Supply (HBWS), provided a brief background of the agency, including its history, infrastructure and operations. He then described a potentially serious problem which arose when some pesticides used in agriculture were detected in some groundwater sources in Central Oahu. Mr. Kawata described how HBWS uses granular activated carbon to remove the chemical contaminants so that we can continue to use these groundwater sources for drinking purposes.

Mr. Owen Narikawa, also from the Honolulu Board of Water Supply, distributed data to show the relatively low levels of total coliforms and even lower levels of fecal coliforms recovered from Oahu’s wells from 2004-2008.

Despite these low levels, the Safe Drinking Water Act has increased the stringency for monitoring and reporting the results of contamination. As a result, HBWS has instituted more treatment and greatly increased the number of wells which are now chlorinated. Moreover, upcoming regulations indicate that newly required monitoring tests will be more complicated.

Mr. Carl Arume from the Kauai Department of Water, described his agency’s experience and results when Kauai chose to incorporate surface water sources into one of their drinking water systems. Although most water utilities in Hawaii use groundwater sources for drinking, each water utility must be prepared to use surface water sources and to overcome the problems which arise



Mr. Carl Arume

when these sources are used. Mr. Arume told the group that surface water sources are characterized by higher coliform and total bacterial counts, higher turbidity, higher nutrient load, and lower pH. The problems identified were the need for higher levels of disinfection, the formation of higher levels of disinfection byproducts, and the release of rust from the walls of the distribution pipes. The solution that the Kauai Department of Water developed was to remove most of the turbidity from the surface water by filtration, increase its pH, use phosphate inhibitor to reduce rust removal, and treat it with higher concentrations of chlorine to control bacterial levels.

A panel discussion session followed to receive questions from the audience related to drinking water issues and for the speakers to respond, and to identify recommendations and future action plans. Dr. Fujioka led the discussion and there was a general consensus that Hawaii’s groundwater drinking water sources are excellent and meet the requirements of the Safe Drinking Water Act. Toxic agricultural chemicals detected in some groundwater sources can be successfully treated with activated carbon. Another problem identified was the use of surface water as alternative drinking water sources. Procedures to treat surface water sources have been developed. Moreover, methods to desalinate water are being investigated. A recent matter of concern has been the reported presence of chemicals such as hormones, personal care products, and pharmaceuticals in some drinking water sources. The identified problem is that there is no testing performed for most of these contaminants. The action plan recommended is for EPA and other health related organizations to monitor for more types of contaminants in drinking water sources. Moreover, it is recommended that complete health effect studies should be conducted for these chemicals and it should be determined which of these should be routinely monitored for.

Session 5: Posters

The following posters were displayed at the conference:

Micromollusks: Biological Indicators of the Sea: The Baseline Studies. Presented by Regina Kawamoto and E. Alison Kay, Department of Zoology and Water Resources Research Center, University of Hawaii.

Impact of Indigenous Microbial Community on the Survival of Fecal Indicators in Hawaiian Beach Sand. Presented by Fan Feng and Tao Yan, Department of Civil and Environmental Engineering, University of Hawaii.

Application and Interpretation of Recreational Waters Assayed by Culture for Fecal Indicators and for Fecal Bacteriodes by QPCR. Presented by R. Fujioka, M.J. Soderlund, V. Kannappan, Water Resources Research Center, University of Hawaii.

Assessment of Fecal Indicator Microorganisms and Human Pathogenic Bacteria in Beach Sand Samples from Hawaii. Presented by S. Hashiro, and R. Fujioka, Water Resources Research Center, University of Hawaii.

Monitoring Environmental Waters for Viruses or Phages that infect a Group of Anaerobic Fecal Bacteria (Bacteriodes spp) Provides Evidence of Human Sewage Contamination. Presented by V. Kannappan, M.J. Soderlund, and R. Fujioka, Water Resources Research Center, University of Hawaii.

Salinity Gradients in Hawaii's Coastal Waters Select for Specific Vibrio Species. Presented by G. Vithanage and R.S. Fujioka, Water Resources Research Center, University of Hawaii.

Benthic Polychaete Communities at the Sand Island Wastewater Outfall 2002-2007. Presented by Dr. Julie Brock, Department of Zoology, University of Hawaii.

Use of Indigenous Mollusks to Bioaccumulate Human Enteric Viruses from Sewage Contaminated Coastal Waters. Presented by A.Y. Asahina, Y. Lu, C. Wu, and P.C. Loh, Water Resources Research Center, Pacific Research Center for Marine Biomedicine, University of Hawaii.

Confirmation of Sewage in a Stormdrain Discharge into Palolo Stream Based on Measurements for Sewage Specific Microorganisms. Presented by Marcus Soderlund, M.S., Department of Tropical Medicine and Water Resources Research Center, University of Hawaii.

Building a Regional Coastal/Oceanic Archive of In-Situ Data for Posterity. Presented by Patrick Caldwell, NOAA Data Center Hawaii Liaison (NESDIS/NODC/NCDDC), Dept. of Oceanography, University of Hawaii.

In Memoriam, Paul Chester Ekern

July 2, 1920 - November 13, 2008

WRRC mourns the recent passing of one of the Center's earliest faculty members Dr. Paul Ekern. Paul was with WRRC from the very beginning back in 1964.



Dr. Paul Ekern

The oldest of eight children, Paul was born in Ardmore, Oklahoma and he grew up in Mexico, Missouri. He received a BA in mathematics from Westminster College in Fulton, Missouri. While in the Army Air Corps, he earned a Professional Certificate in Meteorology from the University of Chicago. He was then stationed at Tinker Field in Oklahoma City and in Manila.

After later receiving his Ph.D. from the University of Wisconsin, Paul, his wife Nancy, and their four daughters moved to Honolulu. Paul worked for the Pineapple Research Institute, the Institute of Geophysics, and the Water Resources Research Center, as a Hydrologist, Microclimatologist, Soil Physicist, and Professor of Soils.

During his 30-odd years with the water center Paul authored a varied body of work, ranging from estimating water use by sugar cane crops to using X-ray diffraction to determine the relative abundance of minerals in sediments in estuaries on Oahu. His work at WRRC focused largely on agricultural water use, wastewater irrigation, and evapotranspiration studies. Paul was a pioneer in the measurement of evapotranspiration in Hawaii.

Paul was a dedicated gardener and enjoyed working in his yard; tending to over 75 different varieties of bromeliads was his passion. He was an avid reader, particularly of magazines, his interest ranging from *Biblical Archeology Review* to *Foreign Policy* to *American Scientist*, *Science* and *Scientific American*.

Those who worked with Paul at WRRC knew him as being extremely knowledgeable, kindly, energetic, hard-working, resourceful, and a good teacher.

We bid our colleague and friend Paul Ekern a fond aloha.