Water Resources Research Center
University of Hawaii at Manoa
March 2008 Bulletin

WRRC Project - Honolulu Airport Fish Pond Water Quality

Many people do not realize that there is an oasis of tranquility in the middle of the bustle of Honolulu airport. These Cultural Gardens have been a landmark feature at the Honolulu International Airport since 1969. The gardens feature three fishponds containing koi (decorative carp to non-Hawaii readers) and other fish. These include the so-called Chinese and Japanese ponds, and the larger Hawaiian pond. The gardens with their ponds provide a beautiful and restive environment for travelers to enjoy while transiting through the airport. The gardens and ponds were upgraded to their present form around 1981.

Unfortunately the ponds have on-going water quality issues. With abundant inputs of nutrients from the fish waste and food, and sunshine, there is a constant battle with algae and ammonia buildup. There are three independent filtration systems servicing the ponds. Despite this and a costly maintenance program the quality of the water in the ponds is sometimes poor. In addition, fresh water use is apparently high.

In 1983, an attempt was made to improve the water quality by installing sand filters and extending the waterfall features to promote attached growth filtration. Later, ozone units were installed to inject ozone gas into the ponds in order to control algae and other deleterious growth. The sand filter was marginally effective and the ozone treatment was not effective. Today, the sand filters remain in operation but the ozone units are no longer operational.

A service contract to clean the ponds is currently in place. The primary function of the contract is to remove debris and deleterious growth from the ponds on a semi-monthly basis. Algae growth has been the primary problem. If left unchecked, the algae will take over the pond within days. This turns the ponds into a stringy green soup with a foul odor. Chemical control is not a feasible option as it would be toxic to fish and beneficial micro flora. Additionally, the overflow from the ponds discharges into drains which lead to State waters. Most chemicals, such as peroxides and chlorine are marine toxins, and are prohibited from direct discharge unless associated with a dechlorination process to reduce concentrations to acceptable levels.

The overall objective of this study is to determine a cost-effective, innovative and sustainable treatment system which improves water quality and reduces maintenance, water wastage, and energy use through the use of photovoltaic panels to supply power to the system.

In order to optimize operation and maintenance of the ponds, it is necessary to determine existing inadequacies and develop innovative solutions. Pond maintenance involves removal of ammonia to maintain concentrations below those toxic to fish, control of algae for water clarity, and reduction/removal of sediment. In the area of biological treatment in particular, there are several potential alternatives which may be more robust and effective than the existing system. Regarding the maintenance of water clarity, the use of ultraviolet (UV) sterilizers is currently being effectively used at other locations to control algae and enhance water clarity. However, appropriate dosage and affects on nitrification (ammonia control) must be determined.

Treatment Evaluation:

Ultraviolet Light is a cellular treatment process which inhibits further growth by altering the genetic code of algal cells through exposure at specific dosages. Once altered, the algae cannot reproduce and thus their population is controlled. Similar to ozone, UV is non-discriminatory and may be detrimental to beneficial bacteria. Specifically, nitrosomas and nitrobacter bacteria are of particular importance because they convert ammonia to nitrites and nitrates. Without such bacteria, the ammonia, a byproduct of the fish, may eventually kill them unless they are fixed and rendered harmless. Unlike the ozone unit which simply injected ozone into the ponds, we propose to evaluate a sidestream UV system to determine the return rate which would be sufficient to control algae growth without severely impacting ammonia removal.

Energy Considerations:

Because UV generation requires an electrical power source, electrical consumption may be an important factor when considering the economic feasibility of a full scale operation. Consistent with current efforts by the State to move toward green technology, research into the feasibility and reliability of utilizing solar panels to supplement electrical demand will be evaluated.

EPA Rescinding Wastewater Waivers - Costs to Exceed $1 Billion

Years of careful study, conducted in part at the Water Resources Research Center, have produced a massive body of evidence indicating that the discharge of primary treated wastewater from the City of Honolulu's ocean outfalls is having no adverse effects on the surrounding ecosystems or human uses. In spite of this overwhelming evidence the Environmental Protection Agency in 2007 tentatively decided to deny both the Sand Island and Honouliuli treatment plants' renewals of the waivers from secondary treatment requirements that the plants have been operating under for many years.

What this means in practical terms for the residents of Honolulu is an enormous expenditure of public funds to polish wastewater to an advanced quality which will have no appreciable impact on ecosystem integrity or human health. These funds (estimated to be more than a BILLION dollars) will either have to be generated by increased taxes/ fees on residents or else they will have to be diverted from other more pressing projects such as coming up with a strategy for disposing of the garbage that is filling up Waimanalo Gulch landfill, improving public transit, or even fixing the wastewater collection network. Mayor Mufi Hanneman has argued the secondary treatment is unnecessary, and that the upgrades would bankrupt the city.

The two outfalls at Sand Island and Honouliuli dispose of the majority of the City's wastewater in deep (around 200 feet) ocean water, safely distant (around 9,000 feet) from shore. In the 1970s, prior to the construction of these long, deep outfalls, wastewater was discharged in much shallower water, much nearer to shore. These discharges, combined with multiple smaller ones coming from, among others, Oahu's military bases, had a significant impact on the nearby marine ecosystems. This is what led the city to extend their outfalls to a point far offshore where the greater dilution easily deals with the discharge.

Sand Island Wastewater Treatment Plant
Honolulu, Hawaii

Now after many years of smooth operation under the waivers, with no die-off of fish or other organisms, no outbreak of human disease, or any meaningful adverse effects of any kind, the EPA has tentatively decided to revoke the waivers. This decision is based on totally inapplicable testing, no evidence of human or animal harm, legal technicality and political correctness. The taxpayers of Hawaii will be the victims of this illogical action.

Hawaii residents have until March 31, 2008 to voice their opinion on the City's request to exempt Sand Island Wastewater Treatment plant from full secondary-treatment requirements.

A public hearing about Sand Island is also scheduled for 6:30 p.m. March 12 at Washington Middle School cafeteria, at 1663 S. King St. The comment period and public hearing for Honoluliuli has already passed.

For more information on the city's application and to submit a comment, visit www.epa.gov/region09/water/ npdes/pubnotices.html.

TMDL Workshop Held in Honolulu

The Water Resources Research Center (WRRC) co-sponsored a workshop on Total Maximum Daily Load (TDML) at the Pagoda Hotel in Honolulu on October 23-25, 2007.

Total Maximum Daily Load refers to the total quantity (or load) of a pollutant that a stream can carry and still conform to designated uses and fishable/swimmable water quality. TMDL also refers to a regulatory/planning process that States, Territories, and authorized Tribes use to determine allowable pollutant concentrations in streams. The TMDL program was designed to provide a safety net, catching water bodies that were not protected or restored by the implementation of the range of general, broadly applicable, pollution control programs authorized in the Clean Water Act. The TMDL program is aimed specifically at assuring attainment of water quality standards.

In all the states "impaired" waters are identified by state regulatory agencies (the Department of Health in Hawaii's case). Any water body that does not meet the State's EPA-approved water-quality standards, whether narrative, numeric, chemical, physical, or biological, after full implementation of existing permits, is considered impaired. (USGS Fact Sheet FS-130-01). This system of identifying "impairment" gives regulatory agencies considerable leeway in deciding which water bodies need attention. Indeed, in some cases the inclusion of a water body is made simply on the basis of a visual inspection.

Under the Clean Water Act's provisions, the states are required to identify impaired waters for which technology-based controls are insufficient to meet applicable water quality standards, and to prioritize these so-called water

continued on page 7

New Research Project - Assessing Effects of Intraborehole Flow in Deep Monitoring Wells on Estimates of Aquifer Salinity Profiles

There is heavy reliance on salinity versus depth profiles from deep monitor wells for the regulation of groundwater withdrawals in some locations in Hawaii. Because of possible intraborehole flow effects, however, salinity profiles from deep monitor wells may not accurately reflect the salinity distribution with depth in the aquifer. Borehole geophysical logging in Hawaii has shown some evidence for subtle intraborehole flow in some cases. The question then becomes: "Is this subtle flow sufficient to invalidate the depth-salinity profiles that are being observed?" Or: "Is the flow great enough that the observed salinity profile in the wellbore is substantially different from the adjacent aquifer?" Some ensuing questions concern the management intent and use of these monitoring wells: Are salinity profiles sufficiently invalid that they can't be used to monitor long-term changes over years to decades? and, What is the anticipated timescale for saltwater intrusion in response to pumping? Thus far, this topic has not been dealt with comprehensively in the published literature.

The objective of this current USGS study, being led by Dr. Aly El Kadi at WRRC, is to evaluate the potential for intraborehole flow to result in inaccurate or misleading information being used for groundwater management in Hawaii.

Two approaches will be used: (1) evaluate and summarize existing work to date; and (2) consult with experts in borehole geophysical logging to design a strategy for further field work. Results will be published in the USGS Scientific Investigations Report series.

Case Studies - Field data and studies in Hawaii on intraborehole flow will be reviewed. Existing geophysical logs will be inspected for evidence of flow and profile disturbance. Some wells are suspected of having sufficient borehole flow that salinity profiles are probably invalid. On Oahu there is a classic case where a fully-open deep monitoring well has been situated too close to large-capacity water-supply wells, and where drawdown from the pumping wells appears to draw brackish water up the bore of the monitoring well. For wells away from obvious pumping disturbances there is much less evidence of salinity-profile disturbance. A second example is in a well at the discharge end of the central Oahu flow system where upward head gradients are expected. Water in this well has lower nitrate concentrations than surrounding wells that tap a degraded, irrigation-return layer, and this may indicate upward flow of "fresher" water from intermediate depths. Considerable chemical and tracer data are available for the well that, if evaluated carefully, may provide insight into the amount of intraborehole flow. Seasonal effects in existing salinity logs will be examined by comparing logs at various dates to see if differences are in the expected direction. Results of the latest geophysical logging in 2001 by Fred Paillet and Delwyn Oki will be reexamined.

Results of the above case studies will be used to design a strategy for field work. It is likely that new logging will be proposed for the Waiehu deep monitoring well in the Iao area of Maui because of its importance in ongoing management of pumping there under a sustainable yield concept. Borehole geophysical specialists will be asked to propose methods to definitively answer the critical question; not to simply demonstrate that there is borehole flow, but to demonstrate that the borehole salinity profile differs substantially from the aquifer salinity profile. Proposed strategies may include induction tools that "look outside" the borehole and into the formation, but it must be clear that a full strategy is possible to reduce the formation resistivity that results in fluid conductivity in the formation (using Archie's Law* and adequate measurement of formation porosity and bulk resistivity of the solid basalt matrix). Other wells may also be proposed for some amount of new work. Approaches may include salinity profiling under ambient and pumped conditions, or repeat profiling at seasonal intervals to take advantage of naturally-imposed vertical head gradients (such as a recent seven foot rise in the regional water table on Oahu that has accompanied a recent recharge event after five dry years). Repeat sampling may be accomplished through ongoing logging programs of the Commission on Water Resource Management and County Water Departments.

Local stakeholders believe that profiles from open boreholes are reasonable indicators of aquifer salinity. Well owners may not be enthusiastic in their support of geophysical research in their wells because they are valuable monitoring sites and it would be expensive to replace or rehabilitate them if they were damaged by logging tools. A network of short-screened or point-piezometer measurements to define vertical head gradients, or the true salinity distribution in the aquifer would provide valuable information, but are not likely to be drilled because of the high cost of drilling deep (>1,000 ft) wells. The work described above is a stepwise approach to assess the significance of the problem. If results from this work show that intraborehole flow causes data from deep monitoring wells to be unreliable, then local stakeholders are likely to become more interested in funding further field work.

*In petrophysics, **Archie's law** relates the in-situ electrical conductivity of sedimentary rock to its porosity and brine saturation.

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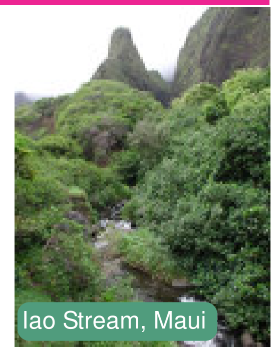
Hawaii Water News

Wailuku Water Contested Case Hearing Developments – Maui


Iao Stream, Maui

"In Wailuku, the State Commission on Water Resource Management began a contested case hearing on the distribution of the water from the four major streams—*Na Wai Eha*—of the West Maui Mountains. For more than a century, those waters have been controlled primarily by Wailuku Sugar Company, which changed its name to Wailuku Agribusiness a quarter century ago, and again recently to Wailuku Water Company.

A hui of groups, including EarthJustice and the Office of Hawaiian Affairs, is seeking to establish in-stream flow standards for stream wildlife, as has been required by the state Water Code since 1987. The Hui o Na Wai Eha and Maui Tomorrow, partners to the contested case, also join in seeking to preserve traditional and customary water uses, such as growing taro." - Rob Parsons, Mauitime Weekly - December 13, 2007

State Testing Drinking Water in Preschools for Lead

In October of last year the Hawaii State Department of Health (DOH) and the Department of Human Services (DHS) launched a program to test the tap water at all licensed child care and preschool facilities in Hawai'i, including those located at private residences. The statewide testing program is expected to span over two years at an estimated cost of $569,000. There are approximately 1,200 licensed daycare facilities in Hawaii, including roughly 550 which operate in private homes. Although the DOH believes that the majority of child care facilities do have safe tap water these tests will determine if individual facilities need to take corrective action to ensure their water supply is safe. The program is federally funded through the EPA Drinking Water State Revolving Fund administered by the DOH. Child care facilities will not be charged for the water analysis. However, they will be required to take responsibility for any remedial actions if problems are found.

Molokai Water Permit Denied

On Dec. 26, 2007 the Hawaii Supreme Court overturned the State Water Commission's 2001 decision granting Kukui (Molokai) Inc. to take around 1 mgd from a well in central Molokai. The firm, now known as Molokai Properties/Molokai Ranch, provides water to most of the west side of Molokai including the industrial park at Palauea; a resort, which includes beach lots, condos and a golf course, at Kaluakoi; and Maunaloa Town, including the ranch's 22-room lodge.

When the State Water Commission took control of groundwater resources on Molokai in 1992 it required users of the water to submit requests for permits for existing uses by July 15, 1993. Kukui Molokai was several months late in submitting it's request. Between the 1993 application and 2001, the Kaluakoi hotel and golf course closed (and so are not needing water). The golf course has since reopened, but the hotel has not. The Supreme Court said the commission failed to adequately scrutinize Kukui Molokai's request and failed to consider the effect of the closure of Kukui Molokai's hotel and golf course on the allocation of water.

Developers on Maui Must Now Prove Long-Term Water Supply

"On Dec. 7, the Maui County Council passed the so-called "Show Me the Water" ordinance, three years after the bill was introduced. Council Water Resources Committee Chairperson Michelle Anderson spearheaded the bill, and brought the debate on the matter to the point that it passed unanimously.

For years, the county Department of Water Supply had issued permits with a caveat that water could not be guaranteed at the time a project was completed, though reservations for water meters were often issued well in advance. The new bill, once signed into law by Mayor Charmaine Tavares, will require developers to substantiate a reliable long-term water supply before receiving zoning or subdivision approvals, with some exceptions. Claims by developers that this would impose a de facto moratorium on development tend to underscore the seriousness of the water shortage issue." - Rob Parsons, Mauitime Weekly - December 13, 2007

School Cesspools to be Replaced

Gang cesspools removed, Hawaii

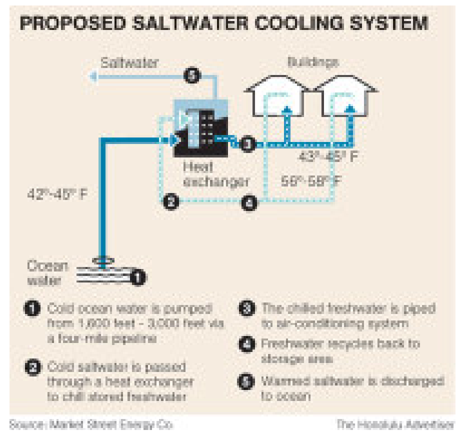
Hawaii relies more heavily on cesspools for sewage disposal than any other state. There are more than 2,291 large-capacity, and many more single home, cesspools in the state. Cesspools are a primitive method of waste disposal and pose a danger to groundwater and human health. The EPA mandated the closure of the large-capacity units in Hawaii by April 2005. In spite of this there are still many such cesspools in use.

Many schools around the islands use these large cesspools. Big Island schools have the most cesspools (132), followed by Kauai (66) and Oahu (55), Maui (42) and Molokai (25), according to Education Department data.

The state Department of Education is asking the state for $49 million dollars in order to replace school cesspools with more environmentally sound systems. This is in addition to the $33.6 million already appropriated by the Legislature to replace the DOE cesspools since 2002. This amounts to around a quarter of a million dollars per cesspool.

The Education Department was originally required to shut down the large-capacity cesspools at 60 campuses or pay federal penalties of up to $32,500 per cesspool/day. However a deal reached with the U.S. Environmental Protection Agency postponed enforcement until Sept. 30, 2009.

New Seawater Cooling Plant in Development



Honolulu Seawater Air Conditioning LLC, an affiliate of St. Paul, Minn.-based Market Street Energy Co. has completed a $10.75 million round of equity financing to fund its proposed system for downtown Honolulu. The company, said more than half of the funding came from Honolulu private investors.

The company plans to break ground on the project next January, and said an additional $141 million for the work will come from construction financing.

The company says it has committed future service for about 50 percent of the system's 25,000 ton capacity, including the Prince Kuhio Federal Building and Hawaiian Electric Co.'s downtown headquarters.

The technology uses cool water pumped from the ocean to chill water moving through a closed-circuit air conditioning system. The company estimates that the system will save customers a net of up to 75 percent on their electric bills. Rates will be set for a 25-year period. - Pacific Business News , January 14, 2008

EPA Assesses Upcountry Maui Water System

Water flume, Upcountry Maui

Officials from the Environmental Protection Agency were on Maui in January to assess the troubled Upcountry water system. There have been concerns about the quality of the water in the system over the last several years. The water is treated with additives intended to prevent the leaching of lead from the pipes in older homes, but residents complained in 2002 that the chemicals used caused them eye and skin irritations. The system changed to a different treatment which reduced the number of complaints.

The visiting EPA scientists worked with state and county officials to review existing research, interview water department employees, visit facilities and conduct sampling as part of the comprehensive "optimization" study of the water system.

In 2003, Maui county received $497,000 from the federal government to study the water system and test children for lead. These studies found no evidence of elevated lead levels in consumers. Critics suggested the study was not thorough enough, and the County Council appealed to the EPA to do a performance evaluation of the entire Upcountry water system.

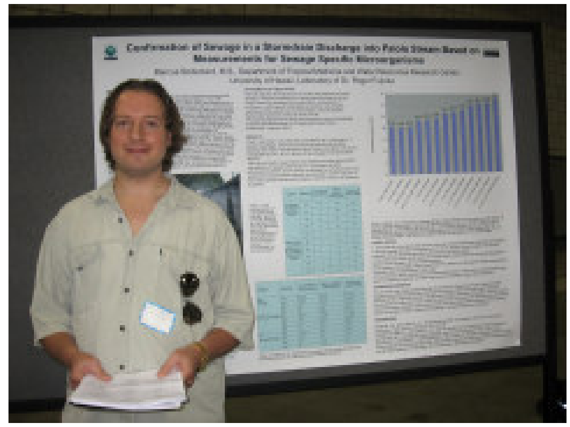
New Maps of Nearshore Environment Available

The National Oceanic and Atmospheric Administration announced the availability of new maps of coral reef ecosystems around the Hawaiian islands. The maps "..will provide the fundamental spatial organizing framework to implement and integrate research programs and provide the capability to effectively communicate information and results to coral reef ecosystem managers." The maps can be viewed at http://ccma.nos.noaa.gov/products/biogeography/hawaii_cd_07/startup.html

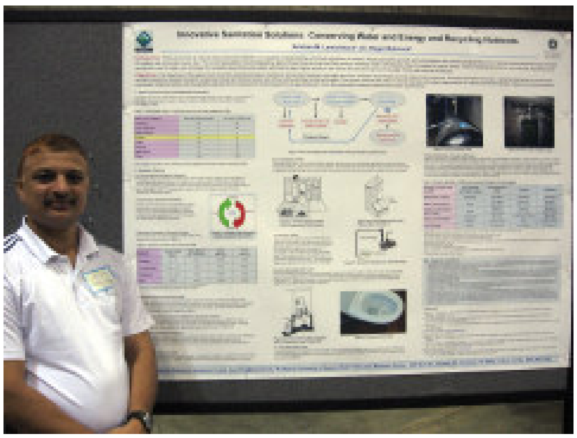
Center Students' Posters Win Awards at HWEA Conference

Two WRRC Graduate Researchers won prizes for their poster submissions at the recent Hawaii Water Environment Federation conference held February 19-21, 2008 at the Hawaii Convention Center.

Marcus Soderlund, a microbiologist and student of WRRC researcher Dr. Roger Fujioka took first prize for his poster describing the work he did in detecting a leak of human sewage into Palolo stream based on the detection of certain sewage-specific microorganisms. Mr. Soderlund is a citizen of Finland. He formerly worked at the Gene Expression and Molecular Biomarker section of the Molecular Pathology Laboratory at the Lombardi Comprehensive Cancer Center in Georgetown University in Washington, D.C. He has been working on a Ph.D. program in Tropical Medicine at JABSOM/UH since 2005, and is currently working on the detection of micro-organisms in the environment at the Manoa campus with Dr. Fujioka and Dr. Yuanan Lu.



Marcus Soderlund with his poster



Krishna Lamichhane with his poster

Krishna Lamichhane won third prize for his poster describing closed-loop waste disposal systems that minimize the use of water and energy and allow for the retrieval of valuable nutrients for soil improvement. Mr. Lamichhane is a student of WRRC researcher Dr. Roger Babcock. He is a citizen of Nepal where he has worked since 1990 for the government of Nepal's Department of Water Supply and Sewerage. This is the lead government agency responsible for water and sanitation in Nepal. Mr. Lamichhane's work involves planning, designing, and executing mostly rural water and sanitation projects in different parts of Nepal. He was also partly involved in the formulation of Nepal's (interim) Drinking Water Quality Standards.

WRRC Personnel News

The Center has recently undergone some personnel changes. Karen Tanoue, WRRC's editor for the last 14 years retired at the end of December. Our new editor will be Henry Bennett. Mr. Bennett has many years of technical editing experience at Bishop Museum, Kamehameha Schools and as a publishing consultant. Dr. Chittaranjan Ray, who had been with WRRC and the University's College of Engineering for the last six years also left at the end of the year to take a position at the University of Georgia in Athens. Dr. Ray's work here focused on the study of contaminant transport through Hawaiian soils.

Dr. Clark Liu is away on a one, or possibly two year assignment to the National Science Foundation in Washington as the Program Director for Environmental Engineering at the Chemical, Bioengineering, Environmental, and Transport Systems (CBET) Division. This division supports research and education in the fields of bioengineering and environmental engineering and in areas that involve the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. CBET research and education contribute to the knowledge base and development of the workforce for major components of the U.S. economy, including chemicals, pharmaceuticals, medical devices, forest products, metals, petroleum, food, textiles, utilities, and microelectronics. Support for environmental work encompasses pollution prevention and remediation as well as life cycle analysis. For more information see (http://www.nsf.gov/eng/cbet/about.jsp).

Drs. Ray and Liu at their going away party in December

TMDL continued from page 2...

quality limited segments (WQLSs) targeted for TMDL development over the next two years. The priority ranking and the list of waters targeted for TMDL development must reflect the severity of use impairment and the type of uses being impaired. This list of impaired waters is referred to as a state's 303(d) list and is submitted to EPA every other year. (A TMDL Primer: *A guide to understanding total maximum daily loads required under state water quality standards. By Matthew D. Garamone, JD, CHMM (*http://www.stevenspublishing.com/Stevens/EPPub.nsf/frame?open&redirect=http://www.stevenspublishing.com/stevens/epPub.nsf/d3d5b4f938b22b6e8625670c006dbc58/ea274c9e4d2f7c0886256a0a006b56f9?OpenDocument)

A feature of the TMDL process is that it allocates proportions of pollutant load to different sources in watersheds, and this allocation is used as the basis for determining who will be responsible for reducing what proportion of the total load each source identified in the watershed needs to eliminate.

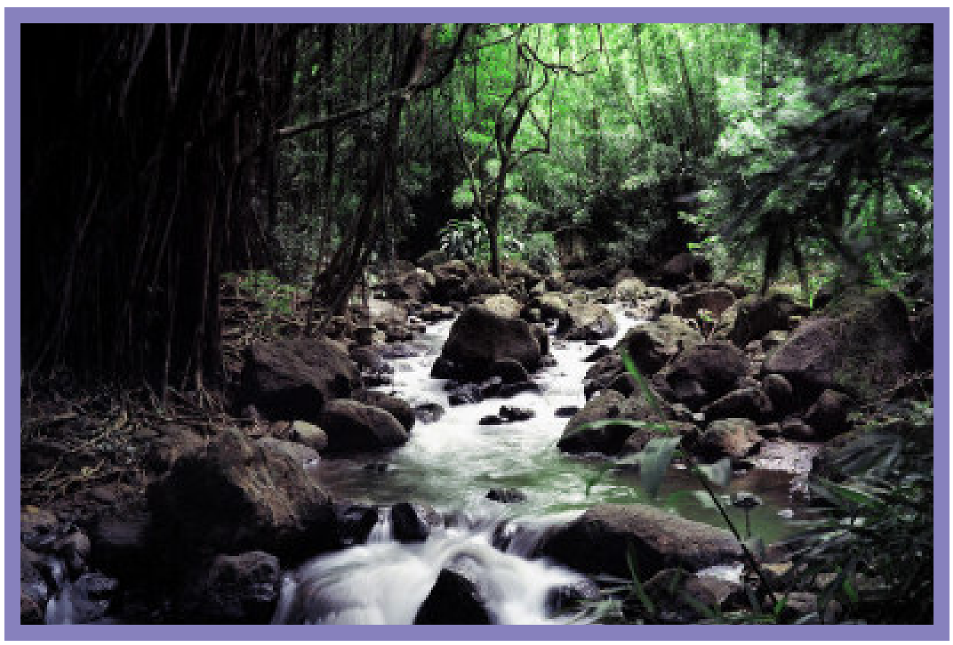
As of the 2004 listing for Hawaii, 244 water bodies have been identified as being impaired and 20 TMDLs have been approved by EPA. Most of the impaired (or water quality limited) waters on Hawaii's list are there due to excess sediment and nutrients.

The October workshop, which focused on how best to develop and implement the TMDL regulations in Hawaii, looked at TDML development across a number of disciplines from engineering and planning to legal and political. The workshop served to introduce TDML and discuss difficulties in the implementation of the process in Hawaii and ways to address these.

WRRC's Dr. Clark Liu was the first presenter at the workshop. He gave a talk providing some background about the TMDL program and about planning provisions for water quality management in relation to the Clean Water Act.

Paul Freedman from the consulting firm Limno-Tech gave the audience a good overview of the TMDL program and associated challenges nationwide. Other speakers, included Dr. Russell Yost of the UH College of Tropical Agriculture and David Penn, the TMDL Coordinator for the Hawaii Department of Health (DOH). Mr. Penn discussed Hawaii's experience with TDML including how it is working today and how it will work in the future, along with a look back at past challenges and what the state has learned from them. Speakers from the State Department of Transportation were on hand to talk about their activities in reducing pollutant loads from airports and harbors under their municipal separate storm sewer system (MS4) permits. Peter Kozelka, TMDL Program Leader from EPA Region 9 was on hand to give the federal agency's perspective to the group.

The workshop participants also benefited from presentations by three members of Virginia Tech's Center for TMDL and Watershed Studies who came to Hawaii to describe the Virginia experience in conducting TMDLs and implementing pollution reduction measures. One of these gentlemen, Kevin Brannan, later came to the Manoa campus to deliver a WRRC seminar regarding modeling issues in TMDL. Brannan described his group's use of computer models to develop TDMLs in Virginia. According to Brannan, the majority of the TMDLs that have been developed to date are related to poor benthic community health and excess bacteria. Brannan explained that the two models most often used to address these impairments are the Hydrological Simulation Program-FORTRAN (HSPF) for bacteria, and the Generalized Watershed Loading Functions (GWLF) for benthic community impairments where the dominant stressor is sediment.



Over 200 Hawaiian streams are on the "impaired" list

Implementation of the TMDL program in Hawaii is complicated by several factors largely stemming from the State's unique hydrology. It was pointed out during the workshop that even under natural conditions many of Hawaii's streams do not meet water quality standards due to sediment coming from the steep undeveloped lands in the backs of watersheds, especially those with large wild populations of pigs and goats. The nature of Hawaii's topography/climate results in very erosive storm events. The extreme steepness and inaccessibility of most of the upper watersheds makes it very difficult to perform adequate inspections in these upper reaches. There is a shortage, or even a complete lack of data for

continued on page 8

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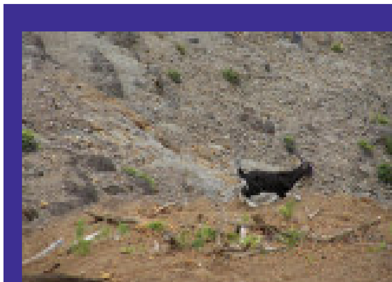
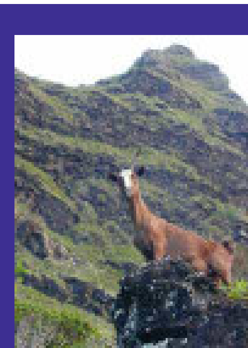
TMDL continued from page 7...

many waters in Hawaii, and very little systematic data collection is being done currently. Without monitoring data it is impossible to know if the State's numerically expressed quality standards are being exceeded or not. Furthermore agricultural concerns are not bound by the findings of TMDL studies, and indeed do not have to permit access to their land to allow inspection of the watershed. It is therefore almost impossible to say what proportion of any pollutant originates on agricultural land, often the largest land use in a watershed.

One of the concerns that emerged during the workshop was that without good monitoring data and without being able to inspect much of the watershed it will be almost impossible to make a good assessment of the source of pollutants. Therefore it could happen that allocation of load (and the responsibility to reduce it) will disproportionately fall on those concerns which are most readily identifiable and not necessarily on those who are actually contributing the contamination.

Other sponsors of the workshop included the Hawaii Local Technical Assistance Program at the UH College of Engineering; the State of Hawaii Department of Health's Environmental Health Administration Branch; the U.S. Environmental Protection Agency, Region 9; the City and County of Honolulu's Department of Environmental Services; the Hawaii Department of Transportation, Highways Division; and the UH College of Tropical Agriculture and Human Resources.





Goats; one cause of excessive sediment in Hawaiian streams.