



2013 NSF – PIRE ANNUAL REPORT



***WHAT ARE THE MAJOR GOALS OF THE PROJECT?**

Based on our proposal application, and working with our external evaluator (Dr. Lisa Kohne, SmartStart), the following major goals were identified for our project, although no specific timelines for completion were associated with each.



Goal 1: *Knowledge/Research/Discovery.*

Increase knowledge and understanding of sustainable urban water systems, and in the process equip a new generation of engineers, natural, physical, and social scientists, policy makers, and educators with multi-disciplinary skills and sensitivities.



Goal 2: *Education.*

Accelerate education and training in the area of urban water sustainability, and diffuse knowledge about sustainability options to US middle-school and high-school students, undergraduate STEM majors, graduate students, post-docs, and faculty.



Goal 3: *Partnerships.*

Improve urban water sustainability research and application through the establishment of new partnerships between university researchers, non-university researchers, and urban water managers.



Goal 4: *Institutional Capacity.*

Increase the capacity of UCI's Henry Samueli School of Engineering (HSSoE) to lead research and educational exchange programs with other units on campus, other universities, non-university research programs, and international partners.



Goal 5: *Workforce Development.*

Contribute to the development of a workforce in urban sustainability science, engineering, and policy that will thrive in the face of transdisciplinary problems.

***WHAT WAS ACCOMPLISHED UNDER THESE GOALS?**

(Goal 1-1)

We put into place a formal process for the solicitation, vetting, and awarding of graduate student support that assures every graduate student project depends critically on intellectual and/or physical infrastructure that could only be accessed through collaboration with our Australian partners. This involves a multi-step process that includes:

- (a) an open call for proposals from graduate students at UCI
- (b) vetting of research proposals by faculty at UCI, UCLA, UCSD, University of Melbourne, and Monash University
- (c) detailed feedback and a request for proposal revisions
- (d) another round of review
- (e) the establishment of a joint committee of US and Australian faculty to supervise the research program of each funded students.

To foster interdisciplinarity, reduce the logistical challenges associated with coordinating reviews from over 20 faculty scattered across five universities and two countries, facilitate transparency, and create a permanent archive of all relevant materials, the review process was implemented on a project management platform called TeamBox.



For the 2013 cycle, eight PhD students were awarded full or partial support under the NSF PIRE program, including: Laura Weiden, Eric Huang, Keah-Ying Lim, Morvarid Azizian, Asal Askarizadeh, Alice Robinson, Ali Mehran, and Kathleen Low. Short descriptions of their research interests can be found on our website (<http://water-pire.uci.edu/graduate-student-2/>). For the sake of brevity, in the next section we describe in more detail only the research activities of the four PhD students who are presently conducting research in Australia.

The research efforts of the other four PIRE PhD students will be detailed in the second annual report, after they begin their research residency in Australia. In addition three postdoctoral scholar positions were filled, one each at UCI (M. Rippey), UCSD (A. Mehring) and UCLA (B. Winfrey). In each case detailed interviews were held and recent PhDs were selected with the intent of directing expertise in contaminant ecology, wetland plant ecology, and wetland animal ecology to the application of natural ecosystem processes for urban water reuse.

The PIRE grant also provided partial support for two post-doctoral researchers to initiate collaborations between groups at UCI and counterparts in Australia. Specifically: (a) Dr. Jochen Schubert in Professor Brett Sander's Group at UCI was given partial support to jump-start a collaboration with Professor Tim Fletcher's watershed-scale modeling group at the University of Melbourne (further described in Goal 1-6); and (b) Dr. Zengchao Hao in Professor Amir AghaKouchak's group at UCI was given partial support to jump-start a collaboration with ARC Future Fellow Murray Peel's climate change modeling group at the University of Melbourne (further described in Goal 1-7).

(Goal 1-2)

PhD students with “boots on the ground” in Australia include Laura Weiden, Keah-Ying Lim, Eric Huang, and Alice Robinson (Alice is planning to travel to Australia by the end of September 2013). The research activities of these four graduate students are briefly described here.



Laura Weiden, a PhD student in Environmental Engineering at UCI, is jointly supervised at UCI by Professor Stanley Grant, Professor Bill Cooper, and Dr. Meg Rippey and at Monash University by Professor Ana Deletic and Senior Lecturer David McCarthy. Laura is studying the partitioning of micropollutants into the surface microlayer that forms at the air/water interface in constructed wetlands and biofilters. Her project builds on the ongoing stormwater and wetland sampling program being carried out by the Cooperative Research Center for Water Sensitive Cities at Monash University. The practical endpoint is a low-energy scheme –something we have named “surface microlayer

harvesting”— for removing micropollutants from stormwater runoff before they contaminate treatment wetlands and biofilters. Laura began her research residency at Monash University in mid June 2013, and has since developed a protocol for sampling and quantifying the surface microlayer using a glass plate sampling technique and fluorescence excitation/emission spectroscopy. She has started sampling the surface microlayer and bulk waters of various constructed wetlands and biofilters in and around Melbourne, including a treatment biofilter and wetland treatment train system that drains a large residential catchment in a south-eastern suburb of Melbourne. Surface microlayer and bulk water samples are being analyzed for both semi-volatile (THR C10-C36, PAH, Triazine, Phthalate, Phenol, and Glyphosphate) and volatile (THR

C6-C9) and THMs) micropollutants. (b) Melbourne is a world-leader in stormwater harvesting and reuse, and therefore the city is an ideal laboratory for quantifying the associated human health risks and ecosystem benefits of this practice.



Keah-Ying Lim, a PhD student in Environmental Engineering at UCI, is developing a quantitative microbial risk assessment (QMRA) of human health risks associated with stormwater reuse and third-pipe recycled water schemes; working on methodological improvements of QMRA, and developing a sustainability index that takes into account the human health risks of using treated stormwater, and the ecosystem risks (energy costs, GHG emissions, impacts on receiving waters) of not reusing stormwater. His project is jointly supervised by Professors Jiang (UCI) and Andrew Hamilton (University of Melbourne), and he will be working closely with another PhD student at the University of Melbourne

(Krystal Burry) who is studying socio-economic factors associated with adopting stormwater and wastewater reuse schemes in Melbourne. Keah-Ying began his research residency at University of Melbourne in late-July 2013. He is presently conducting a survey of Melbourne households to serve as input to his QMRA and sustainability index models, and has already submitted a manuscript to the journal *Water Research* entitled “Reevaluation of health risk benchmarks for sustainable water practice through risk analysis of rooftop-harvested rainwater”. Biofilters are a popular low-energy treatment scheme for stormwater runoff, in part because they have small footprints and thus are easy to integrate into space-constrained residential communities. Present guidelines for biofilter construction (e.g., the plants and filter media utilized) optimize nutrient and heavy metal removal, but stormwater runoff also contains microorganisms (viruses, bacteria, and protozoa) that cause human disease.



Eric Huang, a PhD student jointly supervised by Jiang (UCI) and McCarthy and Deletic (Monash University), will leverage the world-class biofilter test facility at Monash University to evaluate the role that plant, animal, and microbial communities in biofilter systems play in the removal of viruses in biofilters. Eric began his residency at Monash University in mid-August (2013) where he is presently conducting biofiltration studies using a fluorescently labeled pathogenic human adenovirus developed in the Jiang lab. As an example of how the NSF PIRE project can add value, the Director of the \$130M Cooperative Research Center (CRC) for Water Sensitive Cities, Professor

Deletic, described Eric’s virus removal research as “critical” to the CRC’s research program. In designing and interpreting his experiments, Eric will work closely with the two ecology teams on the PIRE project — Professor Richard Ambrose and his post-doc Dr. Brandon Winfrey (at UCLA) and Professor Lisa Levin and her post-doc Dr. Andrew Mehring (at Scripps Institution of Oceanography). The UCLA and SIO ecology teams are focused on the role that plant and animal communities, respectively, play in pollutant removal in biofilters and constructed wetlands. (d) In addition to low-energy approaches for treating stormwater runoff, Melbourne is also a world leader in the use of wastewater stabilization ponds (WSPs) for treating domestic wastewater. Approximately 50% of Melbourne’s sewage is treated by passage through the world’s largest WSP system (Melbourne Water’s Western Treatment Plant), and WSPs of various sizes are scattered throughout the Greater Melbourne Metropolitan area.



Alice Robinson, a PhD student in Environmental Engineering at UCI, is evaluating the risks and benefits associated with adopting WSPs over more conventional wastewater treatment schemes. Her research, which is jointly supervised by Professors Diego and Grant (UCI) and Hamilton (University of Melbourne) will involve a full life cycle analysis of GHG emissions and energy costs associated with a set of WSPs operated by Goulburn Water, a wastewater utility that services urban and peri-urban communities north of downtown Melbourne. One novel (cross-disciplinary) element of Alice’s project involves an evaluation of how animals influence nitrogen cycling in WSPs. The ecology

team at Scripps Institution of Oceanography (Professor Lisa Levin and Dr. Andrew Mehring) together with Dr. Meg Rippy (UCI) have hypothesized, based on recent experimental evidence, that certain midges (fly larvae) common in WSPs are significant sources of the potent greenhouse gas nitrous oxide. Alice will

begin her modeling and experimental program when she takes up residency at the University of Melbourne in late September 2013.

(Goal 1-3)



Faculty, post-doctoral researchers, graduate students, and undergraduate students from UCI, UCLA, and UCSD traveled to Melbourne to participate in a mini-conference and workshop centered around the research being carried out as part of the \$130M CRC for Water Sensitive Cities at Monash University (<http://watersensitivecities.org.au/>). The workshop/mini-conference was held July 11th and 12th, 2013. The first day was devoted to biophysical aspects of biofilter and constructed wetland design, and included presentations from Monash researchers (Professor Deletic and graduate students Gayani Chandrasena, Yali Li, Kefeng

Zhang, Emily Payne, Kent Feng, Harsha Fowdar), UCI researchers (Professor Stanley Grant, Professor Sunny Jiang and graduate student Laura Weiden), and Dr. Andrew Mehring from Scripps Institution of Oceanography.

The second day was devoted to institutional, governance, and economic dimensions of water sensitive urban design, and included presentations from Monash researchers (Professor Jo Lindsay, Professor Rebekah Brown, Professor Paul Raschky, Professor Lionel Frost) and UCI researchers (Professor David Feldman and Professor Jean-Daniel Saphores). Both days included time for brainstorming about potential collaborative research projects, and a number of US/Australian research projects were identified and/or refined, including:

- (a) Laura Weiden's focus on harvesting surface microlayers to control micropollutant input to biofilters and wetlands;
- (b) refinement of Eric Huang's project on the removal of human pathogenic viruses in biofilters;
- (c) a potential joint project between UCSD/SIO (Professor Lisa Levin, Dr. Andrew Mehring, UCLA (Professor Richard Ambrose, Dr. Brandon Winfrey), UCI (Dr. Meg Rippey), and several faculty at Monash University (including Professors Jenny Davis, Perran Cook, and Mike Grace) on the use of biomass harvesting to improve nutrient removal in biofilters, and the effect of animals on nutrient cycling and biodiversity in biofilters and wetlands;
- (d) a comparison of institutional design and public responses toward decisions of water utilities in Melbourne and the southwest US (Professor David Feldman and Professor Rebekah Brown); and
- (e) a comparison of attitudes toward wastewater reuse among the general population in Melbourne and in the Southwest US (Professor Jean-Daniel Saphores and Professor Paul Raschky).



The two-day workshop at Monash provided a stimulating forum to share information and develop collaborations across a variety of academic disciplines (engineering, ecology, microbiology, sociology, political science, history, and economics), across all academic levels (undergraduates, graduate students, post-docs, and university faculty), and across four of the five universities participating in the PIRE grant (UCLA was not represented because Professor Richard Ambrose was unable to travel to Australia during this time frame, and his post-doc Brandon Winfrey had not yet been hired). An ecology-focused meeting was held in August with ecology team members from UCI, UCSD (SIO) and UCLA to further develop plans for collaborative research with Monash University.

(Goal 1-4)

Researchers from UCI (Professors Stanley Grant, David Feldman, Jean-Daniel Saphores, and graduate student Kathleen Low), Monash University (Professor Perran Cook), and The University of Melbourne (Professors Andrew Hamilton and Michael Stewardson, and graduate student Kristal Burry) joined together to write a feature article for the upcoming special issue on the design of sustainable urban water systems in the prestigious journal *Environmental Science and Technology*. The manuscript, which is entitled "Adapting Urban Water Systems to a Changing Climate: Lessons from the Millennium Drought in Southeast Australia", was accepted for publication on May 2, 2013; a preprint of the article is included as an attachment.



(Goal 1-5)

Two faculty (Professors Stanley Grant and Sunny Jiang) and two post-docs (Drs. Megan Rippey and Andrew Mehring) traveled to Australia in early July to carry out wetland and biofilter field sampling, in association with a PIRE-funded undergraduate research experience in Australia called the UPP Down Under program (described below under Goal 2-1). In addition to a research experience for the undergraduates, this field effort provided:

- (a) a "first-look" at Australia's biofilter and constructed wetlands, including an opportunity to coordinate directly with the researchers, construction crews, and managers who design, build, and maintain these systems;
- (b) an opportunity to characterize water quality of the influent and effluent to each system; and
- (c) an opportunity to characterize the plant and animal communities resident in a variety of constructed and natural wetland and biofilter systems of varying age and physical scale.



In all, five biofilters and four wetlands (including a natural wetland system) were sampled in and around Melbourne, including Royal Park Treatment Wetland, Hampton Park Treatment Wetland, Wikes Reserve Biofilter, Lynbrook Estates Biofilter and Constructed Wetland (the first such systems implemented in Melbourne), Edithvale Natural Wetland, and Hereford Biofilter in Little Stringybark Creek. For this effort a temporary laboratory was set-up at the University of Melbourne where water samples were analyzed for standard water quality parameters (*E. coli* and enterococci bacteria, chlorophyll, total suspended solids). Water concentrates were shipped back to the US for molecular analysis for human pathogen (a suite of viruses, bacteria, protozoa) in Professor Jiang's laboratory at UCI, and sediment cores were preserved and shipped back to the US for analysis of detritus and animal communities in Professor Lisa Levin's laboratory at Scripps Institution of Oceanography.

The experiences and data obtained from this effort are providing an invaluable baseline information for discussions between US and Australian researchers about future research collaborations, including those initiated during the two-day workshop at Monash University described in item (Goal 1-3) above. The PIRE team also gained on-the-ground experience navigating the complexities and permitting associated with carrying out fieldwork in Australia, and shipping samples back to the US.

In the first instance, many discussions were conducted with a variety of partners (researchers and practitioners) to first identify a set of representative systems and then to gain permission from the

appropriate landholder (Melbourne Water for the set of systems sampled in 2013). Once permission was granted, a detailed risk assessment had to be prepared by the PIRE team before the fieldwork could be carried out. Setting up the laboratory at the University of Melbourne also proved complex, because many of the analyses we wanted to carry out involved shipping equipment and supplies to Australia from the US. In the second instance, detailed export permit proposals had to be crafted and submitted to the Australian Department of Sustainability, Environment, Water, Population, and Community. Our experiences with this first round of fieldwork will greatly simplify the planning for field expeditions in future years.

(Goal 1-6)



UCI Professor Brett Sanders and post-doc Jochen Schubert have engaged in research activities with University of Melbourne Professor Tim Fletcher and his research team including research fellow Geoff Vietz and post-doc Matthew Burns. The collaboration is studying the impact on flood risk that may arise when efforts are implemented to restore urban riverine habitats and promote catchment sustainability.

The Little Stringybark Creek watershed (Melbourne, AUS) is being used as a test site for this collaboration where, under the supervision of Professor Fletcher, a number of stormwater control measures (SCMs) are being implemented at the property level to capture stormwater. Using a hydrologic model for the Little Stringybark Creek watershed, under development by Professor Fletcher and post-doc Matthew Burns, and a 2D hydraulic model of the river floodplain, under development by Professor Sander and post-doc Jochen Schubert, the collaboration is seeking to understand how these SCMs may be utilized to restore a stream's ecosystem while effectively managing flood risk. Thus a number of research questions have been identified:

- 1) What is the impact of SCMs on channel flow velocities and shear stress acting on channels during storm events?
- 2) How does channel and floodplain storage affect peak flow hydrology and what channel and floodplain morphologies are most effective in attenuating downstream hydrologic impacts?
- 3) How will SCMs affect the occurrence and extent of overbank flows, particularly those flows that represent a hazard to development, and
- 4) Is it possible to link specific SCMs to specific flood risk reduction benefits and could this information help with the development of more effective SCM incentive programs?

(Goal 1-7)

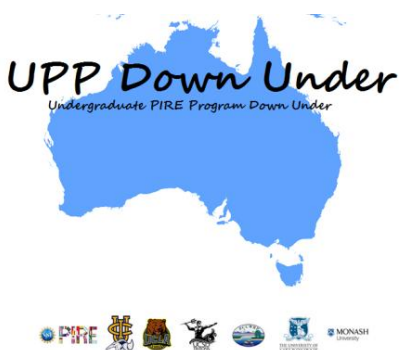
Professor Amir AghaKouchak's group at UCI is working together with ARC Future Fellow Murray Peel at the University of Melbourne to generate global circulation model (GCM) predictions of reservoir inflows for the four key Melbourne Water catchments. These modeling efforts, which are being carried out by PIRE graduate student Ali Mehran and post-doctoral researcher Dr. Zengchao Hao, have already resulted in several PIRE cited journal manuscripts, including one that was recently published [Hao Z., AghaKouchak A., Phillips T., 2013, "Changes in Concurrent Monthly Precipitation and Temperature Extremes", *Environmental Research Letters*, 8(4), 034014 doi:10.1088/1748-9326/8/3/034014] and several that have been submitted [AghaKouchak A., Mehran A., 2013, Extended Contingency Table: Performance Metrics for Satellite Observations and Climate Model Simulations, *Water Resources Research*, minor revision submitted; Mehran A., AghaKouchak A., and Phillips T.J., 2013 Evaluation of CMIP5 Continental Precipitation Simulations Relative to GPCP Satellite Observations, *Journal of Geophysical Research*, under review]



(Goal 2-1)

In our proposal to NSF we outlined an undergraduate experience that involved designing and building a biofilter on the UCI campus; due to funding constraints, travel to Australia was not included. However, after attending the NSF PIRE PI meeting in September 2012 and after discussions with the NSF Program Manager and our PIRE evaluator, it became clear that an Australian experience should be intrinsic to all aspects of the PIRE project, including the undergraduate program. To that end, and with additional financial support from the Henry Samueli School of Engineering and the Department of Civil and Environmental Engineering at UCI, the PIRE undergraduate program was reconceived to include three primary elements:

- 1) a one-week introductory “bootcamp” held at UCI on constructed wetlands and biofilters and the policy and institutional context surrounding their employment;
- 2) a two-week field expedition in Melbourne, Australia; and
- 3) three-weeks back at UCI focused on analyzing data collected in Australia and summarizing the results in the form of posters, oral presentations, written reports, and video presentations.



We called the new program the Undergraduate PIRE Project Down Under or “UPP Down Under”. Relative to the original proposal, the UPP Down Under is an amalgamation of several activities, including the “SWEET program” and the “Biofilter Frenzy Week”. Indeed, the UPP Down Under had the triple-benefit of providing undergraduates with a life-changing experience in Australia, bringing together the intellectual content for a new e-book on urban water sustainability (one of our proposal deliverables), and providing a forum for US and Australian researchers to develop a cross-disciplinary and international research program in urban water sustainability (through the mini-conference held at Monash University which the undergraduates attended, as outlined in Goal 1-3 above).

The 2013 UPP Down Under cohort consisted of 12 undergraduate students (plus one UCI chaperone, Ms. Nicole Patterson) hailing from UCI (Amanda Jimenez, Ava Moussavi-Aghdam, Cameron Patel, Edgar Gomez, Jessica Satterlee, Kevin Tran, Norma Galaviz, Maria Castillo), UCLA (Emily Parker, Kimberly Duong, Sam Zabb-Parmley), and UCSD/SIO (Garfield Kwan). The cohort was roughly evenly split between women (7) and men (5), and included students from a range of ethnic backgrounds including Mexican, Chinese, Eastern Indian, Iranian and Caucasian. Several of the students were from ethnic backgrounds underrepresented in STEM fields. The majority (9) of the students are finishing their B.S. degree in engineering (Environmental, Chemical, and/or Civil) at UCI, one recently finished his B.S. in Ecology from UCSD/SIO, another recently finished her B.S. in Meteorology from UCLA, and one is a Public Health Sciences and Psychology Cognitive Sciences double major at UCI. Short biographies for these 12 undergraduates is included on the UCI Water PIRE website (<http://water-pire.uci.edu/undergraduate/>).



The programming for this six-week undergraduate event is detailed in the attached agenda, which provides an hour-by-hour accounting of the activities experienced by the undergraduates over the six week program. A copy of the agenda with links to power-point presentations, video recordings of the lectures, and student posters, reports, presentations, and student videos is available at the following URL: <http://water-pire.uci.edu/uppdowntounderabout/>. An overview of the UPP Down Under program, and undergraduate reaction, are included below.

The first week of the UPP Down Under program was focused on providing a broad perspective on the scientific, engineering, and social science challenges associated with implementing low-energy systems for urban water sustainability. Students came to UCI to hear from leading researchers and practitioners on three broad topics:

- (a) climate change, resource economics, and governance;
- (b) wastewater treatment and reuse; and
- (c) stormwater capture and reuse.

Lecturers included professors associated with the PIRE project (Professors Grant, Jiang, Saphores, Feldman, Brouwer, Rosso, and AghaKouchak as represented by Postdoctoral Scholar Z. Hao), a Senior Lecturer in the Department of Ecology and Evolutionary Biology (Professor Peter Bowler), a practitioner from Orange County who talked about the new OC regulations for on-site retention of stormwater runoff (Richard Boon), and a researcher from the Southern California Coastal Water Research Project (SCCWRP) on the urban stream syndrome (K. Schiff). The lectures were moderated by Professor Feldman (UCI) and Dr. Sengupta (SCCWRP). The afternoon of each day consisted of guided tours of water reuse facilities, including Los Angeles' first wastewater reclamation facility (LA County Sanitation District's Wastewater Reclamation Plant in the City of Industry), the world's largest indirect potable reuse facility (Orange County's Groundwater Replenishment System in the City of Fountain Valley), UCI's stormwater capture and reuse projects (on campus at UCI), and the San Joaquin Storm Water Treatment wetlands adjacent to the UCI campus.



After the wetland/biofilter bootcamp at UCI, students traveled to Australia where they set up residence at Trinity College on the campus of The University of Melbourne. For the next two weeks they spent the majority of their time in either the field or the lab. Field experiences included a guided tour of the largest wastewater stabilization pond in the world (Melbourne Water's Western Treatment Plant), water quality and ecological field measurements in the five wetlands and four biofilters described in Goal 1-5, and time in the laboratory assisting with

spectrophotometric measurements of chlorophyll, nitrate, and phosphate, suspended solids measurements, and culture-based measurements of the fecal indicator bacteria *E.coli* and enterococci bacteria. The field sampling and laboratory experience was followed by a mini-conference at Monash University (described in Goal 1-3), the goal of which was to put the undergraduate's on-the-ground experience of wetlands and biofilters in Melbourne into a broader research context. One of the highlights of the Australian trip was a breakfast for the PIRE students and staff hosted by the Chair of the Department of Infrastructure Engineering at the University of Melbourne. Students heard short talks from the Chair of the Department (Professor Abbas Rajabifard), the Deputy Dean of the Melbourne School of Engineering (Professor Peter Scales), and the Head of the Environmental Engineering program (A/Professor Michael Stewardson).

After their two weeks in Australia, the students traveled back to the US for a final three weeks of programming. During the first week back in the US they:

- (a) obtained hands-on experience using molecular methods to detect microbial pathogens and learned about quantitative microbial risk assessment (Professor Sunny Jiang and graduate student Eric Huang);
- (b) learned about how to develop a good research question, the Scientific Method, types of data, and taking notes, and basic statistical approaches for analyzing data including ANOVA and parametric statistical testing (Dr. Andrew Mehring);
- (c) learned more advanced statistical techniques for analyzing experimental data, including non-parametric statistical tests, boot strap methods, principal component analysis, and generalized linear models (Dr. Megan Rippy);
- (d) learned about the role of wetland plants in water quality improvement (Dr. Brandon Winfrey) and
- (e) learned how to communicate research results to scientific and lay-audiences (Dr. Alison Cawood).



The last two weeks of the program were spent analyzing the data collected in Australia under the supervision of Professor Stanley Grant and Dr. Megan Rippey, and then summarizing results in the form of posters, oral presentations, research reports (<http://water-pire.uci.edu/presentations/>), and video presentations for lay-audiences. Two videos were generated by the undergraduates, one focused on their research experience in Australia and another entitled, “Science is Fun” (<http://water-pire.uci.edu/2013-upp-down-under-videos/>). The program culminated in a UPP Down Under symposium at UCI on August 1, 2013. The symposium included 10-minute talks from four student teams, a screening of the two UPP Down Under movies, and a poster session in which the students talked informally about their research with attendees. The symposium was open to the public and well attended by PIRE-affiliated faculty, graduate students in the Environmental Engineering program at UCI, and friends and family of the UPP Down Under cohort. Students in the program also spent one day at Scripps Institution of Oceanography (UCSD) where they examined treatment pond invertebrates under dissecting and compound microscopes for the first time, viewed the SIO invertebrate collection, examined pier based field studies and visited the Birch Aquarium-Museum.

Students in the UPP Down Under program were asked to write reflection papers on how the program affected them from both a cultural and academic perspective. Excerpts from several of these reflection papers are included below:



“Before this program, I knew nothing about Melbourne’s recent drought or water conservation measures. I had no idea that California and Melbourne faced such similar water scarcity issues, and most of all, I had no idea that California and Melbourne could also utilize similar solutions. Now I feel armed with the knowledge and experience necessary to help California pursue these solutions. For example, I was able to walk into a civil engineering interview last week and have an intelligent conversation about urban runoff with the interviewer. I can talk about how biofilters and wetlands work from first-hand experience, not just from reading articles. I can speak for the success of Melbourne’s public outreach campaigns not just by reciting some statistics, but also by recounting the time I was in a public restroom and overheard an Australian mother telling her young daughter about the recycled water used to flush the toilets. I can discuss the benefits of nutrient removal not only by describing it in the context of Australia’s Port Phillip Bay, but also by analyzing nitrate and phosphate levels in Melbourne’s constructed wetlands.”

–Emily Parker, UCLA 4th year major in Environmental Science.

“Traveling to Australia through the Undergraduate Pire Program – Down Under, has been a life-changing experience. I have had the opportunity to learn first-hand about the great leaps in urban water sustainability that the city of Melbourne, Australia has made. Most importantly, I have gained a better understanding of what graduate research is composed of, how hypotheses are constructed, tested and often reformulated. Dr. Stan Grant, Dr. Sunny Jiang and all of the other outstandingly brilliant professors and post-doctorate students I travelled with. This experience has shaped my perspective on the future of urban water sustainability and how it can be applied back at home in California and nationwide. My career path will be shaped by this experience, I now hope to involve myself in collaborative research with industry that focuses on decentralized, low-energy, small scale approaches to water treatment and reuse especially in developing countries.”

–Norma Galaviz, UCI 4th year double major in Civil Engineering and Environmental Engineering





“Overall, PIRE has been one of the most valuable, fulfilling, and incredible experiences of my life. Reflecting on it has been an emotional process. Despite rough weather in the field, late nights in lab, preparation of our research poster, and nerves over presenting at the symposium, writing my reflection paper has been the most difficult part of the program. It astounds me that I can learn so much in 6-weeks. Involvement in the program truly left me with profound insights and affirmations that I'll carry throughout my life.”

-Maria Castillo, UCI 4th-year double major in Public Health Sciences and Psychology/Cognitive Sciences

As for my future, I have developed a passion for studying water sustainability. Being originally from Northern California where it rains fairly often, I never realized how much of an issue water sustainability was for Southern California. After going to school at UCLA and studying water sustainability in this program, I realize just how large of a task our society is faced with. It will be up to me as well as my generation to lead the next steps in what amounts to be a very large obstacle. However in taking one step at a time, or many such as in this PIRE program, we can tackle and conquer this challenge.



-Samuel Zabb-Parmley, UCLA 3rd year major in Civil and Environmental Engineering

(Goal 2-2)

The PIRE Team organized a teacher professional development workshop on August 8, 2013. Dr. AghaKouchak developed and presented two hands-on projects with the objective to foster student interest in Earth systems science and important issues surrounding climate change. The session included two parts: understanding

- (a) climate change impact on water resources and
- (b) societal impacts of drought.

The idea was to introduce the science behind these two topics using simple and hands-on projects such that can be integrated into K-12 curriculum. In this event, 12 math/science middle and high school teachers participated.

(Goal 3-1)

Through our partnership with the Southern California Coastal Water Research Project (SCCWRP), the PIRE team will give five presentations at the California Stormwater Quality Association (CASQA) 9th Annual Stormwater Conference in Lake Tahoe, California on September 12, 2013. Talks include:

- (a) Dr. Ashmita Sengupta (SCCWRP) will be presenting an overview of the research program with Australia, and how lessons learned in Australia might apply to California stormwater managers;
- (b) PIRE graduate student Ms. Morvarid Azizian will be presenting her work on modeling pollutant removal in treatment systems;
- (c) PIRE graduate student Asal Askarizadeh will be presenting her research on detecting changes in hydrology at the watershed scale following the installation of biofilters and rain gardens in Little Stringybark Creek in Melbourne;

- (d) PIRE graduate student Kathleen Low will be presenting her work analyzing the time scales over which Melbourne reduced its per capita water consumption by over 50% during the Millennium Drought; and
- (e) PIRE post-doc Dr. Megan Rippey will describe trade-offs in pollutant removal efficiency associated with current wetland and biofilter designs.



**CALIFORNIA STORMWATER
QUALITY ASSOCIATION®**

Dedicated to the Advancement of Stormwater Quality Management, Science, and Regulation

(Goal 3-2)



SCCWRP has reached out to the key storm water managers in southern California through the California Stormwater Quality Association (CASQA), Southern California Stormwater Monitoring Coalition (SMC), and the Commission's Technical Advisory Group (CTAG) for an Australian/US Workshop on Storm Water Capture and Reuse, to be held in November at the CASQA quarterly meeting. The proposed workshop will present a synthesis of Australian research on technological development and implementation of low energy options (or best management practices) for stormwater management and discuss the viability of these ideas with southern California stormwater managers. Three outcomes of the workshop are expected:

- 1) Southern California stormwater managers will receive information on the latest innovations in Australian stormwater technology,
- 2) discussions will help to clarify how NSF PIRE research can better serve the stormwater management community, and
- 3) results will help inform the development of joint US-Australian research programs on the capture, treatment, and reuse of stormwater runoff.

SCCWRP also organized a PIRE PI and graduate student meeting in April to brainstorm about potential research areas and collaborations. SCCWRP's research will focus on southern California (potentially Santa Margarita River) to complement the efforts of the PIRE modeling team in Australia. The goal is to predict instream algal response to changes in the water quality after biofilters, raingardens, and constructed wetlands are installed in a watershed.

(Goal 3-3)

Senior Lecturer in Ecology and Evolutionary Biology Dr. Peter Bowler (Department of Ecology and Evolutionary Biology, UCI) presented a conference paper at the Headwaters to Ocean H2O Conference 2013 and hosted a community seminar that described the PIRE project's use of the UC Natural Reserve System's San Joaquin Marsh Reserve. Dr. Bowler led a field trip for the UPP Down Under group to the Newport Bay estuary and salt marsh habitats, the UCI Arboretum, and to the UCNRS San Joaquin Marsh Reserve. A copy of the Headwaters to Ocean H2O Conference 2013 paper is posted at

http://www.coastalconference.org/h2o/2013_presentations.php



(Goal 3-4)

PIRE Graduate student Eric Huang was hired to create a website for the PIRE project. The website, which is now being maintained by James Beam in the Department of Civil and Environmental Engineering, can be found at the following URL: <http://water-pire.uci.edu/>

(Goal 4-1)



Producing and implementing the UPP Down Under program required forging new relationships and agreements between the Henry Samueli School of Engineering (HSSoE) and other units on campus, as well as between UCI, the University of Melbourne, and Monash University. Ms. Leyla Riley (HSSoE) took the lead on logistics for the UPP Down Under program, including preparing the student application forms, reviewing applicants, selecting the 2013 cohort, programming at UCI, obtaining Australian visas, arranging lodging at the University of Melbourne, and travel to/from Australia. To guide the design of the program, Ms. Riley adopted NSF's "Looking Beyond the Borders: A Project Director's Handbook of Best Practices for International Research Experiences for Undergraduates". This required networking with multiple units on the UCI campus, and working closely with the Manager of Infrastructure in the School of Engineering at the University of Melbourne, Ms. Michelle Mackay.

(Goal 4-2)

As noted earlier, our proposal to NSF did not include travel to Australia for the undergraduates, and adding this task back into the project entailed many new costs which were not included in the original NSF budget. To offset these new costs, The Henry Samueli School of Engineering and the Department of Civil and Environmental Engineering at UCI jointly pledged to contribute \$30,000 annually to the UPP Down Under program. Furthermore, the Graduate Division at UCI agreed to restructure their financial support for the PIRE program from a sixth year following the end of the project (the original pledge) to annual installments of \$40,803 (FY1), \$72,878 (FY2), \$107,193 (FY3), \$67,114 (FY4), \$35,399 (FY5) for a grand total of \$323,387. The combination of matching support provided from these three groups (HSSoE, CEE, and Graduate Division) allowed us to greatly strengthen the undergraduate UPP Down Under program, and in particular provide on-the-ground Australian experience for the 2013 cohort.

(Goal 4-3)

In our original proposal to NSF, the UCI Environmental Institute (EI) was to serve as the primary forum for the undergraduate and graduate student activities planned at UCI. However, between the time of proposal submission and the funding of the proposal, the UCI Office of Research decided to sunset the EI. To offset the loss of the EI, the Office of Research pledged \$20,000 annually to support the PIRE project. The \$20,000 from the Office of Research was matched by the Henry School of Engineering-- enough to fund a 50% time staff member in the Department of Civil and Environmental Engineering. This staff member (Mr. James Beam) assists with the day-to-day logistics of running the PIRE program.



(Goal 4-4)

The Associate Dean for Research in the Henry Samueli School of Engineering at UCI (Professor William Tang) worked with his counterparts at The University of Melbourne and Monash University to establish the ground rules for conducting joint research across the five universities involved in this project (UCI, UCSD/SIO, UCLA, University of Melbourne, and Monash University). These discussions led to the conclusion that agreements about data sharing, publication rights, authorship order, and IP ownership should be negotiated between the relevant parties on a project-by-project basis. This approach proved the most sensible, given the different procedures in place at the various institutions for handling everything from grant recharge accounts, to authorship on papers, to intellectual property issues.