ANNUAL REPORT

July 1, 2007 – June 30, 2008

Submitted by:

The Center for Water and Society Advisory Committee

Contact Information:

Dr. Alex S. Mayer, Director
Michigan Technological University
Department of Geological & Mining Engineering & Science
427 DOW Environmental Sciences & Engineering Building
1400 Townsend Drive
Houghton, MI 49931
phone: (906) 487-3372
email: asmayer@mtu.edu

Center for Water and Society
email: mtcws@mtu.edu
web-site: http://www.mtcws.mtu.edu/
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2. CWS Mission Statement

The mission of the Center for Water and Society (CWS) at Michigan Tech is to support research, education, and outreach in all disciplines at Michigan Tech related to water issues. The goal is to establish Michigan Tech as a state, regional, national and international leader in these disciplines and, in particular, in interdisciplinary approaches to solving water-related problems. CWS is a “virtual” Research Center. By virtual, we mean that the CWS will not occupy physical space, but is a consortium of people at Michigan Tech whose focal point is water-related activities.

The objectives of the Center for Water and Society are:

- To serve as a focal point for instructional and research activities in water-related fields and water-related outreach activities across the Michigan Tech campus
- To provide an organizational structure that supports continuing growth in water-related fields and outreach activities and encourage interdisciplinary projects
- To promote the visibility of Michigan Tech’s water-related research in state, regional, national and international arenas
- To support interdisciplinary graduate and undergraduate education and research in water related fields
- To pursue external funding opportunities to support these objectives and to facilitate the acquisition of external support by faculty participating in CWS.

CWS has 49 faculty/staff participants and 45 graduate student and 3 undergraduate student participants in 13 units across the Michigan Tech campus (see Appendices 1 and 2). CWS is governed by a director and advisory committee (see Appendix 3)
3. CWS Year in Review

3.1. *World Water Day Events Sponsored by CWS – March 24, 2008*

Events included a keynote address “The Great Lakes Water Wars,” by Peter Annin, Author of “The Great Lakes Water Wars” and Associate Director, Institute for Journalism and Natural Resources; a research seminar, “Temperature in the Great Lakes” by Jay Austin, Assistant Professor, Large Lakes Observatory and Department of Physics, University of Minnesota, Duluth; a demonstration of watercolor techniques by MaryAnn Beckwith, Visual & Performing Arts Professor, MTU, a Research Poster competition, and a Fine Arts competition. The awards for the Research Poster and Arts competitions are as follows.

**Research Poster Awards**

Andrea Hernandez ($250)
“*The Impacts of Climate Change and Variability on Water Resources in a Semi Arid Region in Mexico: The Rio Yaqui-Basin*”

Kevin Endsley, Silvia Espino, Josh Richardson ($150)
“*Groundwater Investigation Using Resistivity Surveys on a Terminal Moraine, Bering Glacier*”

Stacey Pilling ($100)
“*Pesticide Exposure in the Yaqui Valley: Perceptions and Realities of the Green Revolution*”

**Photography Awards**

Stacey Pilling ($200)
“*Salto de Agua*”

Bode Morin ($100)
“*Closed*”

**Watercolor Award**

Valerie Fuchs ($200)
“*Cavus Exploratus (the water beneath)*”

3.2. *Degree Subcommittee Activities*

(Members: Nancy Auer, Kathy Halvorsen, Alex Mayer, Joan Chadde)

The primary activity of the Degree Subcommittee was the review of the Graduate Student Research and Travel grants awarded by CWS. The following grants were awarded in 2007-8.

3.2.1. *CWS Graduate travel awards*

**Cory McDonald ($300)**
PhD student in Environmental Engineering
Event: 6th European Conference on Ecological Modeling (ECEM07) in Trieste, Italy
Date: November 27-30, 2007
Abstract: "An information-theoretic approach to aquatic biogeochemical modeling in Lake Superior"

**Stacey Pilling ($300)**
MS student in Social Sciences
Date: November 28 – December 2, 2007

**Joe Dammel ($300)**
Environmental Engineering undergrad
Event: 2008 ISSRM (International Symposium on Society & Resource Management), University of Vermont
Date: June 10-14, 2008
Poster Presentation Title: “Lake Superior’s Vulnerability to Global Environmental Problems”

### 3.2.2. CWS Graduate research awards

**Heather Wright ($500)**
PhD student in Environmental Engineering
Date: March 13, 2008
Research Topic: Wetland Rehabilitation in Santa Cruz, Bolivia

### 3.3. **Seminars & Symposia Subcommittee Activities**

(Members: Noel Urban, Kathy Halvorsen, Christine Anderson, Alex Mayer)

The primary activity of the Seminars & Symposia Subcommittee was the planning and organization of CWS seminars. The following seminars were sponsored or co-sponsored in 2007-8 by CWS.

**Thomas E. Croley II, Great Lakes Environmental Research Laboratory**
"Great Lakes Hydrology Modeling with the Advanced Hydrologic Prediction System"
October 8, 2007

**Melvyn Visser, Chemical Engineer, MTU Class of 1959**
"Persistent Organic Pollutants (POPs) in the Great Lakes: Evolution of the Understanding of their Source and Transport"
September 24, 2007

**Peter Annin, Associate Director of the Institutes for Journalism and Natural Resources**
"The Great Lakes Water Wars"
March 24, 2008
Colin Brooks, Research Scientist, Michigan Tech Research Institute
“The connection between land use / land cover and water quality in the agricultural Upper Tiffin River watershed of southeastern Michigan”
April 24, 2008

3.4. Awards and Recognition for CWS Participants

Andrea Munoz-Hernandez
Hydrology section of American Geophysical Union (AGU): Outstanding Student Paper Award
"The Impacts of climate change and variability on water resources in a semiarid region in Mexico: The Rio Yaqui-Basin"

Cory MacDonald
American Society of Limnology and Oceanography (ASLO): Outstanding Student Presentation Award
"An Information-Theoretic Approach to Aquatic Biogeochemical Modeling"
Summer Meeting in St. John's, Newfoundland

Brian Barkdoll: elected Fellow of the American Society of Civil Engineers

Nancy Auer: elected to the board of the Lake Superior Watershed Partnership

3.5. Participation of CWS Director in Initiatives, Conferences and Workshop in support of CWS.

1. Brookings Institute Freshwater convening

The Brookings Institution, along with the Great Lakes Science Center and the Great Lakes Commission, held a regional convening at the Great Lakes Science Center in Cleveland in Myer 2008 to discuss the region’s assets and challenges for emerging as a freshwater leader. CWS Director Mayer was invited to participate. This conference, the first of two, brought together representatives from the freshwater industry, research, education, and policy to share their expertise in exploring the potential for such an initiative. The goal of this project is to identify the core competencies available in the region – industry and business leadership, infrastructure capacity, natural abundance of freshwater, leading national and international research institutions and labs, human capital, and experiential know-how in cooperation and collaboration across multiple sectors and jurisdictions – that can serve as a foundation for enabling the Great Lakes region to emerge as a leader in freshwater research, technology and industry.

2. Michigan Economic Development Corporation Water Technology Cluster

CWS Director Mayer was invited to participate in the Michigan Economic Development Corporation (MEDC) Water Technology Cluster. In January 2008, the MEDC launched the
Michigan Water Technologies Cluster Initiative to more effectively coordinate and leverage existing assets such as the abundance of freshwater, extensive university expertise, advanced R&D capabilities, manufacturing know-how and environmental leadership. The overarching goal is to attract capital investment, spur job growth, and develop cutting-edge water technologies for industrial and municipal use. The Cluster includes representatives from industry, universities, and state agencies. CWS Director Mayer has attended or participated in five meetings of the cluster. CWS Director Mayer also is participating in the Environmental Resources and Agriculture and Forestry work groups.

3. IBM - T.J. Watson Research Center

In February 2008, CWS Director Mayer traveled to the IBM TJ Watson Research Center to explore potential collaboration between CWS participants and IBM researchers. This visit was arranged by John Soyring, an MTU alumnus and Vice President at IBM. IBM is pursuing several high performance computing initiatives in the water sector. In particular, MTU and IBM may collaborate on monitoring and modeling of Lake Superior or the Great Lakes in general. Discussions have continued between IBM and MTU.

4. Sustainability Faculty Hiring Initiative

CWS Director, Alex Mayer, served on the Sustainability Faculty Hiring Initiative committee and solicited CWS members for nominations for the SFHI positions. CWS participants were requested to submit nominations and encouraged to advertise the positions through their disciplinary professional associations. Three faculty members submitted suggestions for potential recruits. Letters from Provost Lovett-Doust were sent to those recruits, and Alex Mayer also made contact via email to encourage them to apply.
4. CWS Budget

CWS Institute O/H Inventive Account

Beginning Balance July 1, 2007 ................................................................. $5,452.18*

Research Incentive Transfer In ................................................................. $9,372.02

Expenditures ......................................................................................... $13,617.53
  CWS Sponsored Lectures ................................................................. $3,204.25
  Project Support ............................................................................... $714.09
  Student Research & Travel Grants ................................................... $1,400.00
  Student Research Poster & Art Competition Awards ....................... $1,000.00
  AISES Native American Student Travel ......................................... $485.00
    (CWS commitment of NSF IGERT review recommendations)
  Administrative Assistant ................................................................. $6,524.19
  Miscellaneous ............................................................................... $290.00

Balance as of June 30, 2008 ................................................................. $1,206.67

*The ending balance reported in the 2006-7 Annual Report of $5478.13 did not include a $25.95 charge made at the very end of the 2006-7 fiscal year. The Beginning Balance for 2007-8 includes this charge to keep the center’s reporting synchronous with the accounting reports.
5. Research

5.1. New Awards 2007-8

New Research Funding 2007-8: $1,904,601

- Collaborative Research: Modeling and Analyzing the Use, Efficiency, Value and Governance of Water as a Material in the Great Lakes Region Through an Integrated Approach
  PI: Alex Mayer
  co-PIs: James Mihelcic, David Watkins, Qiong (Jane) Zhang
  Sponsor: NSF
  $1,078,322 (9/2007 – 8/2012)
  Award Date (8-20-2007)

- Streamside Lake Sturgeon Culture for the Ontonagon River, Michigan
  PI: Nancy Auer
  Sponsor: MI DNR
  $33,846 (10/2006 – 9/2008, Second Year of Funding)

- Evaluating Riparian Timber Harvesting Guidelines: Phase 3, Result 2 Evaluate Aquatic Habitat Impacts
  PI: Casey Huckins
  Sponsor: USDA Forest Service, Northern Research Station

- Characterizing Lessons Learned from Federal Biomass Removal Projects
  PI: Kathy Halvorsen
  Sponsor: U.S. Forest Service
  $35,603 (9/30/2007 - 3/31/2009)

- Graduate student scholarships to advance a global outlook of economic and social prosperity that protects the environment
  PI: Judith Perlinger
  co-PIs: Veronica Griffis, James Mihelcic, Kurt Paterson, Qiong Zhang
  Sponsor: NSF
  $599,978 (6/1/2008 - 8/31/2012)

  PI: John Gierke
  co-PI: Carla Alonso
  Sponsor: Univ of MI
  $5,000 (5/1/2008 - 4/30/2009)

- Intergovernmental Personnel Act Agreement with US Army Corps of Engineers
  PI: Dave Watkins CEE/CWS/SFI
  Sponsor: US Army Corps of Engineers
  $42,347 (1/7/2008 - 6/6/2008)

- Erosion Reduction by Air Entrainment, Phase I
  PI: Brian Barkdoll
  co-PI: Mohan Rao
  Sponsor: S. Florida Water Management District
  $49,916 (3/1/2008 - 9/30/2008)

- Engaging Social Scientists in the WATERS Initiative: Special Sessions at the 2008 International Symposium on Society and Resource Management
  PI: Alex Mayer
  co-PI: Kathleen Halvorsen
Sponsor: NSF  
$10,600 (5/1/2008 - 11/1/2008)

- Associations Between Groundwater-Surface Water Dynamics and Coaster Brook Trout Spawning Habitat in the Salmon Trout River, Marquette County, Michigan  
  PI: Alex Mayer  
  co-PI: Casey Huckins  
  co-PI: Matthew VanGrinsven  
  Sponsor: Huron Mountain Wildlife Foundation  
  $1,400 (4/15/2008 – 4/14/2009)

5.2. **Active Research Projects Affiliated with CWS, 2007-8**

Total Research Expenditures 2007-8: ...................... $453,218

- **Sedimentation in Schoharie Reservoir: Temporal Dynamics**  
  PI: Noel R. Urban  
  Sponsor: Upstate Freshwater Institute (pass through funding from NYC Dept. Environmental Protection)

Sediment cores were obtained at six sampling stations down the length of Schoharie Reservoir to determine the spatial and temporal patterns of sediment accumulation within the reservoir. Sediments were characterized physically (bulk density, porosity, grain size), chemically (carbon content), and radiometrically (activities of $^{210}$Pb and $^{137}$Cs). Establishment of chronologies is difficult because the models typically applied to $^{210}$Pb must be modified before application to these sediments. Nevertheless, general patterns of sediment accumulation are clear. Schoharie Reservoir is experiencing high sedimentation rates that are typical of many reservoirs. Rates of sediment accumulation in this reservoir are well within the range reported for other reservoirs. Highest rates of sediment accumulation occur at the southern end of the reservoir near the entrance of Schoharie Creek. Stations at the northern end of the reservoir, however, experience higher rates of sedimentation than do stations (2.0, 2.5) in the middle of the reservoir. A significant portion (15-40%) of the total sediment accumulated at each station was deposited during storm events. Rates of sediment accumulation have changed over time; there has been an increase in the median sedimentation rate at the southern end of the reservoir in the past two decades relative to earlier years. At the northern end of the reservoir, sedimentation rates have declined in recent years.

- **ExCit: Expanding Cities - People, Water and Infrastructure**  
  PI: Alex S. Mayer  
  Sponsor: US Dept. of Education

ExCit stands for Expanding Cities: People, Water and Infrastructure. ExCit is a student exchange program consortium of six universities in Canada, Mexico, and the U.S. The focus area for the program is decision making for meeting the growing demands on urban water resources systems. Student activities will consist of three stages: intensive language training, coursework in water resources and sustainable development, and professional or research internships with local businesses, municipalities, agencies or at the host university.

- **REF: Air: A Conduit between Water, Society, and Space**  
  PI: Alex Mayer  
  Sponsor: State of Michigan – REF

This project supported the acquisition of advanced analytical instrumentation for CO$_2$ (CO$_2$ analyzer) and for mercury (mercury analyzer and mercury air sampling equipment). The equipment is suitable for study of climate-change related issues and mercury contamination, two of the more pressing water resources issues facing the world as well as the Great lakes region. The new instrumentation has been integrated with an existing package of micrometeorological equipment currently in use on MTU’s campus, and has enabled researchers to measure fluxes of CO$_2$ and mercury between the Great Lakes and the atmosphere. This enhanced system will be used extensively in other Great Lakes research projects.
• **Herring Gull BioSentinal Sampling Program Cooperative Agreement**
  PI: Judith Perlinger  
  Sponsor: Clemson Univ  
  The purpose of the overall project is to develop a contaminant monitoring protocol for Michigan using herring gull (Larus Argentatus) eggs. The herring gull is a good indicator species to monitor trends in contaminant concentrations because it is near the top of the food chain. It is also a good indicator species because the protocol for using herring gull eggs for monitoring trends in contaminant levels has already been established by the Canadian Wildlife Service (CWS).

  As part of a proposed Cooperative Agreement between Michigan Technological University, Clemson University, Michigan State University, Michigan Tech personnel collect gull eggs once annually from Gull Island in Lake Superior off W. Marquette County, Michigan, utilizing Michigan Tech’s research vessel, the R/V Agassiz, and coordinate gull egg collection from Net Island off of Isle Royale with National Park Service personnel. In May each year, Gull eggs from Gull Island will be enumerated. Gull eggs collected from Gull Island and Net Island will be shipped according to specifications to the University of Windsor for chemical analysis and publication of the results of the monitoring work.

• **Streamside Lake Sturgeon Culture for the Ontonagon River, Michigan**
  PI: Nancy Auer  
  Sponsor: MI DNR  
  Lake sturgeon were once abundant in the Ontonagon River but the Michigan DNR could not recover adults during several attempts in the 1980-1990s. In 2006 the State of Michigan agreed with other state and federal agencies to manage for lake sturgeon (Acipenser fulvescens) rehabilitation using best stocking practices. The objective of this project is to raise lake sturgeon in a streamside hatchery using ambient Ontonagon River water so that fish will imprint to the river to assure less chance of fish straying to other rivers as well as increase the greater likelihood of successful rehabilitation of the Ontonagon population. Using ambient river water enables the researchers to evaluate the effects of turbidity on lake sturgeon egg incubation and subsequent fish survival. The lake sturgeon reared in the Ontonagon streamside facility were raised from eggs taken on the Sturgeon River, Michigan, in the spring of 2007.

  The fish in the streamside rearing facility were released into the Ontonagon River at two locations, and fifteen of the largest fish were selected for telemetry work. Ten of these fish will be fitted with ATS transmitters and released into the Ontonagon River to be located daily to determine movement patterns and habitat selection in the Ontonagon River.

  Master’s student, Tim Wilson, spent the summer of 2007 monitoring operations in the streamside facility and giving tours to the public. His research involves the study of maximum raceway rearing densities and possible disruptions the exotic ruffe (Gymnocephalus cernuus) may have on sturgeon recruitment and feeding.

• **Collaborative Research: The carbon balance of Lake Superior: modeling lake processes and understanding impacts on the regional carbon budget**
  PI: Noel Urban  
  Sponsor: NSF  
  The purpose of the North American Carbon Program (NACP) is to (1) to develop quantitative scientific knowledge, robust observations, and models to determine emissions and uptake of CO2, CH4, and CO1 changes in carbon stocks, and factors regulating these processes for North America and adjacent ocean basins; and (2) to develop the scientific basis for full carbon accounting on regional and continental scales. The Laurentian Great Lakes over 25% of the land area of the 8 Great Lakes states, and CO2 emission and seasonal cycling from them may be comparable to local terrestrial ecosystems. Although their contributions to the regional carbon balance may be significant, these fluxes are currently poorly understood. CO2 fluxes from Lake Superior are of particular interest because they may directly impact observations at nearby AmeriFlux towers.

  Motivated by the need for improved knowledge of Great Lake CO2 fluxes, we will couple an exosystem-carbon module to an existing hydrodynamic model of Lake Superior to estimate these fluxes and their spatial and temporal variability. We will also obtain new wintertime observations of carbon parameters in the lake to constrain this model. Using model output, we will evaluate the impact of Lake Superior CO2 fluxes on observations at AmeriFlux towers and on the regional carbon budget.

  Sampling of water intakes has clearly shown the annual cycle in pCO2, chlorophyll, and other analytes.
Comparison of municipal water intakes with ship-based sampling has revealed that while comparable results were obtained at one intake location, a second location has yielded large differences. All biological parameters (bacterial counts, bacterial growth rates, carbon fixation rates) are markedly lower in the samples from the Ontonagon municipal water intake than in samples collected from a boat at the same location.

Measurements of CO2 concentrations in air above the lake have been collected with an open-path IRGA mounted on the ferry to Isle Royale over the 100-km route across the open lake from the Keweenaw Peninsula to Isle Royale. While concentrations above the lake are higher than above land at the corresponding time, we do not yet know if this is just the result of the time lag as an air mass is advected across the lake. We anticipate being able to make eddy covariance measurements of CO2 fluxes on at least three occasions this year.

Development of the lower-food web model is being conducted by Cory McDonald, the doctoral student on the program. Cory is using information theory to derive an optimized food web model with a minimum number of components. This modeling shows that while model fit to experimental data generally improves with increasing number of calibration or fitting parameters, the Akaike Index reaches a minimum in models with an intermediate number of fitting parameters. The ratio of number of measurements to number of fitting parameters determines the optimal complexity of the model. Results from this work have been presented at four international conferences, and the first manuscript will be submitted in August 2008 to Ecological Modeling.

- **Evaluating Riparian Timber Harvesting Guidelines: Phase 3, Result 2 Evaluate Aquatic Habitat Impacts**
  PI: Casey Huckins  
  Sponsor: USDA Forest Service, Northern Research Station

  Our primary objective is to assess long-term effects of riparian harvest techniques on stream ecosystem function at the LCMR sites and Pokegema Creek sites. The following objectives are included into the study plan:

  1. Quantify available food resources for stream food webs (periphyton and detrital standing crops), and macroinvertebrate response (biomass of functional feeding groups and diets) in stream reaches subjected to various riparian harvest treatments.
  2. Evaluate breakdown rates of leaf litter and wood in streams under the different riparian treatments.

  Results from this research will be used to validate or revise the State of Minnesota's riparian forest management guidelines and demonstrate the use of functional measures of ecological integrity for assessment of stream health.

- **Huron Creek Watershed Management Plan**
  PI: Alex Mayer  
  Sponsor: MI-EPA

  The Huron Creek Watershed is located in north-central in Houghton County in the Upper Peninsula of Michigan. The 3.4 square mile watershed includes portions the City of Houghton and Portage Township. Land use in the Huron Creek watershed is forested land (40%), commercial and residential developments (20%), and wetlands (20%). The Huron Creek watershed has been affected by human activity for decades. Historical mining activities, aging septic systems, and closed landfills constructed before modern environmental requirements have contributed to water quality concerns. Commercial development in the watershed since the mid-1970’s has resulted in significant areas of impervious surface in the watershed. The creek has been traditionally used for recreation activities and runs through a heavily used public park before emptying into the Portage Canal.

  These activities have catalyzed the development of a community-made watershed management plan formulated to address water quality issues in the Huron Creek watershed. A series of chemical, physical and biological surveys were conducted by the Michigan Tech Center for Water and Society, which indicated that the defined designated uses of the watershed were either impaired or threatened by metals, nutrients, sediment, “Flashy Flow”, invasive plant species, and bacteria. Best Management Practices (BMPs) were identified as part of, or in combination with several of the recommended actions. BMPs are structural, vegetative, or managerial practices used to treat, prevent or reduce water pollution. Suggestions for potential project partners have been identified for each recommended action, along with an estimated implementation schedule, suggested milestones, estimated costs, and possible funding sources.

- **Collaborative Research: Modeling and Analyzing the Use, Efficiency, Value and Governance of Water as a Material in the Great Lakes Region Through an Integrated Approach**
  PI: Alex Mayer
This multidisciplinary 5-year research project (funded by the National Science Foundation MUSES program) will determine, through integrated physical and economic models and under various scenarios of population growth, climate change, land use, and emissions, the impact of direct and indirect drivers on water quality, quantity, and availability in the Great Lakes region.

Though it is well known that nearly every product in global commerce is dependent on water, water has not traditionally been considered a material characterized by integrated analyses to quantify flows and stocks, opportunity costs, and full valuation (i.e., social, environmental, and service costs) through its myriad of uses. This has led to an undervaluing of water as a finite resource.

The Great Lakes region is chosen due to its large volume of available freshwater (but low rate of replacement), high economic impact, complex governance issues including an international border, and increasing competition for water allocation among industrial, agricultural, municipal, recreational, and ecosystem needs, as well as existing and future threats of water quality deterioration.

• **Characterizing Lessons Learned from Federal Biomass Removal Projects**
  PI: Kathy Halvorsen
  Sponsor: U.S. Forest Service

Since the inception of the National Fire Plan in 2001, fuels reduction treatments have increased from about 2.1 million acres to more than 3.0 million acres annually in 2006 (Healthy Forests and Rangelands 2007). Biomass utilization is seen as a growing component to treating greater numbers of acres at high risk of wildfire, particularly within an ever-expanding wildland-urban interface. There are however challenges to biomass removal that impede progress. Understanding those challenges and how land managers and community partners have worked together to overcome them is a necessary part of reducing the threat of wildfire.

We focus on understanding the challenges faced by and innovations created to overcome them that managers and communities around the U.S. have encountered as they try to reduce fire risk. To do this we have done 12 case studies of federal and tribal land management chosen based on a set of key characteristics. These case studies range from the Green Mountain National Forest in Vermont, to the South Carolina Francis Marion, to the Southwestern Four Corners area, to the Shasta-Trinity National Forest in Northern California, and to the Superior National Forest in Northern Minnesota. We have completed our case studies conducting about 150 open-ended interviews with managers, NGO staff, community members, and industry employees. Transcriptions of the interviews will be analyzed for patterns, and case studies will be prepared on our findings for distribution to the fire management community and publication in peer reviewed publications.

• **Graduate student scholarships to advance a global outlook of economic and social prosperity that protects the environment**
  PI: Judith Perlinger
  co-PIs: Veronica Griffis, James Mihelcic, Kurt Paterson, Qiong Zhang
  Sponsor: NSF

Judith Perlinger, Veronica Griffis, James Mihelcic, Kurt Paterson, Jane Zhang of the Civil and Environmental Engineering's Michigan Tech Center for Water and Society have received an award in the amount of $599,978 from the National Science Foundation for a project titled Graduate Student Scholarships to Advance a Global Outlook of Economic and Social Prosperity that Protects the Environment. The project provides up to eighteen need-based scholarships annually to an integrated community of MS and PhD graduate students who are not only educated in the economic, social, and environmental pillars of sustainability but will also transfer research techniques and knowledge from their different graduate perspectives. This program partners with the U.S. Peace Corps incorporating 2+ years of overseas engineering service.

• **Testing of Remote Sensing Methods for Delineating Fracture Systems in Volcanic Terrains to Cavity Networks in Karst**
  PI: John Gierke
  co-PI: Carla Alonso
  Sponsor: Univ of MI

Groundwater in bedrock aquifers occurs in fractures. Fracture networks are incredibly difficult to characterize because of the inadequate information available from drilling records and conventional mapping. My current
research is aimed at helping to develop methods for analyzing remote sensing data to delineate fractures in volcanic terrains, in an attempt to improve well siting strategies in Pacific Latin America. This led me to consider another type of environment that surrounds my home: karst. Geologists refer to the terrain in Puerto Rico as Northern Karst, which is a series of mogotes (hills), underlain by a network of cavities connecting sinkholes. The Northern Karst is the main supply of water for inhabitants and surface water bodies. Karst areas are more susceptible to drought, subsidence, and contamination. I am testing the methods I am helping to develop for volcanic terrain to characterize the cavity network in karst systems.

- **Intergovernmental Personnel Act Agreement with US Army Corps of Engineers**
  PI: Dave Watkins  
  CEE/CWS/SFI  
  Sponsor: US Army Corps of Engineers

  This project involved the development of a design document for the next generation of the HEC-FDA (Flood Damage Analysis) software tool. The design document incorporates suggestions and research items discussed during a two previous workshops. It also accommodates those recommendations that the Corps concurred with from the National Research Council (2000) report on the Corps implementation of risk analysis for flood damage reduction, and it will aide in implementing the Chief of Engineers' "Actions for Change." This new tool may include event sampling, the ability to do scenarios analysis, structure-by-structure analysis, cost analysis and agricultural damage analysis.

- **Erosion Reduction by Air Entrainment, Phase I**
  PI: Brian Barkdoll  
  co-PI: Mohan Rao  
  Sponsor: S. Florida Water Management District

  Excessive scour of sediment can be a problem at hydraulic structures if the scour depth is such that it undermines the structure's foundation, which can lead to sliding, tilting, and potentially to the collapse of the structure. Scour is induced by flowing water in the various modes of sediment rolling, saltation, or entrainment into the flow as suspended load. Moreover, drought conditions followed by a large storm may result in excessive scour due to the low-flow depth protecting the sediment from scour downstream of hydraulic structures. Under such conditions the flow sediment carrying capacity can be exacerbated by the type and length of the hydraulic jump at the terminal structure, which will, in turn, scour large holes in the channel bed downstream of the terminal structure.

  The SFWMD has numerous gated control structures in which there is not only flowing water but plunging water as well. The primary objective of Phase I of this project is to demonstrate that the introduction of an air-bubble curtain downstream of the terminal structure of a gated spillway may be an inexpensive way to reduce the scour depth.

- **Engaging Social Scientists in the WATERS Initiative: Special Sessions at the 2008 International Symposium on Society and Resource Management**
  PI: Alex Mayer  
  co-PI: Kathleen Halvorsen  
  Sponsor: NSF

  Two sessions were conducted at the International Symposium on Society and Resource Management (ISSRM) Conference in Burlington, Vermont, June 11, 2008. The purpose of Session One was to familiarize the audience with the WATERS program and to present initial ideas about key fundamental social science questions and approaches that could be answered through participation in the WATERS program. Session Two was a facilitated discussion of potential fundamental social science questions and approaches to answer them that could fit within the overall structure of WATERS. This included a discussion of how the infrastructure-orientation of WATERS might fit with key social science research. WATERS provides an excellent opportunity to support the intensive, panel-based (repeated surveys over time) investigation of important research questions important to theory development about human relationships to water.

- **Associations Between Groundwater-Surface Water Dynamics and Coaster Brook Trout Spawning Habitat in the Salmon Trout River, Marquette County, Michigan**
  PI: Alex Mayer  
  co-PI: Casey Huckins  
  co-PI: Matthew VanGrinsven  
  Sponsor: Huron Mountain Wildlife Foundation, Trout Unlimited, DeVlieg Foundation
The Salmon Trout River (STR) is the only river on the south shore of Lake Superior known to sustain a reproducing coaster brook trout population. Related studies demonstrate that brook trout tend to select spawning sites, based on the presence of groundwater discharge into the river. The results of these studies also suggest that groundwater presence is vital to the reproductive success of CBT. Previous studies of the STR have characterized the life history strategies and ecology of CBT, but to date no study has investigated the influence of groundwater on CBT spawning habitat in the STR. We hypothesize that spatial distributions of groundwater inflows through river-bottom sediments are a critical factor in the selection of spawning sites.

In this study, high-resolution data collection methods are implemented to quantify the interaction between the groundwater and surface water in order to verify the presence or absence of groundwater discharge into the river at sites that support a reproducing population of coaster brook trout. By independently inverting temperature and pressure measurements the exchange of water between groundwater and surface water can be simultaneously analyzed, permitting a more precise estimate of groundwater velocity.

- **Limnological Research in Lake Superior for Middle/High School Students, Teachers and Communities**
  PI: Joan Chadde (Western U.P. Center for Science, Mathematics & Environmental Education)
  Sponsor: Michigan Space Grant Consortium

  This MSGC-funded program provides scientific excursions aboard Michigan Tech’s research vessel (R/V) Agassiz on Lake Superior and connecting waters for community members and middle/high school students and teachers in the Upper Peninsula.

  These scientific excursions provide firsthand experience in how Great Lakes research is conducted, the equipment used, and what research is telling us about the health of the Great Lakes. Project goals are to: (i) increase middle/high school students’ interest in science by providing real-world science applications; (ii) enhance citizen understanding of Great Lakes science and how research is conducted; and (iii) introduce teachers and students to careers in earth science and Great Lakes research. The scientific excursions are led by MTU scientists and graduate students from the Departments of Civil & Environmental Engineering, Chemistry, and Biological Sciences.

- **Lake Superior Education Program for Teachers, Students and Communities**
  PI: Joan Chadde (Education Program Coordinator) and Shawn Oppliger (Director), Western Upper Peninsula Center for Science, Mathematics and Environmental Education
  Sponsor: Copper Country ISD (subcontract) with funding from Michigan Department of Environmental Quality Coastal Management Program;

  The project has four major components: i) K-12 and community education programs aboard MTU’s research vessel (R/V) Agassiz; ii) educational workshops for decision-makers, developers, and business owners in four shoreline communities; iii) Lake Superior Educators Instructor Manual; and iv) a five-day Great Lakes Watershed Investigations Teacher Institute in June 2008. This program is projected to reach 800-1,000 middle/high school students, teachers and community members through the teacher institute and Lake Superior education programs aboard the R/V Agassiz.

- **Lake Superior Stewardship Initiative**
  PI: Joan Chadde (Western U.P. Center for Science, Mathematics & Environmental Education)
  Funding Source: Copper Country ISD

  The Western Upper Peninsula Center for Science, Mathematics and Environmental Education received a $200,000 grant from the Great Lakes Fishery Trust to create a hub for the Great Lakes Stewardship Initiative that will partner 11 Copper Country schools with 15 community organizations in Houghton and Baraga counties. The goals are to implement place-based education, engage students in real-world learning and to serve as valued resource in their communities. The Initiative incorporates three strategies:
  (1) Implementing ‘place-based curricula’ in the classroom that engages students in learning about their community, cultural heritage, local watershed, and the Great Lakes;
  (2) Providing teacher-training and student programs that increase content knowledge about the Great Lakes and opportunities for students to visit and learn about Lake Superior, tributary streams, wetlands, forests, and other outdoor environments near their schools;
  (3) Developing school-community partnerships with local units of government and community organizations to address local needs by working together on local stewardship projects. For more information about the Lake Superior Stewardship Initiative, visit [http://www.wupcenter.mtu.edu/lssi](http://www.wupcenter.mtu.edu/lssi).
5.3. Proposals Submitted under CWS, 2007-8

- Global Watershed: Integrating Rural and Global Perspectives with Research and Technological Advances
  PI: Alex Mayer  
  co-PIs: Linda Nagel, Casey Huckins, Bradley Baltensperger  
  Sponsor: NSF- GK12  
  $2,287,782 (7/1/2008 - 6/30/2013)

- Characterizing Lessons Learned from Federal Biomass Removal Projects
  PI: Kathy Halvorsen  
  Sponsor: U.S. Forest Service  
  $35,603 (9/30/2007 - 3/31/2009)  
  Awarded

- Scholars Award Examining Society’s Changing Knowledge of and Interactions with the Nitrogen Cycle, 1880 to the Present
  PI: Hugh Gorman  
  Sponsor: NSF  
  $88,013 (5/1/2008 - 12/31/2009)

- Graduate student scholarships to advance a global outlook of economic and social prosperity that protects the environment
  PI: Judith Perlinger  
  co-PIs: Veronica Griffis, James Mihelcic, Kurt Paterson, Qiong Zhang  
  Sponsor: NSF  
  $599,978 (6/1/2008 - 8/31/2012)  
  Awarded

  PI: John Gierke  
  co-PI: Carla Alonso  
  Sponsor: Univ of MI  
  $5,000 (5/1/2008 - 4/30/2009)  
  Awarded

- Fall 2008 EPA Greater Research Opportunities (GRO) Fellowships for Undergraduate Environmental Study:
  Carla Alonso  
  PI: Alex Mayer  
  Co-PI: Carla Alonso  
  Sponsor: US EPA  
  $41,500 (9/1/2008 - 8/31/2010)

- Intergovernmental Personnel Act Agreement with US Army Corps of Engineers
  PI: Dave Watkins  
  Sponsor: US Army Corps of Engineers  
  $42,347 (1/7/2008 - 6/6/2008)  
  Awarded

- Water Quality Evaluation Initiative for Best Management Practices on Stream Restoration Projects
  PI: Casey Huckins  
  Sponsor: Conservation Resource Alliance  
  $24,000 (5/1/2008 - 4/30/2010)

- Erosion Reduction by Air Entrainment, Phase I
  PI: Brian Barkdoll  
  co-PI: Mohan Rao  
  Sponsor: S. Florida Water Management District  
  $49,916 (3/1/2008 - 9/30/2008)  
  Awarded
• Engaging Social Scientists in the WATERS Initiative: Special Sessions at the 2008 International Symposium on Society and Resource Management
  PI: Alex Mayer
  co-PI: Kathleen Halvorsen
  Sponsor: NSF
  $10,600 (5/1/2008 - 11/1/2008)
  Awarded

• SustR: Sustainable Development for Rural Communities: Social, Health, Economic, and Environmental Advances
  PI: Alex Mayer
  co-PI: Carol MacLennan
  co-PI: Blair Orr
  Sponsor: U.S. Dept. of Education Fund for the Improvement of Post-Secondary Education
  $180,000 (9/1/2008 - 8/31/2012)
  Awarded in FY2008-09

• IGERT: Multi-scale stressors and the sustainability of the Lake Superior basin
  PI: Alex Mayer
  co-PI: Noel Urban
  co-PI: Judith Perlinger
  co-PI: Kathy Halvorsen
  co-PI: Casey Huckins
  Sponsor: NSF IGERT
  $2 (Pre-proposal, 7/1/2009 - 6/30/2014)

• Coastal stream inventory in support of flow-based, aquatic community protection
  PI: Casey Huckins
  Sponsor: MI DEQ
  $38,724 (1/1/2009 - 3/31/2010)

• Herring Gull BioSentinal Sampling Program Cooperative Agreement
  Judith Perlinger
  Sponsor: Clemson Univ.

• Associations Between Groundwater-Surface Water Dynamics and Coaster Brook Trout Spawning Habitat in the Salmon Trout River, Marquette County, Michigan
  PI: Alex Mayer
  co-PI: Casey Huckins
  co-PI: Matthew VanGrinsven
  Sponsor: Huron Mountain Wildlife Foundation
  $1400 (4/15/2008 – 4/14/2009)
  Awarded

• Characterizing Human Health and Ecosystem Impacts of Increasing Sediment and Pollutant Transport in Great Lakes Watersheds Induced by Climate Change
  PI: Dave Watkins
  co-PI: Veronica Griffis
  co-PI: Alex Mayer
  co-PI: Colin Brooks
  co-PI: Robert Shuchman
  Sponsor: EPA
  $799,998 (1/1/2009 - 12/31/2012)

• Enhancing the Capacity for Sustainable Forest Management in Chiapas and Oaxaca
  PI: Alex Mayer
  Co-PI: Kathleen Halvorsen
  Sponsor: Higher Education In Development/USAID
  $250,000 (1/1/2009 - 12/31/2011)
6. Publications by CWS Participants, 2007-8

Publications are ordered by first CWS author or co-author and include journal articles, books, and chapters in books that are published, in press, forthcoming, or accepted. Items which are in press, forthcoming, or accepted will be counted as published with complete references in the next CWS Annual Report.

Published journal articles, books, and book chapters ..............................................................38
Proceedings ......................................................................................................................................24
Journal articles, books, chapters, and proceedings in press, forthcoming, or accepted...........27
Presentations ....................................................................................................................................81
Patents ............................................................................................................................................1
FY 2006-7 references which completed publication in 2007-8...............................................16
FY 2006-7 references in press in 2007-8......................................................................................3

6.1. Journal articles, books, and book chapters


10. Melville, B. W.; van Ballegooy, S.; Coleman, S. E.; Barkdoll, B. “Riprap size selection at wing-wall abutments


18. Flaspohler, D.J., C. Webster, and R. Froese. (In press) Bioenergy, Biomass, and Biodiversity: A review of key issues for terrestrial and aquatic ecosystems. Chapter 7 in Renewable energy from forest resources in the United States, B. Solomon and V. Luzadis, eds. Publisher


6.2. Proceedings


### 6.3. Presentations


17. **Chadde, J.** Michigan Science Teachers Association, March 6-8, 2008, Lansing, MI.
    MEECS Water Quality Workshop (w/ Jessica Wagenmaker)
    Summer Teacher Institutes at MTU are Fun!
    Changing Land Uses: Engaging Students in Assessing Environmental Impacts! (w/ Gary Cousino, teacher, Hart Middle School, Rochester, MI)
    Great Lakes Maritime Transportation Why Don’t Those 1000’ Freighters Sink?

18. **Chadde, J.** Making A Great Lake Superior, October 29-31, 2007, Duluth, MN

19. **Chadde, J.** Ship Operations Cooperative Program, April 2-4, 2008, Baltimore, MD Great Lakes Maritime Transportation Teacher Education & Outreach Programs.

    Family Engineering Programs Prepare Students & Parents for the Future
    Measure Environmental Impacts of Changing Land Use
    Family Engineering Programs Prepare Students & Parents for the Future


27. **Gorman, H.**, Managing Resources versus Managing a Commons: Sustainability and Societal Interactions with the Nitrogen Cycle," presented at the conference “Managing the Unknown” sponsored by the German Historical Institute, Feb. 21-23, 2008, Washington, D.C.


53. **McDonald, C. P., Urban, N. R.** Reinventing "REINVENTING THE WHEEL" in aquatic biogeochemical modeling, 30th Congress of the Internat. Assoc. of Theoretical and Applied Limnology (SIL), Montreal, 8/06

54. **McDonald, C. P., Urban, N. R.** Using Information Theory To Determine Optimal Model Complexity In Aquatic Biogeochemical Modeling, AGU Ocean Sciences meeting, Orlando, FL 3/08


56. **Pypker T. G.,** Climate Change and Hydrology, Ecosystems and Climate change seminar series, Xi Sigma Pi National Forestry Honor Society, Michigan Technological University, April 4, 2008.


61. **Pypker, T. G.,** Forest hydrology and micrometeorology, In House Seminar Series, School of Forest Resources and Environmental Science, Michigan Technological University, Sept. 27, 2007.


64. **Pypker, T. G.,** Toward using carbon isotopes to monitor ecosystem physiology of forests in mountainous terrain. USDA Forest Service, North Central Research Station, Grand Rapids, MN, Sept 6, 2007.


70. Urban, N. R., Auer, M. T., Green, S. A., McDonald, C. P., Lu, X., and Apul, D., Are the Laurentian Great Lakes a source or sink of CO2 to the atmosphere?, 30th Congress of the Internat. Assoc. of Theoretical and Applied Limnology (SIL), Montreal, 8/06


6.4. **Patents**

8. Appendix 1: CWS Faculty/Staff Participants

**Biological Sciences**
Nancy A. Auer  
Susan T. Bagley  
Casey J. Huckins  
Charles W. Kerfoot

**Chemistry**
Sarah A. Green

**Civil & Environmental Engineering**
Martin T. Auer  
C. Robert Baillod  
Brian D. Barkdoll  
Kristine L. Bradof  
Veronica Griffis  
David W. Hand  
Neil J. Hutzler  
Alex S. Mayer  
James R. Mihelcic  
Kurtis G. Paterson  
Judith A. Perlinger  
Noel R. Urban  
David W. Watkins  
Qiong Zhang

**Educational Opportunity**
Christine S. Anderson

**Geological & Mining Eng. & Science**
Judith R. Budd  
Suzanne J. Beske-Diehl  
John S. Gierke  
Alex S. Mayer  
Wayne D. Pennington

**Humanities**
R. Craig Waddell

**Mechanical Engineering**
John W. Sutherland

**Michigan Tech Research Institute (MTRI)**
Colin Brooks  
Liza Liversedge

**School of Business & Economics**
William S. Breffle  
Gary Campbell  
Thomas E. Merz  
Christa L. Walck

**School of Forest Resources & Environmental Science**
David J. Flaspohler  
Margaret R. Gale  
Kathleen E. Halvorsen  
Martin F. Jurgensen  
Linda M. Nagel  
Blair D. Orr  
Tom G. Pypker  
James M. Schmierer

**Social Sciences**
Hugh Gorman  
Kathleen E. Halvorsen  
Carol A. MacLennan  
Patrick E. Martin  
Susan R. Martin  
Timothy Scarlett  
Bruce E. Seely  
Barry D. Solomon

**Visual & Performing Arts**
Mary Ann Beckwith

**Western UP Center for Science, Mathematics & Environmental Education**
Joan F. Schumaker Chadde
9. Appendix 2: CWS Student Participants

**Biological Sciences**
Kevin Mann
Emily Ninmann
Tim Wilson
Foad Yousef

**Chemistry**
Qili Hu

**Civil & Environmental Engineering**
Mark Anderson
Meredith Ballard
Josh Cowden
Joe Dammel, undergrad
Phillip DePetro
Carly Dusseau
Lauren Fry
Valerie J Fuchs
Albert Galiciniao
Santosh Ghimire
Rabi Gywali
Maureen Habarth
Jennifer Heglund
Fredline Ilorme
Ashwini Kashelikar
Linda Kersten
Matthew J. Kucharski
Cory McDonald
Andrea Munoz
Jennifer Mwangi

**School of Forest Resources & Environmental Science (SFRES)**
Elizabeth Boisvert
Kassidy Yatso, undergrad

**Social Sciences**
Genevieve Borg
Khila Dahal
Jessica Koski, undergrad
Andrew Kozich
Stacey Pilling

**Geological & Mining Engineering & Sciences**
Jill N Bruning
Miriam Rios-Sanchez
Matt Van Grinsven
Randall E Fish
Essa L Gross
Robert F. Hegemann
Jeremy M. Jenson
Cara W. Shonsey
10. Appendix 3: CWS Advisory Committee

**Director**
Alex S. Mayer
asmayer@mtu.edu
Geological & Mining Engineering & Science

**Administrative Assistant**
Carol J. Asiala
cjasiala@mtu.edu
Geological & Mining Engineering & Science

**Advisory Committee**

Nancy A. Auer
naauer@mtu.edu
Biological Sciences

Sarah A. Green
sgreen@mtu.edu
Chemistry

Noel R. Urban
nurban@mtu.edu
Civil & Environmental Engineering

Christine S. Anderson
csanders@mtu.edu
Educational Opportunity

John S. Gierke
jsgierke@mtu.edu
Geological & Mining Engineering & Science

R. Craig Waddell
cwaddell@mtu.edu
Humanities

John W. Sutherland
jwsuther@mtu.edu
Mechanical Engineering-Engineering Mechanics
Sustainable Futures Institute

Colin Brooks
colin.brooks@mtu.edu
Michigan Tech Research Institute

William S. Breffle
wbsreffl@mtu.edu
School of Business & Economics

Thomas G. Pypker
tgpykker@mtu.edu
School of Forest Resources & Environmental Science (SFRES)

Kathleen E. Halvorsen
kehalyor@mtu.edu
Social Sciences

Mary Ann Beckwith
mabeckwi@mtu.edu
Visual & Performing Arts

Joan F. Schumaker-Chadde
jchadde@mtu.edu
Western Upper Peninsula Center for Science, Mathematics & Environmental Education