

Thirteenth Annual Maine Water Conference 2007

March 21, 2007
Augusta Civic Center North Wing
Augusta, Maine

NEW AGENDA
Details inside



Senator George J. Mitchell Center for Environmental and Watershed Research
University of Maine, Orono, Maine

United States Geological Survey
Maine Water Science Center, Augusta, Maine

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MAINE WATER CONFERENCE

The Maine Water Conference was founded in 1994 by the Senator George J. Mitchell Center for Environmental and Watershed Research at the University of Maine as an annual forum for water resource professionals, researchers, consultants, citizens, students, regulators, and planners to exchange information and present new findings on water resource issues in Maine.

The conference format includes two concurrent sessions and a morning plenary session. During breaks and lunch, posters and displays by students, organizations, agencies, departments, consultants and businesses are available for viewing and discussion. Because the Maine Water Conference is the main meeting for many Maine water resource professionals, adequate breaks are intended to allow for one-on-one networking and discussion.

Program At-A-Glance

CONFERENCE AGENDA

7:30am Registration, Continental Breakfast, Poster & Exhibit Viewing

8:30am Morning Concurrent Sessions

Session i: Legislative Issues

Session ii: Volunteer Monitoring – Developing a VRMP

Session iii: Water Resources & Climate Change

Session iv: Landscape Change: Changes in fish assemblages

Session v: Contaminants and Toxic Metals

10:00am Morning Break — Poster & Exhibit Room

11:00am Plenary Session — Welcome & Introduction

David Hart, Conference Co-Chair

11:05am M. Gordon “Reds” Wolman, Johns Hopkins University

Water: Myths and Realities

11:40am Introduction

Glenn Hodgkins, Conference Co-Chair

11:45am Cameron Wake, Climate Change Research Center, University of New Hampshire

Climate Change in the Northeast: Past, Present, and Future

12:20pm Poster award presentations

Robert Lent, Director, USGS Maine Water Science Center

Whitney King, Conference Poster Chair

Scholarship award presentations

David Hart and Glenn Hodgkins

Conference Co-Chairs

12:30pm Lunch

1:30pm Afternoon Concurrent Sessions

Session iv: Landscape Change: Watershed management tools and assessment

Session v: Contaminants and Toxic Metals

Session vi: Sustainable Water Use

Session vii: Models for Municipal Planning

Session viii: Water Science Education

2:30pm Afternoon Break – Poster & Exhibit Room

3:00pm Afternoon Concurrent Sessions (continued)

4:00pm Conference close

Program At-A-Glance

MORNING CONCURRENT SESSIONS

	8:30am - 8:55am	9:00am - 9:25am	9:30am - 9:55am
Session i: Legislative Issues Facilitator: Rob Sanford	Session includes short presentations of each topic followed by panel discussions. Topics: public water supply protection, state water use planning, lake water quality, laws governing setbacks. Presenters: <i>Andy Tolman, Jeff McNelly, Maggie Shannon, Jennifer Burns.</i> Panelists: <i>Rep. Ted Koffman, Rep. Robert S. Duchesne, Andy Fisk, additional panelists to be announced.</i>		
Session ii: Volunteer Monitoring - Developing a VRMP Facilitator: Barbara Arter	Session includes short overview presentations followed by a focused panel discussion*. Presenters/Panelists: <i>Ted Walsh, Jeff Varricchione, Lili Pugh, Scott Williams.</i> Additional Panelists: <i>Forrest Bell, Tracey Gamache, Nonny Ferriday, Bill MacDonald.</i> *Please note that this discussion will continue during the lunch break (12:30pm-1:15pm).		
Session iii: Water Resources & Climate Change Chair: Glenn Hodgkins	Climate-related changes on northern New England rivers and lakes during the last century Glenn A. Hodgkins	Preparing for climate change: A small city's mid-century culvert drainage needs Michael H. Simpson	Susceptibility of wetlands to changes in water availability resulting from climate change Martha G. Nielsen
Session iv: Landscape Change - Changes in Fish Assemblages Co-Chairs: Sarah Nelson & Kathleen Bell	Fisheries then and now: A 60-year comparison of lake fish assemblages in Maine Peter Vaux	A habitat on the brink? An assessment of the status of fishless lakes in Maine Cynthia S. Loftin	Invasive crayfish in Maine: Potential impacts on fish, plants and benthic invertebrates Karen A. Wilson
Session v: Contaminants and Toxic Metals - Part I Co-Chairs: John Peckenham & Bob Lent	An overview of arsenic in Maine groundwater Robert G. Marvinney	An update on a public health research program regarding Arsenic in Maine well water Andy Smith	The natural end of landfill leachate: Examples from Maine Peter Garrett

AFTERNOON CONCURRENT SESSIONS

	1:30pm - 1:55pm	2:00pm - 2:25pm	3:00pm - 3:25pm	3:30pm-3:55pm
Session iv: Landscape Change - Watershed management tools/assessment Co-Chairs: Sarah Nelson & Kathleen Bell	Large recent increases in Cl in northeastern lakes as an indicator of regional development pressure Steve Kahl	A hydrogeomorphic lake classification system for lake assessment and management Katherine Webster	Monitoring rates of change in Maine rivers Aaron Corr	Developing a watershed planning tool to prioritize riparian restoration activities David D. Hart
Session v: Contaminants and Toxic Metals - Part II Co-Chairs: John Peckenham & Bob Lent	Arsenic and geochemical characteristics of groundwater from domestic wells in greater Augusta, ME Yan Zheng	Approximating the fate of Arsenic from drinking water supplies in Maine John Peckenham	Effects of Arsenic valence and well-water chemistry on Arsenic removal efficiencies Charlie Culbertson	Panel Discussion: Arsenic research: Gaps and needs
Session vi: Sustainable Water Use Chair: Robert Marvinney	Watershed-at-risk analysis as a guide for ground water management Robert Marvinney	Analyzing the sustainability of groundwater pumping in the Fryeburg sand and gravel aquifer Charlie Fitts	Sustainable water resources management in a changing climate Shaleen Jain	Managing for water supply and ecological flows Brian Joyce
Session vii: Models for Municipal Planning Facilitator: Brenda Zollitsch	<i>The first half of this session introduces three technical models. Short presentations of the models will be followed by a panel discussion.</i> Presenters/Panelists: <i>Fred Dillon, John Lough, Ethel Wilkerson.</i>			
Session viii: Water Science Education Co-Facilitators: Beth Owen & Laura Wilson	This session will include short presentations followed by a panel discussion. Presenters/Panelists: <ul style="list-style-type: none"> • Molly Schaffler, Steve Norton, and Medea Steinman UMaine Ctr. for Science & Maths. Edu. Research 			
2:30pm - 3:00pm: Afternoon break		Poster & Exhibit Room		
		<i>The 2nd half of this session showcases two successful models for collaborative action. Short presentations of the models will be followed by a panel discussion.</i> Presenters/Panelists: <i>Brenda Zollitsch, Ken Locke, Zach Steele, Jane Disney.</i>		
		<ul style="list-style-type: none"> • Sarah Kim & Sarah Morriseau, Vital Signs Program, Gulf of Maine Research Institute • Rex Turner, Maine Lakes Conservancy Institute • Jurij Homziak, Lake Champlain Sea Grant Program 		

Plenary Session

11:00AM WELCOME & INTRODUCTION

David Hart

Co-Chair, Maine Water Conference

David Hart joined the Senator George J. Mitchell Center for Environmental and Watershed Research as Director in June 2006. He serves on the Penobscot River Science Steering Committee and leads the Environmental Solutions Initiative, a new effort to more closely integrate environmental expertise at the University of Maine with the needs of the state. Also a professor in the Department of Biological Sciences at the University of Maine, Hart has several research interests including the role played by flowing water as a "master variable" governing river ecosystems and the effectiveness of river restoration and watershed management practices. A 2005 fellow of the Aldo Leopold Leadership Program, Hart is a member of scientific advisory committees to the Heinz Center for Science, Economics, and the Environment, the Ecological Society of America, and American Rivers. David Hart is the former director and current vice president of the Patrick Center for Environmental Research at the Academy of Natural Sciences in Philadelphia, PA.

11:05AM M. GORDON "REDS" WOLMAN

B. Howard Griswold Professor of Geography and International Affairs, Johns Hopkins University

Water: Myths and Realities

M. Gordon "Reds" Wolman, a National Academy of Sciences member, pioneered the study of how rivers influence the shape of the earth's landforms. Many of his professional and policy interests have been fostered by field work and exposure to resource issues in the American West. A central theme of Wolman's research is the relative roles of human and natural forces in shaping the land and waters of the earth.

Wolman is the recipient of numerous awards and accolades for his contributions to modern water resource management, most recently the Benjamin Franklin Medal from the Franklin Institute in Philadelphia in 2006, and a Lifetime Achievement Award from the National Council for Science and the Environment in 2004. Wolman has served on numerous national, international, and regional committees and panels concerning water policy, water quality, and the management of surface water processes.

11:40AM INTRODUCTION

Glenn Hodgkins

Co-Chair, Maine Water Conference

Glenn Hodgkins, a hydrologist with the U.S. Geological Survey (USGS) in Maine and Indiana since 1990, focuses his current research on historical trends in water-related variables in eastern North America such as river flows, river ice, lake ice, and snowpack, and on their relation with meteorological variables. He is lead or second author on eight journal articles and four USGS reports on this topic since 2002. Other areas of research include river flooding and bridge scour. Hodgkins received his Bachelor's degree in civil engineering from the University of Maine and Master's degree in engineering from Purdue University.

Plenary Session

11:45AM

CAMERON WAKE

Climate Change Research Center, University of New Hampshire

Climate Change in the Northeast: Past, Present, and Future

Climate changes. It always has and always will. What is unique today is that human activities are also causing our climate to change. Cameron Wake, research associate professor at the Climate Change Research Center at UNH, will present evidence of increasing warming trends across the northeast United States over the past three decades from a variety of indicators of climate change. He will also discuss how our climate may change over the next 100 years based on analysis of output from a series of global climate model simulations developed for the IPCC Fourth Assessment Report and based on a variety of greenhouse gas emission scenarios. The results clearly indicate that the decisions we make over the next few years regarding how we produce our energy will determine the climate future generations experience across the Northeast.

Cameron Wake studies regional climate and environmental change through the analysis of ice cores and instrumental records. Currently he is leading research programs to reconstruct climate change from ice cores recovered from glaciers on the Tibetan Plateau and in the Canadian Arctic. Wake is also involved in the AIRMAP project (<http://airmap.unh.edu>), which seeks to improve understanding of New England's changing climate and air quality. He leads the related INHALE project (<http://inhale.unh.edu>) that is investigating the links between air quality and human health in New England. As part of the Northeast Climate Impact Assessment (<http://www.northeastclimateimpacts.org>), he was co-lead on two research papers and a series of reports detailing past and future climate change in the US Northeast.

Wake received a B.Sc. in geology (1984) from the University of Ottawa, an M.A. in geography (1987) from Wilfrid Laurier University, and a Ph.D. in geochemical systems (1993) from the University of New Hampshire.

12:20PM

POSTER & SCHOLARSHIP AWARD PRESENTATIONS

Presentation of poster awards by Robert Lent, Director, USGS Maine Water Science Center, Whitney King, MWC 2007 Poster Chair, and a representative from the Maine Wastewater Control Association.

Presentation of scholarship awards by conference co-chairs David Hart and Glenn Hodgkins.

12:30PM

LUNCH

Session i

Legislative Issues

This session will discuss water-related issues that are currently or may potentially be before the state legislature in 2007. Discussions will focus on the following topics: public water supply protection, state water use planning, improving lake water quality, amending setback laws. Additional panelists will be added as session plans are finalized.



SESSION FACILITATOR:

Rob Sanford, University of Southern Maine

A resident of Gorham, Maine, and a former land-use hearing officer for the state of Vermont, Rob Sanford teaches in the Department of Environmental Science at the University of Southern Maine. His research interests include stream buffer protection in land use planning. He received his M.S. and Ph.D. in environmental science from the State University of New York College of Environmental Science and Forestry at Syracuse.

PRESENTERS/PANELISTS

Andrews L. Tolman, Maine DHHS Drinking Water Program

Jeff McNelly, Maine Water Utilities Association

Maggie Shannon, Maine Congress of Lake Associations

Jennifer Burns, Maine Audubon

Session i: Legislative issues

PANELISTS

Representative Ted Koffman (D-Bar Harbor), Chair, Committee on Natural Resources
Representative Robert S. Duchesne (D-Hudson), Committee on Natural Resources
Andy Fisk, Director, Bureau of Land and Water Quality, Maine Dept. of Environmental Protection
Additional panelists to be announced.

This session will follow a panel-based discussion format. Presenters will provide a five minute overview of each topic which may include history, relevant past legislation, a summary of current legislation, and other potential implications including future policy applications, enforcement issues, environmental impacts, etc. The facilitator will then ask the panel to respond to key questions on each topic. This will be followed by general discussion and questions from the floor.

TOPIC 1: PUBLIC WATER SUPPLY PROTECTION

Presenter: Andy Tolman, Water Resources Team Leader, Maine Drinking Water Program, Department of Health and Human Services

In 2005, the first session of the 122nd Legislature adopted Resolve 029 (LD 1265, as amended).

Summary

The amendment requires the Drinking Water Program within the Department of Health and Human Services, in consultation with the Department of Environmental Protection, the Department of Conservation, Maine Geological Survey and the Department of Agriculture, Food and Rural Resources to submit a report to the Joint Standing Committee on Natural Resources by February 1, 2006. The report must address whether additional requirements are needed for source water protection in Maine and describe recommended options to address those needs. The amendment also authorizes the Joint Standing Committee on Natural Resources to report out legislation to the Second Regular Session of the 122nd Legislature requiring the Drinking Water Program to establish a process to allow public comment and to report to the Joint Standing Committee of the Legislature having jurisdiction over natural resources matters with any subsequent recommendations after consideration of the comments.

THE REPORT OF THE RESOLVE 029 TASK FORCE

Submitted to the Joint Standing Committee on Natural Resources

Prepared by: Maine Department of Health and Human Services, Center for Disease Control, Division of Environmental Health, Drinking Water Program

February, 2006

Executive Summary

Water supply protection is the first line of defense in protecting public health. Protecting a water supply source has long been recognized as the cornerstone of providing safe drinking water. The most effective source protection method is to keep the area contributing water to the supply open and undeveloped. The Maine Drinking Water Program's (DWP) recently completed five-year assessment of source protection for public water supplies identified rapid residential and commercial development in source protection areas as the most significant threat to water quality and quantity, and few water suppliers are prepared to deal with these risks. Public Water Systems (PWS) have a very limited suite of

Session i: Legislative issues

tools for source protection: they can purchase land, inspect existing activities, and ask local government to enact (and enforce) protective ordinances. Only one in five of Maine's community water systems have effective source protection plans in place after more than fifteen years of encouragement and incentives.

The effectiveness of water supply protection depends on numerous state and local government decisions and activities. Most of the programs that influence source protection exist for another purpose, and usually do not consider water supply protection in their decision making. PWS operators have few resources to intervene in local and state decision making, so their concerns are often not heard. To protect public health, state and local authorities should include water supply protection as a required part of their decision making criteria, and state agencies should adopt a consistent policy favoring source protection. Based on our review of existing statutes and practices, and in light of the current threat of development in source protection areas, we offer the following recommendations:

Recommendation 1: Establish consistent policies among all state agencies to enhance source protection in all state decision making, development, and practices.

Recommendation 2: Create an effective program to maintain agricultural and forestry land uses in source protection areas.

2.1 Existing programs to maintain environmentally responsible agricultural and forestry uses should be provided with resources and given a focus to work in source protection areas to encourage land conservation.

2.2 Provide resources and direction to agricultural and forestry programs including nutrient management, sustainable forestry, and right to farm to work with landowners in source protection areas to minimize the impact of their activities.

Recommendation 3: Mitigate the effects of existing and new development on drinking water quality through the use of education, incentives and enforcement.

3.1: Encourage active management (BMP's) of existing potentially threatening uses in source protection areas through municipal, PWS and state inspection of activities.

3.2 Develop a plan to target enforcement of existing environmental laws in source protection areas.

3.3 Add proximity to public water supplies as a review criterion for environmental review programs, particularly NRPA and Site Location.

3.4 Set minimum standards for local source protection ordinances.

3.5 Amend PL 761 to require that a PWS's written response to notification of proposed changes in land use activities in source protection areas be required prior to approval of a local permit.

Our review shows that the second phase of Resolve 029, a public discussion of source protection options, refinement of these recommendations, and a report to the 123rd Legislature, is appropriate and necessary. The protection of water supply sources is a crucial part of Maine's economy, public health, and environment. We have the opportunity to build this understanding into existing state and local programs and make them more effective. As more land is developed in source protection areas, it becomes increasingly difficult and expensive to provide safe and adequate supplies of drinking water. Maine has been blessed with abundant, clean water. Unless we consider our actions carefully, we will lose that advantage.

Session i: Legislative issues

TOPIC 2: A COMPREHENSIVE WATER USE PLAN FOR MAINE

Presenter: Jeff McNelly, Maine Water Utilities Association

RESOLVE TO DEVELOP A COMPREHENSIVE WATER USE PLAN FOR THE STATE OF MAINE

Maine Farm Bureau, Maine Water Utilities Association, Maine Potato Board, Wild Blueberry Commission

March 13, 2007

Why Do We Need a Comprehensive Water Use Plan?

- Water is a vital resource necessary for fish and wildlife as well as human activities including residential, agricultural, commercial, and industrial uses.
- Inadequate water resources can have negative impacts on fish and wildlife, communities and the economy.
- Maine's water resources may be significantly impacted by climate change over the next several decades and these impacts need to be studied and planned for.
- A comprehensive water use plan should form the basis of state policies and regulations concerning water use.
- Without a comprehensive water use plan, Maine will be unable to manage its water resources in a sustainable fashion.

What Will the Comprehensive Water Use Plan Tell Us?

- The comprehensive water use plan will:
- evaluate the state's water resources by watershed;
- determine water flows necessary for fish and wildlife;
- assess the current and projected human needs for water within each watershed; and
- where supply is projected to be inadequate, identify additional sources of water supply and the estimated costs to develop those sources.

How Will the Plan be Developed?

- The Plan will be developed through a professional planning process conducted by a private technical consulting firm selected by a steering committee made of up agency staff, legislators and public and private organizations.
- The Land and Water Resources Council will enter into a contract with the consultant. The Maine Geological Survey will provide staff support to the steering committee and serve as the lead agency on the committee.

When Will the Comprehensive Water Use Plan Be Completed?

- The Plan will be completed by September 30, 2008 and the final report and recommendations will be submitted to the Joint Standing Committee of the Legislature having jurisdiction over natural resource matters by January 15, 2009.

Bottom Line:

Good policy only comes from good planning.

Our water resources are too important to try to manage without a comprehensive plan.

Session i: Legislative issues

TOPIC 3: LAKE WATER QUALITY

Presenter: Maggie Shannon, Maine Congress of Lake Associations

LD 587 — AN ACT TO PROTECT AND IMPROVE LAKE WATER QUALITY

Summary

This bill amends the Maine Revised Statutes, Title 38, section 419, which bans cleaning agents containing phosphates, to add a prohibition against the sale or use of fertilizer containing phosphorus for nonagricultural lawn or turf unless a soil test indicates that additional phosphate is needed or the fertilizer will be used in the establishment of a new lawn. When establishing new grass on bare soil, the fertilizer must be tilled into the soil. The seller of fertilizer containing phosphorus for use on lawn or turf shall identify such fertilizer by a sign approved by the Department of Environmental Protection indicating that the product may not be used except as indicated. The sign must be positioned between 4 and 7 feet above the floor and prominently posted where fertilizers containing phosphorus for use on lawn or turf are displayed.

TOPIC 4: LAWS GOVERNING SETBACKS

Presenter: Jennifer Burns, Maine Audubon

LD 258 — AN ACT TO AMEND THE LAWS GOVERNING SETBACKS UNDER THE NATURAL RESOURCE PROTECTION LAWS

Summary

This bill addresses criteria adopted by the Department of Environmental Protection to regulate significant vernal pools, waterfowl and wading bird habitat and shorebird nesting, feeding and staging areas may not regulate an area exceeding 100 feet from the edge of the protected feature. The intent of the bill is to reduce the area regulated from 250 feet to 100 feet.

Session ii

Volunteer Monitoring: Developing a Volunteer River Monitoring Program

This session will focus on volunteer monitoring in Maine and the next steps for development of a Volunteer River Monitoring Program (VRMP).

The need for a Volunteer River Monitoring Program in Maine has been under discussion for several years. Several well-established monitoring groups are already in existence, as are many smaller, less-coordinated groups. This session will provide attendees with an opportunity to discuss the goals and objectives for a centralized VRMP. Documentation of this session will provide an initial assessment tool to be used to seek funding for further development and planning.



SESSION FACILITATOR:

Barbara Arter, BSA Consulting

Barbara S. Arter has been working for over 10 years as a consultant and project manager specializing in ecosystem management, land use and watershed planning, water quality interpretation, and Atlantic salmon habitat restoration. She holds degrees in forest management and riparian forest ecology. After 20 years of college teaching, research management, and administration, Ms. Arter has focused her attention on strengthening multi-stakeholder watershed research, planning, and management throughout the state of Maine.

PRESENTERS/PANELISTS

Ted Walsh, NH DES Volunteer River Assessment Program

Jeff Varricchio, Maine Dept. of Environmental Protection

Lili Pugh, Sheepscot Valley Conservation Association

Scott Williams, Maine Volunteer Lake Monitoring Program

Session ii: Volunteer Monitoring – Developing a VRMP

ADDITIONAL PANELISTS

Forrest Bell, Presumpscot River Watch, Great Works River Watershed Coalition

Tracey Gamache, Narraguagus/Pleasant River Watershed Coalitions

Nonny Ferriday, Bagaduce Watershed Association

Bill MacDonald, Maine Rivers

This session will follow a panel-based discussion format. The session will begin with presenters providing short overviews of their involvement with volunteer monitoring. The panel will then be asked to respond to key questions. This will be followed by general discussion and questions from the floor.

Please note that for those interested, this discussion will continue during the lunch break from 12:30pm - 1:15pm. Additional information will be provided during the session.

PRESENTATIONS:

Ted Walsh, NH DES Volunteer River Assessment Program

Ted Walsh will provide an overview on the volunteer river monitoring program in New Hampshire. Tom will cover how the NH program works, and his experience with what hasn't worked. He will also discuss how the program started, where funding for the program comes from, the future of monitoring in New Hampshire, and his recommendations for a Maine VRMP.

Jeff Varricchione, Maine Dept. of Environmental Protection

Jeff Varricchione has been working with volunteer river monitoring groups for a number of years. Jeff will provide historical and background perspectives for Maine VRMP. He will also discuss the development of the Mitchell Center/DEP partnership, and potential next steps including legislative initiatives, funding objectives, and leadership.

Lili Pugh, Sheepscot Valley Conservation Association

The Sheepscot Valley Conservation Association (SVCA) started its Water Quality Monitoring Program in 1994. As one of the longest running river water quality monitoring programs in the state, Lili will discuss the successes and challenges that the program has faced over the years.

Scott Williams, Maine Volunteer Lake Monitoring Program

Scott will provide insight into the Maine Volunteer Lake Monitoring Program, one of the largest and oldest citizen-based lake monitoring programs in the country. He will discuss the history of VLMP, funding for the program, its organizational structure, along with challenges the program have faced.

TOPICS FOR PANEL DISCUSSION

Discussions will focus on some of the following topics: the current state of volunteer monitoring in Maine, how other states are working with volunteer monitors, what state needs are/are not currently being met, future state needs, the need for a centralized, coordinated, standardized VRMP program, improvement of coordination between volunteer monitoring groups, the needs of existing organizations, and support and development of existing monitoring efforts.

Session iii

Water Resources & Climate Change

You may have heard anecdotal stories of changing climate in Maine from friends and relatives, or noticed changes yourself. What do historical water-resources data tell us? What has changed — or not changed? This session will summarize some of the known changes to Maine's lakes and rivers in the last 50 to 150 years. What do climate changes mean to water-resources managers? Two possible impacts will be discussed in this session: impacts on wetlands in Acadia National Park and on culverts in a New Hampshire city.



SESSION CHAIR:

Glenn Hodgkins, U.S. Geological Survey (USGS)

Glenn Hodgkins, a hydrologist with the USGS in Maine and Indiana since 1990, focuses his current research on historical trends in water-related variables in eastern North America such as river flows, river ice, lake ice, and snowpack, and on their relation with meteorological variables. He is lead or second author on eight journal articles and four USGS reports on this topic since 2002. Other areas of research include river flooding and bridge scour. Hodgkins received his Bachelor's degree in civil engineering from the University of Maine and Master's degree in engineering from Purdue University.

8:30AM - 8:55AM

Glenn A. Hodgkins, Robert W. Dudley, Thomas G. Huntington

U.S. Geological Survey, Augusta, ME, 207/622-8201, gahodgki@usgs.gov, rwdudley@usgs.gov, thuntington@usgs.gov.

CLIMATE-RELATED CHANGES ON NORTHERN NEW ENGLAND RIVERS AND LAKES DURING THE LAST CENTURY

Researchers from the U.S. Geological Survey and other organizations have analyzed trends over time in many hydrologic variables in New England that are sensitive to climatic variability. Spring has

Session iii: Water Resources & Climate Change

arrived earlier in northern New England in the last 30-40 years, based on several lake and river data sets. Lake ice-out dates at many lakes have become significantly earlier in northern New England since the 1800s. The overall change in dates at Moosehead Lake between 1850 and 2000 was nine days and for Damariscotta Lake was 16 days; much of the change toward earlier ice-out dates occurred from about 1968 to 2000. River ice-out dates at 12 out of 16 rural, unregulated rivers in northern New England became significantly earlier during the 20th century. Most of the 11-day average change for nine rivers, from 1936 to 2000, occurred from the 1960s to 2000. Winter/spring high river flows became significantly earlier during the last century at all 11 rivers in areas of northern New England where snowmelt runoff has the most effect on river flows. Most of the one to two week change (depending on the site) occurred in the last 30 years. Lake and river ice-out dates and river high-flow dates were highly correlated with March through April air temperatures ($r = -0.7$). There have been few changes over the last century in summer low flows or in fall river ice-in dates.

9:00AM - 9:25AM

Michael H. Simpson¹, Latham Stack², Thomas Crosslin³, Sigurd Spearing⁴, Emily Hague⁵

¹ Resource Management and Conservation Program, Environmental Studies Department, Antioch/New England Graduate School, Keene, NH, 603/283-2331, msimpson@antiochne.edu.

² Syntectic International, Portland, Oregon, 503/901-1939, lstack@syntectic.com.

³ Integral Consulting, Portland, Oregon, 503/284-5545, thomas.crosslin@mac.com.

⁴ ECS, Brattleboro, VT 05301, 802/257-1195, sspearing@ecsconsult.com.

⁵ Monadnock Conservancy, Keene, NH, 603/357-0600, emily@monadnockconservancy.org.

PREPARING FOR CLIMATE CHANGE: A SMALL CITY'S MID-CENTURY CULVERT DRAINAGE NEEDS

Numerous studies report that climate change induced precipitation intensification will stress civil infrastructures. Climate change preparation, generally called adaptation in the literature, has become a focus of many recent studies, accompanied by recognition of the need for specific projections at the local level.

Our study focused on the White Brook watershed in Keene, NH. Using the current Global Climate Change models (GCM), we projected the percentage of culverts to be undersized due to an increased frequency of more intense precipitation amounts, which can be expected to manifest itself for this part of the Northeast. We then combined our statistical analysis of the GCM with a watershed build-out projection based on current city zoning. The study also estimated the associated cost to upgrade the projected failed culvert infrastructure. Finally, we sought to clarify the impact of advancements in statistical methods on future design storm estimates.

Results projected 48% of culverts in the study site are likely to be undersized at an upgrade cost of \$226,000. Extrapolating this undersized rate to the city's 248 culverts yields a total upgrade cost of \$2.5 million, in current dollars. With such projections, the City of Keene, and other such communities, may have a window of opportunity to prepare.

This study makes an important contribution to climate change preparation, by establishing the feasibility of specific estimates of civil infrastructure vulnerabilities, as planners and engineers consider preparing for predicted increases in rainfall intensity and watershed runoff.

Session iii: Water Resources & Climate Change

9:30AM - 9:55AM

Martha G. Nielsen

U.S. Geological Survey, Augusta, Maine, mnielsen@usgs.gov.

ANALYZING SUSCEPTIBILITY OF WETLANDS TO CHANGES IN WATER AVAILABILITY RESULTING FROM POTENTIAL CLIMATE CHANGE, ACADIA NATIONAL PARK, MAINE

Climate change has the potential to impact freshwater wetlands substantially. If summer and annual temperatures increase as projected, increases in evaporation may put many types of wetlands at risk of reduced water availability during the growing season. Conversely, projected increases in precipitation could result in increased groundwater recharge, which could benefit other wetland types.

Reduced water availability could result in decreases in the duration of standing water and soil-surface saturation, which can influence vegetation distributions, the success of amphibian breeding, and other wetland benefits. A GIS analysis of 186 wetlands in Acadia National Park, Maine, was conducted by the U.S. Geological Survey, using available landscape-scale data for each wetland and its catchment area. Catchment areas for each wetland were mapped, and landscape variables related to the hydrologic function of the wetlands were analyzed. The landscape variables used included size of the wetland compared to the catchment size; soils data; topography; slope of the catchment; and presence of streams, rivers, and lakes or ponds as potential sources of water. Overall, 11 variables were analyzed, resulting in a score that was used to rank the wetlands from most susceptible to disruptions in water availability under projected climate change to least susceptible to disruptions.

Session iv

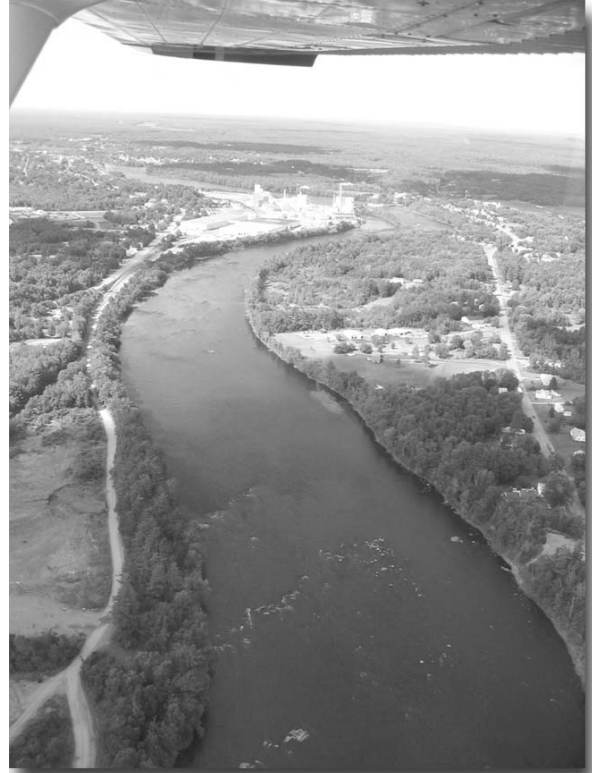
Landscape Changes

Part One (morning): Changes in fish assemblages

This session will examine changes in fish assemblages at the landscape scale using historic data, proxy measures, and experience from other regions. Topics will include fish stocking, invasive species, and temporal changes in the abundance of several species and indicators. Water quality, landscape context, and human activities related to these changes in fish assemblages are discussed, as are management implications.

Part Two (afternoon): Watershed management tools and assessment

This session features the development of science-based watershed planning and restoration tools. Connections between landscape change and water systems are explored to support the design and prioritization of restoration and lake and stream management activities. Topics addressed include riparian restoration, changes in physical properties of rivers, hydrogeomorphic lake classification, and management of chloride in Northeastern lakes.



SESSION CHAIRS:

Sarah Nelson, Senator George J. Mitchell Center for Environmental & Watershed Research

Sarah Nelson is an assistant scientist at the Mitchell Center. Her research interests are watershed geochemistry, including atmospheric deposition, hydrologic and landscape controls on mercury transport, responses to climate, fire, and land-use changes, quantitative ecology, and integration of GIS and geochemical data. Nelson has worked in upland stream watersheds at Acadia National Park since 1998 and recently co-edited a special issue of Environmental Monitoring & Assessment (11 papers) dedicated to mercury and nitrogen biogeochemistry. She is completing a Ph.D. in ecology and environmental sciences (water resources option) at the University of Maine.

Kathleen Bell, Dept. of Resource Economics & Policy, University of Maine

Assistant Professor Kathleen Bell received her Ph.D. in Economics from University of Maryland in 1997 and joined the Resource Economics and Policy faculty at the University of Maine in 2001. Her current research program focuses on the economics of land use change, economic valuation of environmental goods and services, spatial econometrics, and the use of GIS methods for economic modeling and policy assessment. Bell is especially interested in the development of spatial modeling tools that jointly address social and ecological processes. She is actively involved in several multi-disciplinary research projects, including a new research project examining sustainable lake management in Maine. Bell teaches environmental and natural resource economics, GIS, and statistics courses.

Session iv: Landscape Change

8:30AM - 8:55AM

Peter Vaux¹ and **Katherine Webster²**

¹ Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, Orono, ME, peter.vaux@maine.edu, 207/581-3256.

² Dept. of Biological Sciences, University of Maine, Orono, ME, katherine.webster@umit.maine.edu, 207/581-2542.

FISHERIES THEN & NOW: A 60-YEAR COMPARISON OF LAKE FISH ASSEMBLAGES IN MAINE

Between 1938 and 1944, G. Cooper and colleagues surveyed 205 lakes, most of which are in the southern and central regions of Maine. Their data provide an excellent baseline from which to explore changes in lake fish assemblages over the past six decades. The greatest change over this period is in the occurrence of largemouth bass, which today are found in over six times as many lakes as was the case 60 years ago. By comparison, smallmouth bass records increased by 30%. Other species that appear to be substantially more widespread today include brown trout (290% increase), white sucker (91%), pumpkinseed and redbreast sunfishes (45% and 68%, respectively) and cusk (54%). White perch, another species known to have been widely introduced around the state, is today found in 17% more lakes than documented by Cooper et al. We examine temporal changes in fish assemblages within the water quality and landscape contexts of these lakes.

9:00AM - 9:25AM

Emily Gaenzle Schilling¹, **Cynthia S. Loftin²**, **Alex D. Huryn³**, **K.E. DeGoosh⁴**

¹ Dept. of Wildlife Ecology, UMaine, Orono, ME, emily.schilling@umit.maine.edu, 207/581-1340.

² USGS-Maine Cooperative Fish and Wildlife Research Unit, UMaine, Orono, ME, Cyndy_Loftin@apollo.umenfa.maine.edu, 207/581-1340.

³ Dept. of Biological Sciences, Uni. of Alabama, Tuscaloosa, AL, huryn@bama.ua.edu, 205/348-4136.

⁴ New England Interstate Water Pollution Control Commission, RI Dept. of Environmental Management, Providence, RI, katie.degoosh@dem.ri.gov, 401/222-4700.

A HABITAT ON THE BRINK? AN ASSESSMENT OF THE STATUS OF FISHLESS LAKES IN MAINE

Fish introductions have resulted in a loss of fishless lakes across the state. This is of concern because fishless lakes provide critical habitat for many taxa. To assess the status of fishless lakes in Maine, we: 1) characterized their invertebrate communities, 2) assessed the effects of introducing fish to these communities, 3) identified species indicating fish absence to enable rapid identification of fishless lakes, and 4) used microfossils of indicator invertebrates from sediment cores to determine if currently stocked lakes were historically fishless. Invertebrates were sampled from 51 lakes (22 fishless; 29 contained fish, 7 of which were historically fishless). Our results showed that the species composition of Notonectidae, Chaoboridae, Dytiscidae, and Gyrinidae differed significantly between lakes with and without fish, with some taxa occurring only in fishless lakes. Microfossil analysis revealed that *Chaoborus americanus* is an indicator of historical as well as current fish absence. Finally, some taxa (Aeshnidae, Corixidae, Dytiscidae, Gyrinidae, Notonectidae) were most abundant in fishless lakes. Our results highlight the unique characteristics of fishless lake invertebrate communities and provide a tool to verify historical fish absence in lakes that have been stocked.

Session iv: Landscape Change

9:30AM - 9:55AM

Karen A. Wilson

Aquatic Systems Group and Dept. of Environmental Science, University of Southern Maine, Portland, ME, 207/228-1674, kwilson@usm.maine.edu.

INVASIVE CRAYFISH IN MAINE: POTENTIAL IMPACTS ON FISH, PLANTS AND BENTHIC INVERTEBRATES

There are over 350 crayfish species in North America, most with discreet native distributions and low range overlap between species. More northerly regions have far fewer species, but the activities of humans, and, in some cases, natural range expansions, have resulted in more and more species establishing in northern areas. Most of these crayfish species are introduced through “bait bucket liberations,” and some escape from aquaculture facilities. Crayfish are trophic generalists, eating everything from plant material to benthic insects to fish and their eggs. As a result, when crayfish are abundant, they can have significant effects on aquatic food webs. In this talk I will discuss the long-term negative impacts of one particularly invasive species, the rusty crayfish, on northern Wisconsin lakes where they became ultra-abundant in the 1980s and 1990s. I will then discuss the known distribution of rusty crayfish and other invasive crayfish in Maine, and the potential for additional spread in the state. I will conclude with reasons why the State of Maine should consider a crayfish control program to prevent the introduction and spread of invasive crayfish species similar to efforts to control invasive aquatic plants.

1:30PM - 1:55PM

Steve Kahl¹, Katherine Webster², Dari Sasson¹, Catherine Rosfjord³, Melissa Greenawalt-Yelle¹, and June Hammond Rowan¹.

¹ Plymouth State University, NH, jskahl@plymouth.edu.

² University of Maine, Orono, ME.

³ West Virginia Department of Environmental Protection.

LARGE RECENT INCREASES IN CL IN NORTHEASTERN LAKES AS AN INDICATOR OF REGIONAL DEVELOPMENT PRESSURE

Recent reports have linked elevated concentrations of Cl in surface waters to application of salt as a road deicer. We report substantial increases in Cl between 1984 and 2004 in Cl in a statistical population of nearly 4,000 low ANC lakes in the Northeast U.S. In 20 years the median Cl in the population increased from 1.7 mg/L to almost 3.5 mg/L. Most of the lake population in urbanized southern New England increased in Cl, compared to only 18% of lakes in more remote Maine. Among lakes classified as salt-impacted (half of the total population), median Cl nearly tripled. The other half of the lakes, those in more remote locations, did not exhibit a change in Cl. This recent increase in Cl reflects increasing inputs from road salting, and is coincident with other NPS pollutants and increasing eutrophication of lakes. Chloride is becoming an issue for potable water and ecosystem function in some areas of the Northeast. In some communities, water quality non-attainment for Cl standards means that future development will be allocated zero Cl in order to meet TMDLs. Mitigation of high Cl will require changes in the density of development, altered winter road

Session iv: Landscape Change

maintenance, modification in the imperviousness characteristics of new development, and/or new chemical approaches to ice control.

2:00PM - 2:25PM

Webster, K.E.¹, **Soranno, P.A.**², **Bremigan, M.T.**³, **Cheruvellil, K.S.**⁴, **Asplund, T.**⁵, **Bacon, L.C.**⁶, **Bell, K.P.**⁷, **Connor, J.**⁸, **Downing, J.A.**⁹, **Renwick, W.H.**¹⁰ and **Vaux, P.D.**¹¹

¹ University of Maine, Orono, 207/581-2542, katherine.webster@umit.maine.edu.

² Michigan State University, East Lansing, 517/432-4330, soranno@msu.edu.

³ Michigan State University, East Lansing, 517/432-3831, bremigan@msu.edu.

⁴ Michigan State University, East Lansing, 517/353-9528, ksc@msu.edu.

⁵ Wisconsin Dept. of Natural Resources, Madison, 608/267-7602, tim.asplund@dnr.state.wi.us.

⁶ Maine Dept. of Environmental Protection, Augusta, 207/287-7749, linda.c.bacon@maine.gov.

⁷ University of Maine, Orono, (207)851-3156, kathleen.p.bell@umit.maine.edu.

⁸ New Hampshire Dept. of Environmental Services, Concord, 603/271-3414, jconnor@des.state.nh.us.

⁹ Iowa State University, Ames, 515/294-8880, downing@iastate.edu.

¹⁰ Miami University, Miami, OH, 513/529-1362, renwicwh@muohio.edu.

¹¹ University of Maine, Orono, 207/581-3256, peter.vaux@maine.edu.

A HYDROGEOMORPHIC LAKE CLASSIFICATION SYSTEM FOR LAKE ASSESSMENT AND MANAGEMENT

Across broad spatial scales, lake trophic status is a function of lake-specific features, landscape setting, and anthropogenic drivers. However, regional-scale studies examining the influence of human activities on lakes often focus on geographic areas with relatively uniform hydrogeomorphology, limiting extrapolation. We used a diverse set of ~2500 lakes in the Northeast (Maine and New Hampshire) and the Midwest (Michigan, Wisconsin, Iowa and Ohio) to examine how broad and interacting gradients in land cover and hydrogeomorphic features influenced lake trophic status. Increasing intensity of agriculture from northeast to southwest combined with gradients in runoff and topographic relief generates spatially complex variation in natural and anthropogenic drivers. We developed a hierarchical classification system that accounted for variation at both the regional and local lake scales. After removing regional variation in total phosphorus (TP), the most important local features defining classes were lake maximum depth and catchment area. We tested the classification system by examining relationships between land cover type and nutrient concentration within classes. We found strong relationships between TP residuals and percent agriculture in the 500m buffer around the lake that differed in intercept among classes. Our results suggest that this hierarchical approach is a useful approach for understanding heterogeneity at the landscape scale and for developing tools for important management goals like setting reference conditions.

2:30PM - 3:00PM

Break

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3:00PM - 3:25PM

Aaron Corr

Parish Geomorphic, Fredericton, New Brunswick, 506/472-8440.

MONITORING RATES OF CHANGE IN MAINE RIVERS

The rate at which the physical properties of rivers change is of particular value to the management, planning and restoration of rivers. Changes can include migration of meanders, erosion of banks, widening, development of bars, and degradation or aggradation of bed levels. Rates of change are determined from historical analysis of aerial photos and maps, as well as from yearly monitoring of the form and process at monumented locations. Rate of change information can be used to help set corridor widths for land conservation, for the development of management plans, and for establishing appropriate restoration priorities and goals. A summary of historical analyses and monitoring data for 10 Maine rivers is presented and compared to other regional relations and models of rates of change. Interpretation of the data and implications to management and restoration of Maine rivers will be presented.

3:30PM - 3:55PM

David D. Hart¹, Thomas E. Johnson², James N. McNair³, and Puneet Srivastava⁴

¹ Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, Orono, ME, 207/581-3257, david.hart@umit.maine.edu.

² Patrick Center for Environmental Research, Academy of Natural Sciences of Philadelphia, Philadelphia, PA.

³ Patrick Center for Environmental Research, Academy of Natural Sciences of Philadelphia, Philadelphia, PA, 215/299-1109, mcnair@acnatsci.org.

⁴ Biosystems Engineering Department, Auburn University, Auburn, AL, 334/844-7426, srivapu@auburn.edu.

DEVELOPING A WATERSHED PLANNING TOOL TO PRIORITIZE RIPARIAN RESTORATION ACTIVITIES

We are developing scientifically-based tools to help guide watershed restoration and protection planning. Our initial efforts have focused on creating a prototype tool to evaluate the potential benefits of alternative riparian restoration and protection efforts. Although the benefits of riparian buffers are widely recognized, we currently lack a tool to identify which riparian restoration activities will have the greatest benefits. For example, we need a tool that will predict how the outcomes of riparian restoration depend on the type, amount (e.g., width and length) and location of buffers within a stream network. We gathered data on physical, chemical, and biological aspects of stream health at 40 sites in the mid-Atlantic piedmont, focusing particularly on small streams in the Schuylkill River watershed. We then used statistical models to examine how stream health was related to spatial variations in land cover, including the type, amount, and location of riparian buffers. Our results demonstrate how stream health is affected by both local riparian conditions and upslope landcover. We show how these relationships can be incorporated in a simple tool that predicts the outcomes of different riparian restoration projects, thereby enabling users to select those projects that will yield the greatest watershed benefits. We conclude by proposing how this type of tool can be calibrated and applied in Maine.

Session v

Contaminants and Toxic Metals

In this session on contaminants in groundwater, arsenic will be the primary focus. Unlike some anthropogenic point-source pollutants, arsenic is unlikely to become less of a problem over time. The occurrence of arsenic in groundwater wells is major public health concern because of the risks from long-term exposures to concentrations in the part-per-billion range. The magnitude of the problem in Maine will be discussed along with the latest information on the health effects and safe limits in drinking water. The nature of arsenic in groundwater in Maine will be described by the results of intensive field studies. Removing arsenic from drinking water makes water safe to drink, but it may just be moving arsenic to a new location in the landscape.



SESSION CHAIRS:

Robert Lent, U.S. Geological Survey

Robert Lent has a Ph.D. in geochemistry from the University of New Hampshire. He worked as a hydrologist and geochemist with the U.S. Geological Survey (USGS) in North Dakota and Massachusetts before becoming District Chief for the USGS in Maine. His research has focused on nutrient cycling and trace metal chemistry of lakes and reservoirs and non-point source evaluations of groundwater and surface water systems. Before coming to Maine, Lent was a water quality specialist with oversight responsibilities for all water quality activities in New England.

John Peckenham, Senator George J. Mitchell Center for Environmental & Watershed Research

John Peckenham is Assistant Director of the Senator George J. Mitchell Center for Environmental and Watershed Research at the University of Maine and Director of the Maine Water Resources Research Institute. Peckenham's research interests are drinking water quality, source water protection, and remediation of contamination. He is a member of the American Water Works Association, American Water Resources Association, National Ground Water Association, and American Geophysical Union and serves on the Board of Directors of the National Institutes for Water Research.

Session v: Contaminants & Toxic Metals

8:30PM - 8:55PM

Robert G. Marvinney

Maine Geological Survey, Augusta, ME, 207/287-2804, robert.g.marvinney@maine.gov.

AN OVERVIEW OF ARSENIC IN MAINE GROUND WATER

Over the past several decades, many institutions have investigated aspects of arsenic in Maine groundwater. In the early 1990s, the Maine Center for Disease Control (MCDC) and the Maine Geological Survey investigated elevated arsenic in several towns in southern Maine. This work showed that more than 10% of the sampled wells had arsenic concentrations above the MCL, 50 ppb at the time, and no clear relationship to geology. Review of available water analyses from MCDC suggested the same statistic for wells statewide. However, later work in NH indicated sampling bias in the Maine datasets from volunteered wells. Subsequent analysis of randomly selected wells in Maine suggested 2-3% at 50 ppb As. However, in the intervening time, the MCL was lowered to 10 ppb, and 10% of the randomly selected wells exceed this level. Work by the USGS during this time suggested a spatial correlation with carbonate rocks.

In the 21st Century, work has focused on the mechanisms of arsenic transport in groundwater. Investigators at the University of Maine researched elevated arsenic in ground water at Northport. This conveniently small watershed with exceptionally high arsenic levels provided an excellent laboratory for studying the evolution of arsenic-rich groundwater. The mechanism of arsenic mobility there is multiphase, involving primary sulfide minerals, iron-oxyhydroxide mineralization on fracture walls, and changing pH-Eh conditions. Current work with Columbia University focuses on elevated arsenic in ground water of the Augusta area, and its relationship to geology.

9:00AM - 9:25AM

Andrew E. Smith

Environmental & Occupational Health Program, Maine Center for Disease Control, Augusta, ME, 207/287-6455, andy.e.smith@maine.gov.

AN UPDATE ON A PUBLIC HEALTH RESEARCH PROGRAM REGARDING ARSENIC IN MAINE WELL WATER

Approximately half of Maine's population obtains its drinking water from private domestic wells. The occurrence of wells with elevated arsenic is well documented. Most of the public health concern regarding arsenic in drinking water has focused on the readily preventable cancer risk. More recent studies are causing an increasing concern about potential effects of arsenic on reproductive outcomes and effects on cognitive development of children. Over the past five years, Maine CDC and its collaborators have engaged in several public health focused research activities to address a range of questions including: a) what percentage of Maine households have wells with elevated arsenic; b) what percentage of Maine households have tested their well water for arsenic; c) is there significant residual exposure to arsenic after a home installs a point-of-use treatment system or switches to bottled water, and is this different for children versus adults; and d) how do household arsenic removal systems perform in the real world. The latest findings from these completed and ongoing studies will be presented and discussed.

Session v: Contaminants & Toxic Metals

9:30AM - 9:55AM

Peter Garrett

Emery & Garrett Groundwater, Inc., Waterville, ME, 207/872-0613, petergarrett@eggi.com.

THE NATURAL END OF LANDFILL LEACHATE: EXAMPLES FROM MAINE

Groundwater contamination from landfill leachate is commonly assumed to be a perennial problem. This is not necessarily so, as examples from Maine demonstrate.

Leachate composition is controlled by: 1) dissolution of soluble materials, 2) decomposition of organic materials, and 3) associated chemical interactions. For instance:

1. Salt is a common soluble material in landfilled waste. Chloride is often a primary constituent in leachate.
2. Decomposition of organic wastes uses up oxygen. This has several consequences including: dissolution of iron and manganese; genesis of methane and other landfill gases; reduced effectiveness of aerobic biodegradation of petroleum hydrocarbons; and allowing the (slow) anaerobic biodegradation of chlorinated solvents.
3. pH is generally high in landfill leachate, which limits metal mobility.

All landfills produce leachate, but only until soluble salts and decomposition are reduced to insignificant levels in the waste mass. Water quality of groundwater downgradient of several old burning dumps and closed landfills in Maine was analyzed to investigate the long-term fate of leachate. These investigations showed that:

- Burning dumps leave an archaeological record of a thin ash layer, bearing non-combustibles such as cans and bottles.
- The archaeological record of unburned, unlined landfills contains more plastic, but is otherwise similar.
- Leachate is no longer detected in groundwater downgradient of the burning dumps and unlined landfills with the exception that...
- Volatile organics, if present in the original waste, may be persistent.

1:30PM - 1:55PM

Yan Zheng

Queens College and Graduate School and University Center, City University of New York, Flushing, NY; Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY.

ARSENIC AND GEOCHEMICAL CHARACTERISTICS OF GROUNDWATER FROM DOMESTIC WELLS IN GREATER AUGUSTA, MAINE, USA

Naturally occurring arsenic in groundwater affects the health of tens of millions of people around the world, including Maine, United States. To investigate the geological, mineralogical and hydrological processes related to arsenic mobilization, water samples from about 800 private wells were collected between June and August 2006 in 12 communities encompassing ~ 1000 km² around the Greater Augusta area of Maine. The area was chosen because detailed bedrock maps are available, and some wells were known to have high arsenic concentrations. Samples were analyzed for a wide range of parameters, including dissolved oxygen, pH, major cations and anions, and trace elements (As, Fe, Mn and U, etc.)

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Arsenic concentrations ranged from < 0.01 ug/L to 325 ug/L, with 31% > 10 ug/L, the current EPA Maximum Contaminant Level (MCL) and 5% > 50 ug/L. Manganese concentrations ranged from 0.62 ug/L to 7190 ug/L, with 22.5% > 50 ug/L, EPA secondary MCL. Uranium concentrations ranged from < 0.01 ug/L to 484 ug/L, with 4% > 30 ug/L, EPA MCL, consistent with high concentrations of Rn (>10,000 pCi/L) from the same set of samples. The spatial patterns of the geochemical parameters and their relationship to the bedrock geology and hydrology will be further investigated to elucidate mechanisms of As release.

2:00PM - 2:25PM

John M. Peckenham¹ and **Gail Lipfert²**

¹ Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, Orono, ME, 207/581-3244, jpeck@maine.edu.

² Dept. of Earth Sciences, University of Maine, Orono, ME, gail_lipfert@apollo.umenfa.maine.edu.

APPROXIMATING THE FATE OF ARSENIC FROM DRINKING WATER SUPPLIES IN MAINE

The maximum concentration limit for arsenic in drinking water is 0.01 mg/L. In Maine, more than 30% of public and private drinking water supply wells exceed this limit. Arsenic in drinking water can be transferred from the ground to three new locations: (1) septic systems; (2) municipal water treatment facilities; (3) and solid waste systems. Septic systems may accumulate arsenic in solids or allow arsenic in solution to recharge aquifers. Arsenic in treatment works may accumulate in solids that end up as solid waste, or land applied as biosolids. Arsenic in solid wastes may be deposited directly into lined or unlined landfills, and leachate from landfills may be collected, or leak to groundwater. Solid wastes may be incinerated with losses to the atmosphere along with the generation of arsenic containing ash (solid waste). A newly developed model of how arsenic moves through the landscape will be presented. The estimate mass-flux of arsenic moving from groundwater to these others locations in Maine is 5 kg per day.

2:30PM - 3:00PM

Break

3:00PM - 3:25PM

Charles W. Culbertson¹, **James M. Caldwell¹**, **Lorraine C. Backer²**, **Carol Haskins³**, **Diane Daigle³**, and **Andrew E. Smith³**

¹ USGS, Maine District, Augusta, ME, 207/622-8201, cculbert@usgs.gov.

² Centers For Disease Control and Prevention, Atlanta, GA.

³ Maine Centers for Disease Control, Bureau of Health, Augusta, ME.

EFFECTS OF ARSENIC VALENCE AND WELL-WATER CHEMISTRY ON ARSENIC REMOVAL EFFICIENCIES OF HOUSEHOLD WATER TREATMENT SYSTEMS

Arsenic in groundwater is linked to a variety of serious human health issues worldwide. While elevated arsenic concentrations typically arise from geologic sources, the mechanism(s) by which arsenic is

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mobilized depends largely on groundwater chemistry. Arsenic in groundwater occurs primarily in the inorganic form, as pentavalent arsenate, or trivalent arsenite. The oxidation state of arsenic in well water greatly affects its removal by water purification systems. Arsenate, having a strong ionic charge, adsorbs to many surfaces and is therefore easily removed by a variety of water treatment technologies; in contrast to arsenite, which is relatively un-charged over a broad pH range, making it more weakly adsorbant and therefore the more mobile and difficult form to remove.

Roughly half of Maine's population derives its water from domestic wells, most of which are drilled bedrock wells. The U.S. Geological Survey, in cooperation with the Maine Centers for Disease Control, and U.S. Centers for Disease Control and Prevention are investigating the effects of arsenic valence and well-water chemistry on arsenic removal efficiencies of household water purification systems in selected households in Maine. Households participating in this study employed several technologies for removing arsenic from their water supplies. The presence of arsenite required different removal strategies compared to the removal of arsenate. Results of this ongoing study will be presented and discussed.

3:30PM - 4:00PM

Discussion: Arsenic Research Gaps and Needs

Session vi

Sustainable Water Use

This session will discuss potential impacts of provisional instream flow rules to Maine's water resources. The first part of the session will cover groundwater withdrawals and includes discussion of two models that will be used to provide legislative recommendations and focus future data collection. The second part of the session will focus on surface waters. Included is a discussion on the potential effects of climate change on surface waters and a project focusing on balancing water resource demands for both human and environmental sustainability.



FACILITATOR:

Robert Marvinney, Maine Geological Survey

Biography not available at time of printing.

1:30PM - 1:55PM

*Loiselle, Marc C. and **Marvinney, R.G.***

Maine Geological Survey, Augusta, ME, 207/287-2804, robert.g.marvinney@maine.gov.

WATERSHED-AT-RISK ANALYSIS AS A GUIDE FOR GROUNDWATER MANAGEMENT

Over the past year, the Maine Geological Survey has been meeting with representatives from state agencies, agricultural irrigators, commercial water bottlers, water utilities, and interested parties to review the regulations that govern groundwater withdrawals. To help focus this effort, the Maine Geological Survey undertook a preliminary analysis of watersheds at risk using available datasets. For this analysis, a “watershed-at-risk” is defined as a watershed where the sum of the required instream flows plus the consumptive water withdrawals exceeds some percentage of the total runoff generated within the basin or watershed. For this GIS exercise, the 12-digit Hydrologic Unit Code (HUC) watersheds were used for comparing net runoff to minimum instream flow requirements plus consumptive water use. The long-term average annual runoff generated in a watershed was estimated from a

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regional regression equation developed by the USGS. We used the provisional instream flow rules adopted by the BEP to determine the instream flow requirements. Finally, we assigned to each watershed consumptive water uses from a number of sources:

- public water supply withdrawals as reported to the Public Utilities Commission.
- reported water use by other major water users as required by law.
- estimates of withdrawals by smaller water users regulated by the Maine Drinking Water Program.
- agricultural water withdrawals as reported to the Department of Agriculture, Food and Rural Resources.
- private domestic water use estimated from 1990 Census data on percent of households on private wells (the latest data of this type available) and 2000 Census population data.

Using a 90-percent threshold, we found 11 watersheds with minimum required instream flow plus estimated consumptive water use equal to or greater than the threshold. This analysis is the basis for recommendations to the Legislature for improved stewardship of Maine's groundwater resources.

2:00PM - 2:25PM

Charlie Fitts

University of Southern Maine Geosciences Dept., Gorham, ME, 207/780-5351, cfitts@usm.maine.edu.

ANALYZING THE SUSTAINABILITY OF GROUNDWATER PUMPING IN THE FRYEBURG SAND AND GRAVEL AQUIFER

The Fryeburg aquifer has seen significant recent increases in groundwater pumping to provide bottled spring water in addition to the town's water supply. The present discharges are sustainable in a purely physical sense, in that pumping does not exceed aquifer recharge. A more relevant concept of sustainability examines these key manifestations of pumping, to determine if they are acceptable:

- Drawdown of the water table
- Reductions in groundwater discharges to surface waters
- The zones of contribution to the wells, which may need land use restrictions

Three-dimensional models of groundwater flow in the aquifer have been developed and used to quantify these under past, present, and future pumping scenarios. These analyses provide at least some of the basis for determining sustainable levels of pumping. In addition, there needs to be an understanding of the surface water ecosystems and how they respond to reduced flows. The results indicate that the currently-permitted levels of pumping significantly diminish flows in the brook that runs through the center of the aquifer. The impacts are especially significant during late summer, when water levels are low and bottled water pumping is high. The modeling process helps point out the greatest sources of uncertainty in our understanding, and guides future data collection.

2:30PM - 3:00PM

Break

Session vi: Sustainable Water Use

3:00PM - 3:25PM

Shaleen Jain

Dept. of Civil & Environmental Engineering, UMaine, Orono, 207/581-2420, Shaleen.Jain@maine.edu.

SUSTAINABLE WATER RESOURCES MANAGEMENT IN A CHANGING CLIMATE

Recent research linking dynamic climate variations to surface water supplies provides two important considerations for sustainable water resources management and rulemaking: (1) The changing envelope of climate variability over the last century is mirrored in water supplies as shifts in the metrics of hydrologic variability — trends in mean and variance of runoff, shifts in seasonality, and frequency of floods and droughts — of relevance to planning, management and design. (2) An improved understanding of the low-frequency (annual to decadal and longer time scale) climate variations promise a foreknowledge of regional hydrologic variability, thus opening a way to develop predictive tools that use climate precursors as a guide to proactively adapt water resources management and operating plans on within-year and longer time scales. We present examples from the current research in this emerging research area linking climate and managed and natural hydrologic systems. Some implications of this research for Maine's Sustainable Water Use Rulemaking are also discussed.

3:30PM - 3:55PM

Brian Joyce¹, **Mark P. Smith**², **Richard Vogel**³, **Jack Sieber**¹, **Stacey Archfield**³, and **Colin Apse**⁴

¹ Stockholm Environment Institute, Somerville, MA, 617/627-3786, jack.sieber@sei-us.org, brian.joyce@sei-us.org.

² The Nature Conservancy, Boston, MA, 617/542-1908, msmith@tnc.org.

³ Tufts University, Dept. of Civil and Environmental Engineering, Medford, MA, 617/627-3211, Richard.Vogel@tufts.edu, sarch@usgs.gov.

⁴ The Nature Conservancy, New Paltz, NY, 845/255-9051, capse@tnc.org.

MANAGING FOR WATER SUPPLY AND ECOLOGICAL FLOWS

Several New England states are developing in-stream flow and water level standards to protect aquatic resources and other water quality criteria. This process presents challenges, because many communities are heavily dependent upon the water resources of rivers and lakes for which ecological standards are being defined. Balancing these water resource demands is critical to human and environmental sustainability and is the focus of this project. This project utilizes a decision support system to provide an efficient and effective means of balancing human and environmental water needs under changing environmental conditions. We have adapted the existing Water Evaluation And Planning (WEAP) model to allow water managers to optimize multiple objectives by simultaneously maximizing the use of water storage capacity, the use of drought management measures, and to adaptively meet variable ecological flow needs based on real-time environmental conditions. By providing a tool for adaptively managing the quantity and timing of reservoir releases, actively managing human water demands through the use of drought management measures, we demonstrate how water supply reservoirs can be managed under variable environmental conditions to substantially maintain the reliability of the water supply yield while more consistently meeting ecological flows requirements. Our results demonstrate the general relationships between reservoir operating rule, storage volume, water-

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shed inflows, and desired releases for environmental flow needs. We also evaluate which environmental flow policies lead to the most favorable tradeoffs between ecological and human uses of water and how the nature of these tradeoffs varies with the storage ratio of the reservoir system.

Session vii

Models for Municipal Planning

This panel-style session will introduce participants to a number of modeling approaches that have been successfully used to aid municipal planning and assessment. The intended audience includes municipal employees, consultants, and environmental companies that work with municipalities. The session will be divided into two segments, each starting with the short presentation of a number of models, followed by panel discussion. Presentations will focus on outcomes, impacts and pros and cons for using the models. Attendees will leave the session with a better idea of what kinds of tools are available to municipalities and an understanding of which types of models will work best for the specific challenges they face.



FACILITATOR:

Brenda Zollitsch, BMZ Consulting

Brenda Zollitsch is a Ph.D. candidate in public policy at the Muskie School of Public Service. Her research focuses on non-point source pollution, specifically stormwater management. Her dissertation studies how collaborations working to implement stormwater regulations are structured and function nationwide. In addition to her research, Zollitsch is a consultant to a number of environmental collaborations in the State of Maine. She is the facilitator of the Bangor Area Storm Water Group (BASWG), a collaboration of 10 regulated entities working to plan and implement stormwater management activities in the Bangor Urbanized Area. The BASWG has developed a number of initiatives that can serve as models for joint action by other municipalities seeking to work together.

PRESENTERS/PANELISTS:

Fred Dillon, FB Environmental Associates

John Lough, Lakeport Hydrology

Ethel Wilkerson, Manomet Center for Conservation Sciences

Zach Steele and Jane Disney, MDI Water Quality Coalition

Brenda Zollitsch, BASWG Facilitator

Ken Locke, BASWG Member and Stormwater Manager, City of Brewer

Session vii: Models for Municipal Planning

QUESTIONS TO BE ADDRESSED:

- For what purpose was the model created and by whom?
- How has the model been used by municipalities to date?
- What are the strengths and weaknesses of the model?
- How useful is the information produced by the model for municipalities?
- Are there specific issues that municipalities should consider when deciding whether and in what way to use the model?
- What are the limitations on transferability of the model between municipalities?
- What assumptions are made in the model that would likely differ between municipalities?

1:30PM - 2:30PM

The first half of the session introduces three technical models: models for conducting impervious cover build-out analysis, determining the effect of different buffer widths on local water conditions, and assessing stratified-drift aquifers as potential large municipal water supplies.

Fred Dillon¹, **Forrest Bell**¹, and **Mary Ellen Dennis**²

¹ FB Environmental Associates, Portland, ME, 207/807-0013, fdillon@maine.rr.com.

² ME Dept. of Environmental Protection, Augusta, ME, 207/287-7729, mary-ellen.c.dennis@maine.gov.

Using an impervious cover build-out analysis to identify potential weaknesses in local land use ordinances. A case study: Penjajawoc watershed in Bangor, Maine.

E. Wilkerson and **J.M. Hagan**

Manomet Center for Conservation Sciences, Brunswick, ME, 207/721-9040, ewilkerson@prexar.com.

Timber harvesting and headwater streams: How well do current state regulations maintain stream temperature and water quality?

John A. Lough¹ and **Russell Congalton**²

¹ Lakeport Hydrology, Portland, ME, 207/409-5007, jlough1@maine.rr.com.

² University of New Hampshire, Durham, NH, 603/862-4644, russ.congalton@unh.edu.

Stratified-drift aquifers have potential to serve as large municipal water supplies in New Hampshire.

2:30PM - 3:00PM

Break

3:00PM - 4:00PM

The second half of the session will showcase two successful Maine-based models for collaborative action, including the engagement of citizens in watershed survey work and the regionalization of municipal storm water management.

Session vii: Models for Municipal Planning

Zack Steele and Jane Disney

MDI Water Quality Coalition, Mt. Desert, ME, 207/288-2598, zsteele22@yahoo.com,
jane@mdiwqc.org.

The Stanley Brook Watershed Survey

Brenda M. Zollitsch¹ and Ken Locke²

¹ BASWG Facilitator, Portland, ME, 207/772-4729, bmzconsulting@aol.com.

² BASWG Member and Stormwater Coordinator, City of Brewer, 207/989-5417, klocke@brewerme.org.

Regionalization of stormwater management in the Bangor urbanized area: A case study of the Bangor Area Storm Water Group.

Session viii

Water Science Education —

Effectively linking water resources science with formal and informal K-12 water education programs in Maine: What are we doing, what works, and how do we know? A forum on program assessment strategies for K-12 water science education.



FACILITATORS:

Beth Owen, Maine Sea Grant

Beth Owen is the education coordinator at the Maine Sea Grant College Program at the University of Maine in Orono. Owen coordinates Maine Sea Grant's formal and informal K-12 education projects throughout the state, and is a liaison to educational organizations in the state, region, and nation. Owen works closely with the Sea Grant/UMaine Cooperative Extension Marine Extension Team to develop K-12 education opportunities associated with Maine Sea Grant's four crosscutting programmatic issues: community-based natural resource management, planning for the future of coastal communities, sustainable seafood, and stewardship through citizen science. Owen received her B.A. from Brown University, and her Master's degree in environmental management from the Yale School of Forestry and Environmental Studies. She came to Maine from Washington, D.C., where she worked as a Dean John A. Knauss Marine Policy Fellow in the National Oceanic and Atmospheric Administration's (NOAA) Estuarine Reserves Division.

Laura Wilson, University of Maine Cooperative Extension

Laura Wilson is an assistant water quality scientist with the University of Maine Cooperative Extension. Wilson organizes and runs the successful Watershed Stewards Program, in addition to participating in New England regional sustainable landscaping and drinking water education efforts. Currently, she is focusing work in the areas of assisting lake groups to design and implement education programs that

Session viii: Water Science Education

can be evaluated for success, and social marketing to elicit behavior change. Through LEAP (the Northern New England Lake Education and Action Project), she is sharing successful water quality programs with Extension and Sea Grant partners in New Hampshire and Vermont. Wilson received her B.S. in water resources management from the University of New Hampshire, and her M.S. in ecology and environmental sciences (water resources) from the University of Maine.

PRESENTERS/PANELISTS:

Molly Schaffler, Steve Norton, and Medea Steinman (graduate student)
University of Maine Center for Science and Mathematics Education Research.

Sarah Kirn and Sarah Morriveau
Vital Signs Program, Gulf of Maine Research Institute.

Rex Turner
Director of Education, Maine Lakes Conservancy Institute.

Jurij Homziak
Executive Director, Lake Champlain Sea Grant Program.

SESSION OVERVIEW

National and State learning standards call for students to apply their learning in science and mathematics to current and genuine problems that are relevant to their lives and communities. At the same time, federal, state, and private research organizations are increasingly focused on strengthening links between academic research and K-12 education. A new body of education research has begun to explore questions about how and why integration of academic science with K-12 science education affects student learning. Along with these developments, formal and informal water science education programs throughout New England have begun to design programs that link K-12 students and teachers with academic research and researchers, and to implement new program assessment tools to evaluate the efficacy of these linkages.

During the first part of this session, faculty and a graduate student from the University of Maine Center for Science and Mathematics Education Research will discuss strategies for designing and implementing effective program assessment tools, and describe one case study in Maine. K-12 water science educators from three organizations in New England will then briefly outline their programs, and describe successes and challenges they have encountered in designing appropriate evaluation tools. The session will close with a panel discussion among all participants, and a fifteen-minute question and answer period.

Poster exhibition

Juried High School Exhibition

The Juried High School Exhibition is co-sponsored by the Maine Wastewater Control Association, the U.S. Geological Survey, and the Senator George J. Mitchell Center for Environmental and Watershed Research.

This is a combined competition for the Maine Water Conference High School Prize and the Maine Stockholm Junior Water Prize. The winner will move forward to represent Maine in the regional competition for the Stockholm Junior Water Prize. Winners also receive a cash award and their names are engraved on a plaque housed at the Mitchell Center.

Undergraduate and Graduate Juried Poster Exhibitions

The Senator George J. Mitchell Center for Environmental and Watershed Research and the U.S. Geological Survey have sponsored a juried student poster exhibition at the Maine Water Conference since 2000. Winners receive a cash award and their names are engraved on a plaque housed at the Mitchell Center. There are separate competitions for undergraduate and graduate students.

Posters are on display throughout the day and can be viewed at any time. The scheduled poster viewing session, when presenters are requested to be available to answer questions, is during the morning break from 10:00am-11:00am.

POSTER CHAIR

Whitney King, Department of Chemistry, Colby College

Miselis Professor D. Whitney King received his B.S. in chemistry from St. Lawrence University and a Ph.D. in chemical oceanography from the University of Rhode Island. He serves the Department of Chemistry at Colby College as an analytical/environmental chemist and teaches general chemistry, environmental chemistry, and analytical chemistry. His research group studies the role sunlight plays in regulating the surface water chemistry of lakes and the ocean. Many of these studies require novel analytical tools. Whitney's group is also actively involved in development of instruments for ultra trace analysis of Fe, Cu, Cr, Mn, H₂O₂, and O₂ in the environment. Over 50 of these instruments are used by other investigators all over the world. Whitney has also served as department chair and director of Colby's Partnership for Science Education, which works with area schools to improve K-12 science education.

Student presenters are indicated in bold type.



Poster Exhibition

HIGH SCHOOL POSTER ABSTRACTS

Jennifer Rowe

Bangor High School, Bangor, ME.

DETECTING THE PRESENCE OF ESTROGEN RECEPTOR AGONISTS IN MAINE LAKES

Estrogen receptor agonists (ERAs) present in river water worldwide have been found to cause various reproductive and homeostatic abnormalities in wildlife and are predicted to have adverse effects on humans. However, the presence of ERAs has not, to the knowledge of the writer, been documented in small lakes. In this paper a solid phase extraction(SPE)-gas chromatography(GC)-mass spectrometry(MS) analytical method was used for the determination of estrogen receptor agonists in lake water. Samples from five developed Maine lakes were analyzed for the presence of the natural estrogens estrone (E1), 17 β -estradiol (E2) and the synthetic estrogen 17 α -ethinylestradiol (EE2). In a water sample from Pushaw Lake, instrumental analysis showed 17 β -estradiol (E2) to be present in a concentration of 1.4 ng/L. This is of importance, as research has indicated that low nanogram-per-liter concentrations of the natural and synthetic estrogens cause abnormalities in fish and other wildlife. Also, two samples from Sebasticook Lake appeared to contain 17 β -estradiol (E2) but in levels lower than those plotted on the standard curve. These results suggest the presence of sewage water in Pushaw and possibly Sebasticook Lake, either from sewage treatment facilities on their watersheds or faulty septic systems of camps along the lakefront.

UNDERGRADUATE POSTER ABSTRACTS

Andrew Adelfio, Dylan Harrison-Atlas, Katherine Renwick, David Firmage¹, Danielle Garneau², and Kirsten Ness³

Department of Biology, Colby College, Waterville, ME.

¹ 207/859-5730; dhfirmag@colby.edu.

² 207/859-5724; dgarneau@colby.edu.

³ 207/859-5747; klness@colby.edu.

ANALYSIS OF LAND-USE PATTERNS IN THE LONG POND NORTH WATERSHED AND THEIR EFFECTS ON WATER QUALITY

In the fall of 2006, Colby College analyzed land-use and development patterns in the Long Pond North Basin watershed to determine their impact on lake water quality. Recently, the Maine Department of Environmental Protection has observed a decreasing trend in the water quality of Long Pond. The decline observed in dissolved oxygen and transparency may be related to an increasing availability of phosphorus, which is often associated with algal blooms. To quantify the various land-use types found in the Long Pond North watershed, we imported 2003 digital orthophoto quadrangles from the Maine Office of GIS into ArcGIS 9.1. The resulting land-use map was used to determine the phosphorus levels entering Long Pond North from each land-use type. An erosion potential model was created in ArcGIS to highlight areas in the watershed with a high likelihood of erosion, which also contributes to the nutrient loading of the lake. Residential and developed areas, particularly along the shoreline, showed the highest risk of erosion and also represented the highest percent of phosphorous input from any land-use type. Our findings indicate that mixed forests, which contribute little to

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phosphorus loading and erosion, constitute 85.6 percent of the watershed. However, the potential for shoreline and watershed development, as evidenced by a large number of approved house lots, poses a threat to Long Pond North's future water quality.

Kelly Bakulski, Ryan Scott, David Firmage¹, Danielle Garneau², and Kirsten Ness³

Department of Biology, Colby College, Waterville, ME.

¹ 207/859-5730; dhfirmag@colby.edu.

² 207/859-5724; dgarneau@colby.edu.

³ 207/859-5747; klness@colby.edu.

DECLINING LAKE WATER QUALITY ANALYSIS IN LONG POND NORTH, KENNEBEC COUNTY, MAINE

During the summer and fall of 2006, Colby College collected data on physical, chemical and biological parameters in Long Pond, North Basin. This water body has been placed on a list of impaired lakes established by the Maine Department of Environmental Protection due to a declining trend in water quality. DEP used decreasing levels of dissolved oxygen and transparency as criteria for their decision, a trend also consistent with data collected during the summer months. Secchi data indicates that the current Trophic State Index of Long Pond North is 38, while historically it was 33. This shows that Long Pond North has remained an oligotrophic lake with a trend towards mesotrophy. Findings indicate that in early August, 0.6 percent of the lake's volume was anoxic but by the middle of the month the volume rapidly increased to 10.1 percent. Long Pond receives 77 percent of its water from Great Pond, thus Long Pond's water chemistry status is largely dependent on factors outside of the direct watershed. The abundance of *Gloeotrichia echinulata*, an invasive cyanobacteria, has increased and can affect phosphorus levels as well as recreational and aesthetic values. Despite negative trends, Long Pond North is a relatively healthy lake but actions must be taken to preserve its current state.

Mark Burton¹, John Lichter², and Jaret Reblin³

¹ Bowdoin College, Brunswick, ME, mburton@bowdoin.edu, 781/492-5132.

² Bowdoin College, Brunswick, ME, jlichter@bowdoin.edu, 207/725-3653.

³ Bowdoin College, Brunswick, ME, jreblin@bowdoin.edu, 207/725-3166.

HUMAN DISTURBANCE AND THE FOOD WEB STRUCTURE OF MERRYMEETING BAY

The Merrymeeting Bay ecosystem provided large quantities of food, including fish and waterfowl, for both Native Americans and Euro-Americans for centuries. However, historical records indicate human disturbance of water quality has negatively impacted its overall health. Dam building, over-fishing, invasive species, and pollution have contributed to the alteration of the food-web structure from a benthic system to a pelagic system. It is possible that these compounded disturbances have caused a shift in the ecosystem phase. Water quality parameters were measured weekly on the six tributary rivers and in the bay itself. Submerged aquatic vegetation (SAVs) depth and distribution as well as fish habitat preference were also recorded. The turbidity is significantly higher on the four smaller rivers than on the two major rivers, which is having a disproportionate influence on the bay. High tide appears to define the photic zone according to the light response curves of tape grass, *Vallisneria americana*. The catch per unit effort for all resident fish species was significantly higher at vegetated than at unvegetated habitat sites. The high level of turbidity in the ecosystem prevents light from penetrating through the

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water column. The lack of light limits the depth distribution of SAVs, which will cause a series of positive feedback loops leading to stability of the turbid phase. The loss of SAV, and subsequent shift to a pelagic food web, has a negative impact on fish populations which utilize them for habitat structure and forage. Thus, the fish populations have been unable to recover to historical levels.

Anthony J. Carrasquillo¹ and **Dharni Vasudevan²**

¹ Bowdoin College, Brunswick, ME, acarrasq@bowdoin.edu.

² Bowdoin College, Brunswick, ME, 207/725.3548, dvasudev@bowdoin.edu.

INFLUENCE OF COMPOUND STRUCTURE ON THE SORPTION OF VETERINARY ANTIBIOTICS AT THE SOLID-WATER INTERFACE.

Veterinary antibiotics are widely used in large scale agricultural practices to both promote growth and prevent disease in livestock. Between 60 and 90% of administered doses are not metabolized and when excreted can directly contaminate soils. Many of these antibiotics become mobile in soils and as a result have been detected in natural waters. Antibiotic fate and bioaccessibility are influenced by the types of interactions that occur at the mineral-water interface, specifically sorptive interactions that largely influence partitioning to aqueous environments. This study compares the nature and extent of sorption of two veterinary antibiotics ciprofloxacin and oxytetracycline at the mineral-water interface by examining the influence of molecular structure. Sorption of oxytetracycline onto metal oxide exceeded that of ciprofloxacin, but the reverse was true of sorption to aluminosilicate clays. Sorption studies of methylated anilines suggested that the presence of methyl groups on the nitrogen did not cause a steric hindrance to oxytetracycline sorption. Instead, repulsion between an ortho-substituted anionic moiety and the negatively charged mineral surface likely decreased the extent of oxytetracycline sorption.

Kimberly E. Fritts, *Anne M. Sleeman, Elizabeth G. Stone DVM, Keith A. Matassa, and Michael J. Dunnington*

Marine Animal Rehabilitation Center, University of New England, Biddeford, ME, 207/602-2670, kfritts1@mail.une.edu.

ESCHERICHIA COLI AND THE SEASONAL AND STORM EFFECTS ON THE LOWER SACO RIVER

From May through October 2006 we conducted a water quality survey on the lower Saco River in southern Maine. The main focus of this study was to attempt to discover correlations between *in situ* coliform levels in the river with seasonal trends and episodic storm events. Combined sewer overflows (CSOs), collapsed septic tanks and fecal coliforms from unknown sources within the area of study may significantly affect the quality of the water. Five sample sites were selected along the course of the Saco River, from the Cataract dams to the river mouth. At each site, water samples were collected from two water column depths: surface and bottom. Samples were tested to provide information on the following: *Escherichia coli*, total coliforms, fecal coliforms, nitrogen cycle, pH, salinity, temperature, alkalinity, total phosphorous, and orthophosphates. *E. coli* and total coliform levels were significantly correlated with water flow over the dam and preceding days' rainfall. The preliminary phase of this research project has prompted the effort for more funding to further the investigation into the non-specific source of fecal contamination in the river via ribotyping.

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Ryan Jennison

University of Maine at Farmington, Farmington, ME, ryan.jennison@maine.edu.

DESICCATION RESISTANCE OF VARIABLE MILFOIL (*MYRIOPHYLLUM HETEROPHYLLUM*)

Variable Water-milfoil (*Myriophyllum heterophyllum*) is an invasive plant capable of altering aquatic habitats. Once established, *M. heterophyllum* displaces native plants and potentially impacts water quality. Aquatic plant fragments can be transported on boats and trailers to other water bodies posing threats of infestation. We investigated the desiccation resistance of *M. heterophyllum* to determine how long plants can remain viable out of water and to better understand the infestation risk they pose. Plants were dried outdoors and then placed in containers of lake water maintained in the UMF greenhouse. The first trial used shoots dried on a clothes rack to simulate fragments found on a boat trailer. Another trial was conducted with milfoil left in a pile on the ground. Milfoil left on the rack for 24 hours or longer showed no signs of viability when returned to the water in the greenhouse, whereas milfoil that was left in piles for up to 29 days remained viable, putting out new shoots when returned to the water. *M. heterophyllum* viability following removal from water varies from hours to days depending upon its moisture content and micro-habitat conditions.

Catherine A. Kropp¹, Alicia Miller², David M. Ellis³, Ashley M. Leen⁴, and Alisa Epstein⁵

¹ School of Forest Resources, University of Maine, Orono, ME. 207/479-5617.

catherine.amy.kropp@umit.maine.edu

² Dept. of Wildlife Ecology, UMaine, Orono, ME, 207/431-1327, alicia.miller@umit.maine.edu.

³ Dept. of Wildlife Ecology, UMaine, Orono, ME, 610/574-7777, david.ellis@umit.maine.edu.

⁴ Dept. of Wildlife Ecology, UMaine, Orono, ME, 207/659-3294, ashley.leen@umit.maine.edu.

⁵ Ecology and Environmental Sciences Program, UMaine, Orono, ME, 860/305-7832, alias.epstein@umit.maine.edu.

A SURVEY OF RIVERINE AND ESTUARINE WETLANDS ON THE LOWER PENOBSCOT RIVER, PENOBSCOT COUNTY, MAINE, USA

Disruptions to the natural processes on rivers resulting in part from dam building and recent opportunities for dam removal have led to the nation-wide emergence of river restoration science. A survey of riverine and estuarine wetlands on the lower Penobscot River, Penobscot County, Maine, USA was conducted prior to the removal of the Veazie and Great Works dams proposed by the Penobscot River Restoration Trust. Information was collected for comparative analyses of pre- and post-dam-removal wetland areas, particularly small wetlands. In the towns of Hampden and Orrington, we determined the presence or absence of wetlands, including the distribution of wetland vegetation species, along approximately 10 km of the river downstream of the proposed dam removals. Geographic Information Systems were used to create maps of satellite information and National Wetland Inventory (NWI) polygons, allowing for a comparison of field information with NWI classifications. NWI classifications overlooked the persistent vegetation present in many wetlands along the river, and some wetlands were not indicated on the NWI maps. *Sagittaria calycina* Englem., a rare-in-Maine aquatic species, was visible in estuarine waters. *Helenium autumnale* L., also rare in Maine, was locally abundant along riverine waters. The invasive *Lythrum salicaria* L. occurred throughout the study area including non-wetland areas. The preliminary results contribute to a scientific understanding of vegetation distribution and abundance in the Penobscot River watershed. In particular, the findings provide baseline data and

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underscore the importance for additional surveys of downstream wetland areas on the lower Penobscot River prior to the proposed dam removals.

GRADUATE POSTER ABSTRACTS

Michael R. Castele and **Noah P. Snyder**

Boston College, Geology & Geophysics, Chestnut Hill, MA, castelem@bc.edu, noah.snyder@bc.edu.

MODELING SEDIMENT TRANSPORT AND QUANTIFYING CHANNEL MORPHOLOGY OF THE SHEEPSCOT RIVER, COASTAL MAINE

We develop a sediment transport model for the Sheepscot River through the use of field measurements and remote-sensing techniques, in order to compare it with previous mapping of areas suitable for Atlantic salmon rearing and spawning habitat. The Sheepscot is a low-gradient, gravel bedded river with a slope of 0.1% to 1% and a median grain size of 1.1 to 8.5 cm at our six field study reaches. We calibrate a predictive model of bed material size that can be entrained under various flood discharges by measuring cross section profiles, vertical velocity profiles and bed grain size distributions at our six study sites, and monitoring bedload transport from July to December 2006 using marked particles at a subset of three reaches. After estimating the roughness coefficient, Shields parameter, basal shear stress, critical shear stress, and stream competence at each study reach the model is extrapolated throughout the watershed based on channel slope and drainage area measurements derived from digital elevation model analysis in order to identify reaches with potentially mobile substrate. Shear stress is the most important factor in a sediment transport model because it sets sediment transport rates. During the study bedload transport was only seen at one of the three sites where tracers were placed. We speculate that this mobility is due to a known sediment source located approximately 1 km upstream of the site. The constant source of sediment keeps the bed from becoming armored, decreasing the stress needed to mobilize the bed.

Lester A. French Jr.^{1,2}, Mitchell Wark¹, Paul Millard¹, and John F. Vetelino^{1,2}

¹ University of Maine, Laboratory for Surface Science and Technology, Orono, ME

² Mainely Sensors, LLC, Maine Target Technology Center, Orono, ME

lester.french@umit.maine.edu, 207/581-2239.

Mitchell.wark@umit.maine.edu, 207/281-2245.

paul.millard@umit.maine.edu, 207/581-2265.

vet@eece.maine.edu, 207/581-2264.

DEVELOPMENT OF A LATERAL FIELD EXCITED IMMUNOSENSOR FOR *E. COLI* IN WATER

The rapid, sensitive detection of biomolecules, microorganisms and cells is critical to human, animal and plant health along with food and environmental safety. The detection of *Escherichia coli* (*E. coli*) is critically important due to its abundance in the environment and the ease at which it can contaminate food and water. Current methods of testing drinking water for *E. coli* have several major drawbacks, which include time- and labor-intensive sample collection and lengthy laboratory analyses that take at least 24 hours. A novel acoustic wave sensor is being developed for the rapid and in situ detection of *E. coli* using a lateral field excited (LFE) sensor with a bilayer functionalized for the detection of *E. coli* O157:H7. The acoustic wave sensor measures the physical and electrical property changes at the sen-

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sensor surface as the pathogen binds at the surface, while the biolayer consists of antibodies selective to *E. coli* O157:H7. The feasibility of the functionalized LFE sensor for *E. coli* has been demonstrated in the lab with a detection limit of about 10^5 CFU/ml in roughly 12 hours. Additionally, the biolayer when exposed to other bacteria is selective only to *E. coli* O157:H7. Research is ongoing to decrease the detection limits and response time of the sensor. The successful development of the LFE sensor will result in a viable sensor for the detection of *E. coli* in drinking water.

This work is supported by the National Science Foundation under grants 0330100 and 0539598.

Eric Hazlinsky and Noah Snyder

Boston College, Department of Geology and Geophysics, Chestnut Hill, MA.

eric.hazlinsky@bc.edu, 617/552.8918.

noah.snyder@bc.edu, 617/552.0839.

DOCUMENTING 20TH CENTURY CHANGES IN RIVER MORPHOLOGY USING AERIAL PHOTOGRAPHS AND FIELD SURVEYS: NARRAGUAGUS AND SHEEPSCOT RIVERS, MAINE

Over the past few centuries the population of Atlantic salmon has decreased in New England. This decrease is attributed largely to over-fishing and alteration of natural fluvial habitat by logging and other land-use changes. The Narraguagus River is located in downeast Maine, and the Sheepscot River is located in midcoastal Maine. These systems are of interest because they are host to remnant wild Atlantic salmon populations. These rivers are now being investigated by land managers and watershed non-profit groups for possible habitat restoration. We evaluate the effects of land-use changes on channel morphology and habitat through field and aerial-photograph analysis in order to investigate the trajectory of channel response in the region. First, we evaluate our remote-sensing methods through quantitative comparisons of channel bankfull width measured in the field at 100-m intervals on 3-5 km reaches of the rivers, with similar measurements made from recent orthorectified and georeferenced aerial photographs using geographic information systems (GIS). Results of this test illustrate that morphology measurements made in the field can also be made accurately using GIS, where the GIS measured widths are systematically 86% of the field measured widths. Next, we document changes in channel width and sinuosity since approximately 1940 using historical aerial photographs. Preliminary results show that four of the nine reaches analyzed on the West Branch of the Sheepscot River have narrowed significantly in the past >60 years, and the rest have remained constant. Finally, we compare these morphologic changes with changes in land-use patterns.

Laura J. Jones¹ and Karen Wilson²

¹ Dept. of Biology, University of Southern Maine, Portland, ME, 207/228-8532, laura.j.jones@maine.edu

² Aquatic Systems Group and Dept. of Environmental Science, University of Southern Maine, Portland, ME, 207/228-1674, kwilson@usm.maine.edu.

TRANSFORMATION OF FRESHWATER SHERMAN LAKE TO A SALT MARSH — YEAR ONE RESULTS

Sherman Lake (Newcastle, Maine) was an artificially impounded pond for 70 years until an unplanned dam breach in October 2005 restored partial tidal flow. Sudden decline in water level caused die-back of aquatic plants and resulted in exposed, bare substrate through early spring. Salt marsh plants colonized areas near the dam breach where pore water salinities were highest but were absent farther from the

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outlet, reflecting their poor dispersal capabilities. However, *Juncus gerardii* (black rush) was common throughout the marsh suggesting its seeds had persisted in lake sediments. A high diversity of freshwater plants colonized areas characterized by low surface water and pore water salinities (0-5 ppt). During this one season, we observed shifts in species composition with loss of some species and increased dominance by others. Results from our vegetation survey and observations indicate that full recovery to a salt marsh system will be limited to areas receiving the greatest tidal flushing. Construction to fully open the channel to accommodate historic flows is proposed for 2008. Future plans include continued monitoring vegetation, salinity and soil conditions and research of fish use of the marsh.

Hun Bok Jung¹, Qiang Yang¹, Charles W. Culbertson³, Robert G. Marvinnney⁴, Marc C. Loiselle⁴, Daniel Locke⁴, Heidi Cheek⁴, Hilary Thibodeau⁴, C. T. Hess⁵, and Yan Zheng^{1,2}

¹ Queens College & Graduate Ctr., City University of New York, Flushing, NY, HBJung@gc.cuny.edu.

² Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY.

³ USGS, Maine Water Science Center, Augusta, ME.

⁴ Maine Geological Survey, Augusta, ME.

⁵ University of Maine, Dept. of Physics, Orono, ME.

GROUNDWATER ARSENIC FROM DOMESTIC WELLS IN GREATER AUGUSTA, MAINE, USA

In order to investigate spatial distribution of groundwater arsenic related to geology, 786 groundwater samples were collected from private domestic wells tapping in a number of bedrock units in 12 towns encompassing ~1,000 km² around Greater Augusta, Maine between June and October, 2006. Arsenic was determined by High Resolution Inductively Coupled Plasma – Mass Spectrometry (HR ICP-MS), with a precision of ±1% and detection limit of 0.01 ug/L. Arsenic concentrations ranged from < 0.01 ug/L to 325 ug/L, and it was found that 31% of the groundwater samples exceeded EPA MCL (10 ug/L) value for As and 5% of the groundwater samples contained As greater than 50 ug/L. Elevated As (> 10 ug/L) is distributed more frequently in the wells tapping Silurian calcareous metamorphic rock rather than undifferentiated metamorphic rock or felsic igneous rock. On the basis of the present study on groundwater arsenic in Greater Augusta and water use information for Maine, approximately ~15,000 households are presumed to drink groundwater contaminated by As greater than EPA-MCL in Kennebec County, Maine. The detailed bedrock geologic map in the area and the high spatial density sampling of groundwater As will be explored to estimate population exposed to > 10 ug/L As in Maine, together with census data.

Dianne Kopec

Dept. of Biological Sciences, University of Maine, Orono, ME. 207/581-2574, dkopec@maine.edu.

MERCURY RESIDUES IN INGESTED HARBOR SEAL (*PHOCA VITULINA*) PREY FISH AS EVIDENCE FOR SELECTIVE FORAGING

Mercury biomagnification in the marine food web increases the mercury concentration in each successive trophic level, yet levels in top trophic predators often exceed expectations based on prey residue levels and predator feeding and assimilation rates. Laboratory studies with mercury-contaminated fish have linked mercury neurotoxicity to behavioral changes associated with reduced predator avoidance. We hypothesized that elevated mercury accumulations in prey increase their vulnerability to pre-

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dition, thereby increasing mercury body burdens in predators through selective foraging on more contaminated prey.

To test this hypothesis, we analyzed the diet of harbor seals from Mt. Desert Rock, an island located 20 miles offshore in the central Gulf of Maine. Four primary summer prey species were identified and collected using bottom trawls, and hook and line. Mercury residues in wild-caught prey were compared to mercury residues of prey ingested by harbor seals by analyzing undigested fish structures (otoliths and eye lenses) sieved from harbor seal scat. Preliminary data, for Acadian redfish (*Sebastes fasciatus*), indicate mercury residues in ingested eye lenses were significantly higher than those in eye lenses of wild-caught fish of the same species ($P < 0.000$). A positive relationship ($r^2 = 0.69$, $P = 0.005$) was found between whole body (16.8 ± 10.7 ng/g wet wt.; mean \pm SD) and eye lens (25.1 ± 7.0 ng/g dry wt.) mercury residues in wild-caught redfish; this allowed us to predict whole body mercury in ingested redfish based on mercury residues in ingested eye lenses. Predicted whole fish residues in ingested redfish range between 60 and 650 ng/g wet weight, levels shown to provoke toxic effects in fish.

Preliminary findings of significantly greater mercury residues in ingested redfish support the hypothesis of selective foraging by harbor seals and may help account for their unexpectedly high mercury residues.

Jamie Pinto¹, **Howard Patterson**², and **John Peckenham**³

¹ University of Maine, Orono, ME, 207/581-1211, Jamie.pinto@umit.maine.edu.

² University of Maine, Orono, ME, 207/581-1178, howardp@maine.edu.

³ Senator George J. Mitchell Center for Environmental and Watershed Research, University of Maine, Orono, ME, 207/581-3254, jpeck@maine.edu.

EFFECTS OF COPPER SULFATE AND CARBARYL ON THE FLUORESCENCE OF THE CHLOROPHYCEAE, *ANKISTRODESMUS FALCATUS*

This research determines the effects of toxic chemicals on algae fluorescence, provides a practical solution for monitoring and protecting public water supplies, and allows for an immediate indication of stress to the aquatic system from contaminants. Monitoring substances entering drinking water sources with algae fluorescence is critical because drinking water supplies are susceptible to a variety of contaminants. The use of algae as a test organism enhances the applicability of bioassays because algae are present in virtually all aquatic ecosystems. Introduction of toxic chemicals to a water supply will kill or harm algae, causing changes in chlorophyll chemistry resulting in variations of *in vivo* fluorescence intensity.

Cultured samples of the Chlorophyceae, *Ankistrodesmus falcatus* were used to determine if additions of two chemical toxins, copper sulfate and carbaryl, caused immediate changes in the algae chlorophyll chemistry. Results indicate that the fluorescence intensity for *A. falcatus* deviates in the absence and presence of copper sulfate and carbaryl. The fluorescence significantly decreased in the presence of copper sulfate at and above the LC50 of 0.2ppm. The fluorescence also significantly decreased in the presence of carbaryl at and above the expected environmental concentration (EEC) of 3.7ppm. These changes in fluorescence intensity indicate that the algae are stressed because of a toxic addition to the culture media. These data show that the fluorescence intensity of *A. falcatus* varies with additions of these toxic chemicals and indicates a potential biosensor for drinking water protection.

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Chris Proctor¹, Collin Roesler², John Peckenham³, and Andrew Thomas⁴

¹ University of Maine, Orono, ME, christopher.proctor@umit.maine.edu, 207/778-1852.

² Bigelow Laboratory for Ocean Sciences, Boothbay Harbor, ME, croesler@bigelow.org, 207/633-9654.

³ Senator George J. Mitchell Center, UMaine, Orono, ME, jpeck@maine.edu, 207/581-3254.

⁴ University of Maine, Orono, ME, thomas@maine.edu, 207/581-4335.

MEASURING ALGAL CONCENTRATION & COMPOSITION AS A PROXY FOR WATER QUALITY

The purpose of this project was to develop a real-time warning system for detecting accidental or deliberate contaminations of domestic water supplies. Paired optical sensors (Ecotriplets, WET Labs, Inc.) were designed to provide continuous observations of the bulk inherent optical properties (IOPs) of a water body. They monitor specific aquatic components: suspended particulate matter, dissolved organic matter, and phytoplankton composition. Perturbations in these parameters, and in particular phytoplankton concentrations and community composition, are used as indices for environmental changes. One instrument measures backscattering at 660nm, fluorescence by colored dissolved organic matter (excitation at 370nm, emission at 460nm) and phycoerythrin (a pigment found in some cyanobacteria and cryptomonads; excitation at 540nm, emission at 570nm). The second sensor is a fluorometer designed to quantify the composition of light harvesting algal pigments. It measures chlorophyll fluorescence at 695 nm resulting from three excitation wavelengths: 435nm, 470nm, and 532nm. Phytoplankton have varying pigment compositions based in large part on taxonomy and thus dominant groups can be identified by the characteristic ratios of these pigments. Calibration and characterization experiments were performed using monospecific cultures of dinoflagellates, diatoms, chlorophytes, prymnesiophytes and cyanobacteria to quantify instrument detection capabilities. Robust calibration results indicated that the instruments are stable, and that phytoplankton grown at controlled nutrient and light conditions have stable and repeatable fluorescence to chlorophyll ratios. Using models made from the calibration information, the sensors will be used to assess the temporal variability of phytoplankton populations, and as a ground truth for satellite derived color data.

P.E. Smitherman¹, C.T. Hess¹, Y. Zheng², M. C. Loiselle³, and C. W. Culbertson⁴

¹ University of Maine Dept. of Physics and Astronomy, Orono, ME, 207/581-1018, paul.smitherman@umit.maine.edu, hess@maine.edu.

² Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, 845/365-8401, yzheng@ldeo.columbia.edu.

³ Maine Geological Survey, Augusta, ME, 207/287-2801, Marc.C.Loiselle@maine.gov.

⁴ USGS, Maine Water Science Center, Augusta, ME, 207/622-8201 x127, cculbert@usgs.gov.

ANALYSIS OF WELL WATER CONCENTRATIONS FROM RADON AND URANIUM MEASUREMENTS IN A COLUMBIA UNIVERSITY ARSENIC STUDY

We have used ArcGIS 9.0 for the analysis of a set of data from a collaborative study with Columbia University and the University of Maine Department of Physics. Radon and uranium concentrations in well water samples from 790 private residences in the Augusta, Maine area were analyzed. The radon and uranium data are both log-normally distributed with geometric means of 2400 pCi/L for radon and 1.02 µg/L for uranium. Maximum concentrations of 208,570 pCi/L for radon and 484 µg/L for uranium were measured. Radon and uranium concentrations in well water are mapped together with township, road, granite pluton and metamorphic grade information showing a confirmation of the correlation of

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radon concentration with granite plutons, with a geometric mean of 5780 pCi/L on the plutons. Uranium is similarly correlated with a geometric mean of 4.68 µg/L on the plutons. Mean radon concentrations on the metamorphic facies are 2200 pCi/L for epidote-amphibolite and greenschist grades, 1460 pCi/L for the low rank amphibolite, 2800 pCi/L for the medium rank amphibolite, and 3290 pCi/L for the high rank amphibolite. Mean uranium values are 0.38 µg/L for epidote-amphibolite and greenschist grades, 0.57 µg/L for the low rank amphibolite, 1.17 µg/L for the medium rank amphibolite, and 2.95 µg/L for the high rank amphibolite. Radon is also correlated with uranium, and a secular equilibrium calculation shows theoretical radon values using the measured values of uranium. This calculation gives supported radon values much lower than the observed values. Continuing work will focus on this disparity and also further examine the metamorphic grade correlations.

Medea H. Steinman

Center for Science and Mathematics Education Research, University of Maine, Orono, ME, 207/581-1031, medea.steinman@umit.maine.edu.

USING ONLINE WATER QUALITY DATA TO TEACH SCIENCE SKILLS TO SECONDARY SCHOOL STUDENTS

Online data that record real-world environmental phenomena are ubiquitous and, to a great extent, freely accessible on the Internet. Examples of such data include stream-flow measurements, water chemistry, plankton levels, and lake ice-out dates. This poster presents findings from an education research study of seventh grade students in Bangor, Maine. The study asked what learning can result when a guided inquiry curriculum employing such online data is used in the classroom. Pre- and post-test instruments were used to evaluate student performance. The results were mixed, and suggest that the learning results may depend on how accustomed students are to applying higher-order thinking (i.e., analysis, synthesis) to classroom assignments. Although all students improved in their ability to interpret graphed data and discern useful from un-useful sources of information, the results showed that overall, students who received the 10-day guided inquiry curriculum (“treatment” method) made no more gains than did the students who received the normal teaching instruction (“comparison” method). Developmental theories, and classroom observations made throughout the semester, suggest that these seventh graders are cognitively capable of attaining greater learning benefits from working with real data sets. Possible explanations for the study results are discussed.

Whitmore, E.A.¹, K.E. Webster¹, and L.C. Bacon²

¹ Dept. of Biology, University of Maine, Orono, ME, elizabeth.whitmore@umit.maine.edu, katherine.webster@umit.maine.edu.

² Maine Department of Environmental Protection, Augusta, ME.

DOES CLADOCERAN COMMUNITY STRUCTURE IN MAINE LAKES CHANGE ALONG SPATIAL GRADIENTS IN HUMIC COLOR AND TOTAL PHOSPHORUS?

Limnologists have long been interested in how nutrient enrichment affects lake ecosystems. In recent years, the concept has been proposed that both nutrients and humic color are important gradients influencing lake ecosystems. Humic color provides insight into the balance between heterotrophic and autotrophic states. Thus, the interaction between nutrient enrichment and humic color could influence foodweb structure and function in lakes. To test this idea, a database compiled by the Maine

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Department of Environmental Protection (MDEP) was used. This database contains information on about 300 Maine lakes, their water chemistry, and their zooplankton species abundance. Our focus was on the cladoceran community, because cladocerans are important in lake pelagic food webs, and reflect both top-down and bottom-up processes. Our results will reveal whether the interaction between total phosphorus and humic color has an effect upon the species richness and abundance of cladocerans in Maine lakes. Ultimately, the results will be used to assess the use of cladoceran indicators related to lake enrichment and food web alteration via the introduction of fish.

Qiang Yang¹, **Hun Bok Jung**¹, **Charles W. Culbertson**³, **Robert G. Marvinnney**⁴, **Marc C. Loiselle**⁴, **Daniel Locke**⁴, **Heidi Cheek**⁴, **Hilary Thibodeau**⁴, **C. T. Hess**⁵, and **Yan Zheng**^{1,2*}

¹ Queens College & Graduate Center, City University of New York, Flushing, NY, QYang@gc.cuny.edu.

² Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY.

³ USGS, Maine Water Science Center, Augusta, ME.

⁴ Maine Geological Survey, Augusta, ME.

⁵ Univ. of Maine, Dept. of Physics, Orono, ME.

**corresponding author*

GROUNDWATER GEOCHEMICAL CHARACTERISTICS IN FRACTURED BEDROCK AQUIFER, GREATER AUGUSTA, MAINE, USA: IMPLICATION FOR TRANSPORT

Naturally occurring arsenic in groundwater affects the health of >100,000 people in New England. In Greater Augusta, Maine, a surprisingly high percentage (31%) of 786 domestic bedrock wells was found to contain > 10µg/L As. Bedrock of Greater Augusta area includes Silurian calcareous metamorphic rocks with granitic intrusions. Elevated arsenic concentrations are more frequently detected in samples with high pH (>7), low dissolved O₂(<1mg/L), low chloride (<30 mg/L), and tapping the Silurian interbedded pelite, sandstone, and limestone/dolostone. Because road salt application has increased significantly in the last 3 decades in Maine, groundwater with high Cl⁻ is likely to be recharged recently whereas groundwater low in Cl⁻ is likely to be older. Therefore, presumably aged groundwater samples down flow path tend to contain elevated arsenic. An inverse relationship between As and Fe, Mn, or SO₄²⁻ is also evident, suggesting a complex mobilization mechanism of oxidation of arsenic-rich sulfide and neutralization by calcite along the groundwater flow path.

Groundwater samples are mainly calcium-bicarbonate water type based on limited analysis of 33 samples. More detailed geophysical and tracer work will be carried out in several areas (~20,000 m² each) to better understand geological conditions, fracture features, hydraulic parameters, and eventually mechanisms of arsenic mobilization and transport in fractured bedrock aquifer.

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PROFESSIONAL POSTER ABSTRACTS

Robert F. Baldwin¹, Aram J.K. Calhoun², and Phillip G. deMaynadier³

¹ Two Countries, One Forest, c/o Dept. of Forest Management, UMaine, Orono, ME, rbaldwin@antiochne.edu.

² Dept. of Plant, Soil and Environmental Sciences, UMaine, Orono, ME, calhoun@maine.edu.

³ Maine Dept. of Inland Fisheries and Wildlife, Bangor, ME, phillip.demaynadier@maine.gov.

CONSERVATION PLANNING FOR AMPHIBIAN SPECIES WITH COMPLEX HABITAT REQUIREMENTS: A CASE STUDY USING MOVEMENTS AND HABITAT SELECTION OF THE WOOD FROG *RANA SYLVATICA*

Conservation of fauna breeding in vernal pools is challenging given their complex life histories. Many species, including the widespread North American wood frog (*Rana sylvatica*), require both aquatic and terrestrial habitat, yet insufficient information exists about movements between these environments, nor fine-scale selection patterns within them. To inform conservation planning, we conducted a radio-telemetry study of seasonal patterns of wood frog movements and habitat selection in southern Maine. Forty-three frogs were tracked an average of 25.6 days each, April to November 2003. In early spring, wood frogs generally selected damp leaf litter retreats on the margins of breeding pools. Following breeding, frogs selected forested wetlands (9.3% of the landscape) over forested uplands (90.7% of the landscape) in 75.3% of radio locations (N=544). Post-breeding movements from breeding pools to nearby, closed-canopy, forested wetlands ranged from 102-340 m (median 169 m, N=8) and included stopovers in upland forest floors ranging from one to 17 days (median two days, N=7). Summer refugia were characterized by shady, moist (nonaquatic), and sphagnum-dominated microhabitats, often in forested swamps. In rapidly urbanizing areas, we recommend a shift from a core-habitat conservation model to a spatially explicit approach that considers pool-breeding amphibian habitat as a network of migration-connected habitat elements (e.g., breeding pools, upland forest, nearby forested wetlands). In our study, this approach reduced the amount of land potentially requiring protection by > 2/3 from that of traditional core habitat models. With the rapid dissemination of GIS technology, spatially explicit planning approach for pool-breeding amphibians is increasingly feasible.

Ronald G. Butler¹ and Phillip G. deMaynadier²

¹ Dept. of Natural Sciences, University of Maine at Farmington, Farmington, ME, butler@maine.edu.

² Maine Dept. of Inland Fisheries and Wildlife, Wildlife Resource Assessment Section, Bangor, ME, phillip.demaynadier@maine.gov.

THE SIGNIFICANCE OF LITTORAL AND SHORELINE HABITAT INTEGRITY TO THE CONSERVATION OF LACUSTRINE DAMSELFLIES (ODONATA)

Human development of pond and lake shorelines may significantly impact native lacustrine biota including a variety of aquatic macroinvertebrate groups. In an effort to better understand the habitat associations and sensitivities of lacustrine damselflies (Odonata: Zygoptera), we sampled adults in littoral macrophyte habitat during two flight periods at 35 randomly selected pond and lake sites in southern Maine during 2000 and 2001. Data were also collected to help characterize water body, shoreline disturbance, and aquatic vegetation at each study site. Nonmetric multidimensional scaling was used for ordination of damselfly assemblages, and coordinates from the most stable solution

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were related to site variables using forward stepwise multiple regression. Our results suggest that the diversity and composition of damselfly assemblages is related to the abundance and richness of littoral zone macrophytes, extent of riparian disturbance, benthic substrate granularity, and lake productivity; all variables subject to anthropogenic degradation on excessively developed waterbodies. Additionally, we developed a Habitat Tolerance Index useful for distinguishing between relative habitat specialists and generalists from among a diverse assemblage of 19 lacustrine species. Finally, species-specific damselfly associations with multiple genera of floating and emergent macrophytes were assessed using both nonparametric correlation and multiplicative regression yielding significant relationships for 17 species, including two damselflies of global conservation concern, New England bluet (*Enallagma laterale*) and scarlet bluet (*E. pictum*). We conclude that the protection of littoral and shoreline habitat integrity, with special emphasis on emergent and floating macrophytes, is critical to the conservation of lacustrine biodiversity.

Adria A. Elskus¹, Lawrence A. LeBlanc², Gregory Mayer³, Carol Kim⁴, Rebecca J. Van Beneden⁵, and L. Brian Perkins⁶

¹ U.S. Geological Survey, Maine Field Office, Dept. of Biological Sciences, UMaine, Orono, ME, 207/581-2579, aelskus@usgs.gov.

² School of Marine Sciences, UMaine, Orono, ME, 207-581-4376, lawrence.leblanc@umit.maine.edu.

³ Dept. of Biochemistry, Microbiology & Molecular Biology, UMaine, Orono, ME, 207/581-2852, gmayer@maine.edu.

⁴ Dept. of Biochemistry, Microbiology & Molecular Biology, UMaine, Orono, ME, 207/581-2803, carolkim@maine.edu.

⁵ Dept. of Biochemistry, Microbiology & Molecular Biology, and School of Marine Sciences, UMaine, Orono, ME, 207/581-2602, rebeccav@maine.edu.

⁶ Dept. of Food Science & Human Nutrition, UMaine, Orono, ME, 207/581-1369, bperkins@maine.edu.

A PILOT STUDY TO EVALUATE THE POTENTIAL FOR RIVER WATER TOXICITY TO INCREASE FOLLOWING DAM REMOVAL

Precipitous declines in Atlantic salmon (*Salmo salar*) populations have led to the loss of all wild salmon in the United States except Maine, where Penobscot River populations have the greatest restoration potential. Dam removal has been identified as the most important restoration strategy, but this can result in the release of contaminants from sediments into overlying waters. To evaluate the toxic potential of Penobscot River sediments, we used a laboratory-based, sediment resuspension design and two well-established aquatic toxicology models, fathead minnows (*Pimephales promelas*) and zebrafish (*Danio rerio*). We collected sediments from Frankfort Flats, downstream of the dams, and characterized them for resuspension-mediated chemical desorption and biological toxicity. Sediment resuspension elevated Penobscot River water concentrations of organic pollutants (PAHs) and several heavy metals, including mercury. Fathead minnow innate immunity was slightly suppressed, and embryo development was slightly delayed in fish exposed to resuspension water, but embryo-larval survival, hatch success, and the incidence of developmental abnormalities were unaffected. CYP1A1 gene expression was elevated up to 70 fold in zebrafish embryos exposed to river water (relative to laboratory water), with or without sediment-suspension. There was no evidence of toxicity due to estrogen-active substances or metals, as measured by zebrafish vitellogenin expression and activation of reporter genes in transgenic zebrafish carrying estrogen-responsive and metal-responsive elements. Thus, although sediment resus-

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pension provoked some biological effects, these were minor and not sufficient to warrant concern. We conclude that resuspension of Frankfort Flats sediments following dam removal is not likely to be a significant source of biologically active contaminants.

David Mitchell, Christine Archer, and Kenneth Heim

ENSR Corporation, Westford, MA, 978/589-3000.

dmitchell@ensr.com, carcher@ensr.com, kheim@ensr.com.

DEVELOPMENT OF A SITE-SPECIFIC WATER QUALITY CRITERION FOR ZINC IN A NORTHEASTERN RIVER

A site-specific water quality criterion (SSWQC) for zinc was developed for a Northeastern river downstream from an industrial facility whose NPDES discharge occasionally exceeded limitations for zinc. To support this potential criterion change, a SSWQC study was initiated that included: (1) monitoring of zinc levels in the facility discharge; (2) three water effects ratio (WER) tests during winter, spring, and summer conditions; (3) Identification of aquatic species and communities for comparison with the list of species used for establishment of the existing zinc criterion; and (4) characterization of hydrological and flow characteristics of the river. The results of the three WER tests indicate that the water chemistry of the river reduced the adverse effects of zinc to aquatic organisms. Results were fairly consistent between seasons, flows, zinc fractions (total vs. dissolved) and test organisms (*C. dubia* and *P. promelas*) with WER values ranging from 2.0 to 2.5. Based on the geometric mean of the results on the primary test organism (*C. dubia*), a final WER of 2.3 was determined. Additionally, using the USEPA methodology for conducting the species recalculation method, a less stringent SSWQC for total zinc was proposed. Based on the results of the WER tests, the recalculation procedure, and characteristics of the River, the SSWQC study concluded that a zinc SSWQC was appropriate and warranted by the available scientific evidence. Results have been reviewed and approved by the regulatory agencies (MA, USEPA) and it is anticipated to result in future reclassification of this segment of the river.

Chris Martin¹ and Keith Kanoti²

¹ Maine Forest Service, Augusta, ME, 207/287-1073, chris.martin@maine.gov.

² Maine Forest Service, Old Town, ME, 207/287-2428, keith.kanoti@maine.gov.

OUTCOME BASED MONITORING OF BEST MANAGEMENT PRACTICES: PUTTING THE DATA TO WORK IN MAINE

The Maine Forest Service (MFS) routinely monitors implementation and the effectiveness of Best Management Practices (BMPs) on timber harvests using an outcome based protocol. Initially developed by MFS and finalized by the USDA Forest Service, this protocol is repeatable and performance-based, built upon underlying principals of water resource protection that rely on measurable evidence rather than specific practice installation. Now in use throughout the Northeast, the Northeast Regional BMP Protocol supplies measurable, repeatable data that are outcome focused. It provides: 1) timely reporting on an important public trust resource, 2) ground-truthed information for responding to inquiries and criticism about harvesting effects on water quality, 3) statewide trends and problem areas, and 4) targeted technical assistance and educational outreach efforts.

Data analysis indicates a preponderance of poorly performing stream crossing structures. Several factors may be contributing: 1) aging land management road infrastructures, 2) improved sizing perform-

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ance standards for crossing structures, 3) increased significant rainfall events, and 4) structure cost. In response, MFS has initiated "Innovative Approaches" to crossing streams in Maine. These initiatives include pilot testing of lightweight yet durable temporary plastic arches, installation of several permanent bottomless culvert demonstration sites, development of a steel bridge panel loaner program, priority watershed-based fish passage inventories, and working with new partners and state agencies.

The Regional BMP Protocol provides credible, reliable and timely data gathering, analysis, and reporting, enabling MFS to identify new cooperative conservation opportunities and resources to get good things accomplished on the ground.

Andrew Reeve, Xavier Comas, Lee Slater

Dept. of Earth Sciences, University of Maine, 207/581-2353, asreeve@maine.edu.

HYDROGEOLOGIC ASSESSMENT OF THE EUTROPHICATION OF THE SIEUR DE MONTS SPRING, ACADIA NATIONAL PARK

The Sieur de Monts spring is a historically significant place in Acadia National Park, providing fresh water for early residents and visitors on Mount Desert Island. The water quality of this spring has deteriorated as severe algal blooms now occur that compromise the ecological integrity and reduce the aesthetic quality of this popular attraction. Several sources for nutrients responsible for the algal blooms have been suggested including on-site wastewater treatment systems and nitrogen-fixing blue green algae. To assess the impact of these sources the following activities were undertaken: near-surface geophysical surveys, interpretation of hydraulic-head data, groundwater sampling for parameters including nutrients and pharmaceuticals, and collection of algal biomass for nitrogen isotope analysis. Geophysical and drilling data indicate that the area is underlain by silty clay inter-bedded with thin sand layers in two basins overlaying medium-grained sand. Hydraulic head data indicate that groundwater flow is generally to the north and west, and is depressed near the Sieur de Monts spring in both the silty clay and deeper sand layer. Downward hydraulic gradients occur in the southern portion of the site, whereas upward hydraulic gradients occur near the spring and northern portion of the study area. Nitrogen and phosphorous concentrations are elevated and trace amounts of 4-nonylphenol are present in two deep wells and a spring pool, indicating that the silty clay layer is either discontinuous (supported by geophysical measurements) or has been breached, allowing wastewater-tainted ground water to migrate into the deep sand layer.

Tin Smith

Wells National Estuarine Reserve, Wells, ME, tsmith@wellsnerr.org.

SEACOAST WATERSHED INFORMATION MANAGER (SWIM) PROJECT

The poster describes a Web site (March release) that supports watershed protection in southern Maine and adjacent New Hampshire by bridging the gap between research, education, and stewardship. The target audience are municipal officials, planning boards, land trusts, watershed coalitions, activists involved in water resource decisions that would benefit from access to research information, reports, data, gis mapping, computer models, workshops, and improved communication. This project is a partnership between the NOAA's Coastal Services Center and the Wells National Estuarine Research Reserve.

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Patricia Bernhardt¹, Tracy Vassiliev², Accelerated Science Students at the James F. Doughty School

¹ James F. Doughty School, Bangor, ME, 207/941-6200, pbernhardt@bangorschools.net.

² William S. Cohen School, Bangor, ME, 207/941-6230, tvassiliev@bangorschools.net.

AN INVESTIGATION OF INVASIVE CRAB SPECIES AT MOOSE POINT STATE PARK

On September 13, 2006 two accelerated science classes at the James F. Doughty School conducted timed transects at Moose Point State Park in Searsport, Maine with support from the Bowdoin College Coastal Science Institute. The purpose of the study was to determine the presence and/or relative abundance of the invasive Asian shore crabs (*Hemigrapsus sanguineus*). Populations of the Asian shore crabs have been discovered at coastal locations in the southwestern portions of the state of Maine.

This study was conducted in the early afternoon at low tide (+0.15 m). Forty students divided a portion of the shore into five transects (10 meters x 2 meters) spanning from the lowest inner tidal point to the mid-tidal range. The students collected all the crabs found within their transect for 20 minutes. At the end of the 20 minutes a total of 197 crabs were collected. They were all European green crabs (*Carcinus maenas*), an established invasive species. The data suggest the Asian shore crab is either absent or present at levels below detection at Moose Point State Park. Thus, green crabs are still the dominant intertidal crab species at this location. We expect, further field studies by future classes will determine if the green crab maintains its status as the dominant crab invader at this site.

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