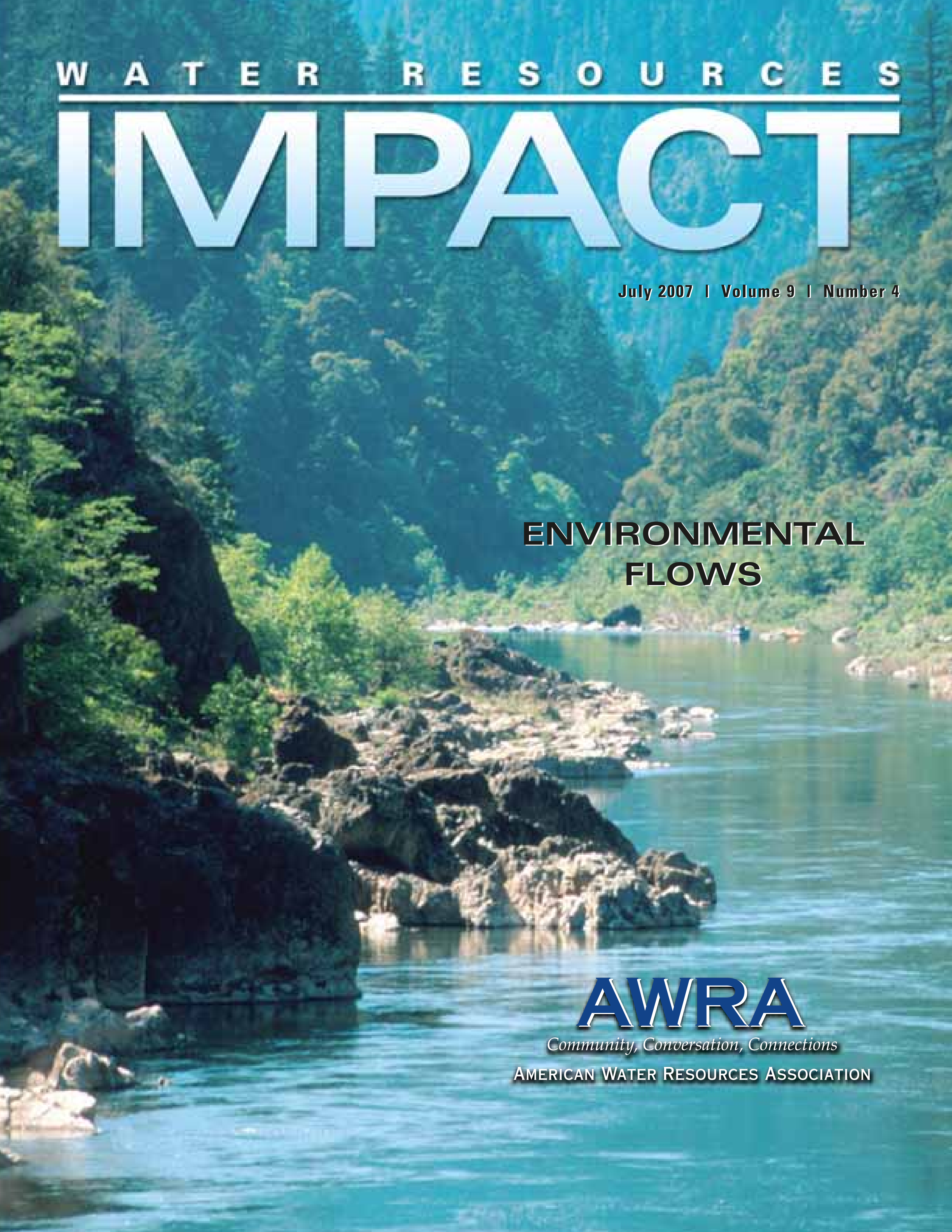

WATER RESOURCES

IMPACT

July 2007 | Volume 9 | Number 4

ENVIRONMENTAL FLOWS

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ENVIRONMENTAL FLOWS

Associate Editor ~ Clay J. Landry ~ landry@waterexchange.com

Guest Editors

Nicole Silk (nsilk@tnc.org) and Andrew T. Warner (awarner@tnc.org)

This issue of *Water Resources IMPACT* focuses on environmental flows and sustainable water management.

WATER RESOURCES

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AMERICAN WATER RESOURCES ASSOCIATION
4 West Federal Street • P.O. Box 1626
Middleburg, VA 20118-1626
(540) 687-8390 / Fax: (540) 687-8395
E-Mail: info@awra.org • Homepage: www.awra.org

EDITOR-IN-CHIEF
N. EARL SPANGENBERG
College of Natural Resources
University of Wisconsin-Stevens Point
Stevens Point, WI 54481
(715) 346-2372 • Fax: (715) 346-3624
E-Mail: espangen@uwsp.edu
(Support for Dr. Spangenberg is provided by the
College of Natural Resources
University of Wisconsin-Stevens Point)

AWRA DIRECTOR OF PUBLICATIONS PRODUCTION
CHARLENE E. YOUNG
3077 Leeman Ferry Rd., Suite A3
Huntsville, AL 35801-5690
(256) 650-0701 • Fax: (256) 650-0570
E-Mail: charlene@awra.org

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Other features in this issue ...

(***Opinions expressed by our columnists are their own and do not represent the opinion or position of AWRA.***)

Scheduled Topics for Future Issues ...

SEPTEMBER 2007
MEASURING MONITORING PERFORMANCE BY LOCAL WATERSHED GROUPS
WINFIELD G. WRIGHT (GUEST EDITOR)
LAUREL E. PHOENIX (PHOENIXL@UWGB.EDU)

NOVEMBER 2007
WATER RESOURCES DISASTER RECOVERY
ERIC J. FITCH (FITCHE@MARIETTA.EDU)

JANUARY 2008
GIS AND WATER RESOURCES
LORRI PELTZ-LEWIS (GUEST EDITOR)
(LPELTZLEWIS@MP.USBR.GOV)

All of the topics listed above are subject to change. For information concerning submitting an article to be included in the above issues, contact the designated Associate Editor or the Editor-In-Chief N. Earl Spangenberg at (espangen@uwsp.edu).

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WATER RESOURCES IMPACT

INTRODUCTION: ENVIRONMENTAL FLOWS

Nicole Silk and Clay J. Landry

THE SUSTAINABLE WATERS PROGRAM

Nicole Silk

Today's water managers face many challenges in their efforts to serve multiple demands upon the world's limited freshwater supply. Allocating water for diverse and often competing traditional uses for water (e.g., industry, agriculture, urban, energy, etc.) is now even more complex due to the implications of climate change. Society's expectation that ecosystem health receive adequate attention and accommodation has expanded this equation even further.

Managing for ecosystem health will certainly benefit both our generation and those that follow us. We simply must take good care of the systems that support us if they are going to continue to support our multiple demands. Historically, such efforts have resulted in choosing either water for people or water for nature. How do we move away from viewing ecosystem needs as competing with human demands for water, from pitting scientists against engineers and lawyers against water management agencies? How do we integrate ecosystem needs into water management?

Discussion about this paradigm shift may sound utopian but change is already underway. Water management agencies around the world who serve interests as diverse as urban water supply, hydropower, flood control, navigation, and irrigation are now considering how to modify their operations to integrate greater accommodation for ecosystem health. Although the motivations for an integrated approach may vary (economic, social, political, environmental, etc.), sustainability has entered our water management lexicon.

This issue of *IMPACT* includes a series of articles that explore the practical side of this trend in water management. We have purposefully left the philosophical underpinnings of and theories behind what has motivated this paradigm shift to other authors. Through the articles included in this issue, we hope that readers will gain a better sense of how this approach is being applied across the country, what tools and methodologies are available to support these efforts, and how one water management agency – the U.S. Army Corps of Engineers – has integrated this approach into their management. Collectively, these articles strive to demonstrate what is possible when we begin working across institutional boundaries and professional disciplines.

The Nature Conservancy is committed to creating a future in which Earth's natural systems are conserved and managed in a sustainable manner for people and nature. Its efforts in working with water managers, scientists, engineers, and others are not an exception to this approach (visit www.nature.org/freshwaters for more information). We hope that this paradigm shift - and the articles included in this edition of *IMPACT* - inspire you as much as they motivate us.

COLLABORATION AND ENVIRONMENTAL FLOWS

Clay J. Landry

With summer in full swing, temperatures are rising across the country. These stresses of summer temperatures coupled with low winter snow and rainfall have left many rivers in places like southern California, the Great Lakes region, and central Alabama water short. The challenges our rivers face this summer may be only the beginning as long term climate changes start to unfold. A recent report by the Intergovernmental Panel on Climate Change (IPCC) warns that river flows throughout the globe are at risk as climate change becomes more acute. While this report may be dire, water users, river managers, conservationists, and scientists are working diligently and collaboratively to address and to balance water needs with environmental flows.

One such partnership began in 2002 between The Nature Conservancy (Conservancy) and the U.S. Army Corps of Engineers (Corps) with a shared mission to restore and preserve rivers across the country. Under the Sustainable Rivers Project, the Conservancy and the Corps will work together to improve dam management in order to protect the ecological health of rivers and surrounding natural areas while continuing to provide services such as flood control and power generation.

This issue of *IMPACT* is a collaborative effort with The Nature Conservancy's Sustainable Waters Program to highlight the cutting-edge work and research the program is conducting. I would like to give a big thanks to Nicole Silk and Andrew Warner of The Nature Conservancy for their hard work in organizing this unique and informative issue as well as their continued dedication to river protection.

Nicole Silk is Deputy Director of The Nature Conservancy's Global Freshwater Initiative. Nicole provides strategic direction and vision as well as managerial support to this global program. She oversees technical, capacity building, and policy related projects as appropriate and contributes to product and tool development related to environmental flow efforts. She also builds relationships with water management agencies, nongovernmental organizations, professional societies, foundations and donors to advance specific aspects of the program's that have greatly improved our ability to identify and study ECs in the environment.

Clay Landry is the managing director and a principal of WestWater Research, a consulting firm providing water marketing and water-asset-valuation services to a range of public and private sector clients. Landry has negotiated and advised on major water transactions throughout the United States.

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WATER RESOURCES IMPACT

WATER: ONE RESOURCE, MANY USES

Lisa T. Morales and Larry J. Prather

As water resources managers, we have a responsibility to meet the growing demands on our Nation's waterways while maintaining economic prosperity, public health, and protecting our precious environmental resources. This is a challenge to all water managers from Federal to local levels. We all must find solutions to manage for competing and conflicting demands on our water resources. Population growth has increased pressure on the demand for water and in some regions, such as the southeast, the southwest, and the far west, population growth has already produced water shortages and will continue to do so in the future. Our intermodal transportation system is stressed by the burdens of meeting the enormous transportation needs of our domestic and international economy. Communities continue to develop in the floodplains increasing the risk to public safety. America's water resources infrastructure is nearing or has surpassed its 50-year planned design life, which has the potential to adversely affect reliability and performance. Overlying these issues is the fact that Americans now place environmental values near the forefront of social priorities. There is increasing emphasis on managing watersheds as integrated systems and meeting the needs of humans and nature simultaneously.

CHANGING ROLES

In the years following World War II, the nation experienced rapid economic and population growth, which placed an unprecedented demand on water supplies. There was a need to reduce flooding in communities that were developing in floodplains and an increased need for stable water supplies. Flood control structures were designed and constructed to meet the needs of these communities, and dams and reservoirs were built to store water to provide the public a dependable water source. The majority of the flood control structures were designed to move water rapidly from vulnerable communities and the most effective engineering solutions were implemented. The solutions implemented during the majority of the 20th Century were not designed using complex computer imaging or modeling, but rather with slide rules, and were the most modern engineering solutions of the time to protect their communities.

These engineered systems allowed communities to prosper economically and to accommodate their growing populations. Some rivers were turned into concrete flood control channels and lost all resemblance of the free flowing, meandering systems that provided habitat for fish and wildlife species. Today, the U.S. Army Corps of Engineers (Corps) is the world's largest public engineering organization, consisting of 30,000 engineers, biologists, economists, ecologists, hydrologists, and many other disciplines. The Corps, along with many other water managers, recognizes the need to keep pace with technology and demands for information so that it can adapt to changing conditions, situations, and social values.

In 2001, the Corps conducted listening sessions around the country. One of the major themes voiced by the public is that there is a critical and growing need for an integrated approach to meeting water challenges. Such an approach recognizes that watersheds are systems providing many different functions and values and that stewardship of watersheds demands consideration of the costs and benefits of the alternative uses of water resources. These systems flow within and between political jurisdictions, adding to the challenges of implementing an integrated approach. Integrated Water Resources Management (IWRM) and the increased formation of watershed organizations is a growing trend. Water managers are shifting the emphasis of water resources management from a project-by-project, jurisdiction-by-jurisdiction approach to a more holistic, integrated approach that requires increased coordination and cooperation at all levels.

As the Corps develops and strenghtens the bonds of partnership for Integrated Water Resources Management among engineers and scientists, it must also bring policy and decision makers and the community of stakeholders into the discussions

IWRM must involve every level from the hydrologic cycle of a watershed, engineering systems, economic development, ecosystems, and responsible governmental systems – Federal, state, and local. Water presents a complex set of challenges and recognizing the interconnection of all the systems means managing on several layers. As water managers, we need to work together to improve our scientific capacity for managing water and do that in cooperation with states, localities, academia, and other partners that have the capacity to build a long term commitment for stronger science and better information.

ENGINEERS AND SCIENTISTS

Engineers and water managers recognize that improving scientific capacity among operators and policy makers is critical to implementing an integrated approach to water resources management. With only 2 percent of all major rivers in the United States remaining unregulated, water managers and engineers exert substantial influence over when and how water moves within our nation. They must take into consideration the extremes of climate variability and natural disasters to ensure uninterrupted water supplies, safe waterborne transportation, and flood risk management to sustain our economy and well being. While meeting these demands they are tasked with maintaining healthy aquatic ecosystems that support threatened and endangered species.

Changes in the flow regimes of highly engineered systems have contributed to loss of riverine and riparian functions and values. Many species have been adversely impacted by changes in water temperature, obstruction of historic migration routes, and anthropogenically altered flow regimes that have not taken ecosystem needs into consideration. The threatened and endangered aquatic species that depend upon healthy ecosystems are indicators that we need to review how we operate our facilities and achieve a more holistic approach while maintaining or improving authorized project benefits, such as preserving reservoir levels and keeping flood damage to a minimum. The Corps has been working to build long-term capacity with its scientific partners including other Federal agencies, nongovernmental organizations, and academia, to improve the ecological performance of these systems. Building this long-term capacity allows us to leverage our limited funds and partner more effectively by sharing information and bringing together a broader body of scientific knowledge.

Another opportunity to restore natural flows is during the re-evaluation of our nation's large water resources capital stock. Over the years the Corps has constructed many water resources projects that have sustained our economy and quality of life. Over time economic and environmental conditions have changed as have the Nation's valuation of environmental outputs. We should commit to continual review of project outputs and consider redirecting project purposes to incorporate environmental factors.

The Corps is bringing together scientists and engineers to review how it operates its facilities and work in partnership with academia and other stakeholders. For example, under the Sustainable Rivers Project, a partnership with The Nature Conservancy, the Corps is reviewing operations on a series of dams on nine different river systems. Although the body of knowledge and science of flow-ecology is relatively young, the Corps is able to contribute to knowledge capital as it develops new tools and modeling systems. By increasing the conceptual, technical, and institutional tools available, the Corps is providing planners and facility operators groundbreaking opportunities to change the way they manage their facilities. This knowledge will help foster more sustainable water management in the U.S. and around the world.

CONCLUSION

As the Corps develops and strengthens the bonds of partnership for IWRM among engineers and scientists, it must also bring policy and decision makers and the community of stakeholders into the discussions. Engineers and scientists must contribute to policy formulation and recommendations for investment or operations. The Corps planning model rests on a sound foundation aimed at systematically identifying water problems and evaluating alternative solutions. Within that framework, engineers, scientists, stakeholders and decision makers can work together synergistically to achieve the plans and strategies to integrate the full range of economic and environmental values within our nation's watersheds. The work will be daunting but we have begun with a solid commitment to collaborative planning to pursue water management improvements that contribute to environmental, national, and regional economic and social goals. We welcome stakeholders to join us in the work and make water management better than ever.

AUTHOR LINK Lisa T. Morales
U.S. Army Corps of Engineers
Directorate of Civil Works
441 G St., NW
Washington, DC 20314-1000
(202) 761-7664 / Fax: (202) 761-5654

E-MAIL Lisa.T. Morales@hq02.usace.army.mil
Larry.J.Prather@hq02.usace.army.mil

Lisa T. Morales currently serves as a physical scientist and program manager at the Headquarters, USACE, in Washington, D.C. She is responsible for managing strategic relationships with national environmental organizations such as The Nature Conservancy, Audubon Society, and Ducks Unlimited. She supports Congressional Committees in development of the Corps authorizing legislation, the Water Resources Development Act, for water and related land resources of the U.S. As Corps Headquarters liaison for the National Sustainable Rivers Partnership with The Nature Conservancy, she guides a small group of Corps scientists and engineers stationed in many Districts in developing ways to operate Corps projects in more environmentally sustainable manners. Ms. Morales completed her Bachelor of Arts in Geography from California State University at Los Angeles in 1991 and continued graduate studies in geography at Cal State Los Angeles.

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HAVE SOME COMMENTS ABOUT THIS ISSUE OF IMPACT?

SEND US YOUR FEEDBACK

Water Resources IMPACT is in its ninth year of publication and we have explored a lot of ideas. We hope we've raised some questions for you to contemplate. "Feedback" is your opportunity to reflect and respond. We want to give you an opportunity to let your colleagues know your opinions ... we want to moderate a debate ... we want to know how we are doing. For this issue send your letters by land-mail or e-mail to Clay Landry (landry@waterexchange.com). Comments may also be sent to Earl Spangenberg (espangen@uwsp.edu). Either way, please share your opinions and ideas. Please limit your comments to approximately 350 to 400 words. Your comments may be edited for length or space requirements.

WATER RESOURCES IMPACT

INCORPORATING ENVIRONMENTAL FLOWS INTO WATER MANAGEMENT

Andrew T. Warner

The scientific community has made substantial advances during the past 10-20 years in understanding the relationship between patterns of river flow, and the health and ability of ecosystems to provide a range of goods and services valued by people. In general terms, this improved understanding recognizes that natural patterns of river flows – from seasonal low flows to periodic floods – are vital for maintaining the long-term health of our rivers and associated floodplains and estuaries. Unfortunately, these advances have not been integrated with or transformed water management practices during this same period. In fact, during the past half a century, societal demands for municipal water supplies, irrigation to support agriculture, industrial water use, flood control, hydropower generation and navigation have resulted in extensive modification of river flows. For example, 98 percent of the major rivers in the United States are regulated by dams. Moreover, these changes have impacted all components of river flows including ecologically important low flows, high flow pulses, and floods. Even when water management has considered environmental concerns, the focus has largely been limited to maintaining some level of "minimum instream flow." The significant improvements in the science of rivers of the past two decades currently influences actual management practices on only a very small percentage of the world's rivers.

Example River Flow Alteration Due to Dam Operations

- Decreased low flows due to agricultural or municipal water supply
- Elevated low flows to accommodate pollution discharges
- Loss of small floods (2-20 year events) for flood control, water supply, or hydropower
- Sustained high flows (near bankfull) for flood control
- Rapid and increased fluctuations in flow conditions for hydropower

Fortunately, an encouraging amount of work is going on globally to develop and implement innovative water policy and river-specific management practices that protect or restore ecosystem health while meeting human needs for water and energy. One process for defining and implementing river-specific environmental flows within an adaptive management context is outlined below, along with lessons learned from its application across the United States and – sparingly to date – in other countries. The focus here is on its application in helping to guide reservoir operations, although it is also applicable to other water management settings.

Environmental Flows

Flow of water in a river or lake that sustains healthy ecosystems and the goods and services that humans derive from them. Effective quantification of environmental flows includes the ecologically important range of flow magnitudes (low flows, high flow pulses, and floods), as well as the timing, duration, frequency, and rate of change of the flow conditions. Globally, "environment flows" is the most common term used, but "ecological flows" or the more dated "instream flows" are also used in some places to have the same intended meaning.

A process for defining and implementing environmental flows within an adaptive management context described by Richter *et al.* (2006) is being applied across the United States through a national collaboration between the U.S. Army Corps of Engineers (Corps) and The Nature Conservancy (Conservancy) under the Sustainable Rivers Project (SRP). While the SRP involves a range of efforts including formal personnel sharing, joint training, and joint software development (see the article by John Hickey in this issue), the cornerstone of the project is the work being advanced at demonstration sites across the country. There are currently nine river systems enrolled in the SRP involving 26 Corps dams (Figure 1), with additional dams and rivers under consideration. The goal of the project is to demonstrate ecologically sustainable water management so that it can be applied at the more than 630 dams operated by the Corps and by other water managers globally.

> *Environmental flows defined using the Savannah Process explicitly ignore all real or perceived constraints to their immediate implementation, including those that are physical, legal, social, political, or financial*

Nicknamed the "Savannah Process" for the river where it was first applied, the process described in Richter *et al.* (2006) is designed to be science-based, deeply interdisciplinary, adaptive, and flexible enough to be customized based on available time and resources. The Savannah Process involves the following five basic steps (Figure 2):

1. *Orientation Meeting* – This is the kickoff of the Savannah Process, bringing together diverse scientists and representatives from all key agencies and organizations with water management interests in the basin. The remaining steps (Steps 2-5), expected timeline, products, costs, and roles and responsibilities are outlined and

Figure 1. Current Sustainable River Project Sites (May 2007).

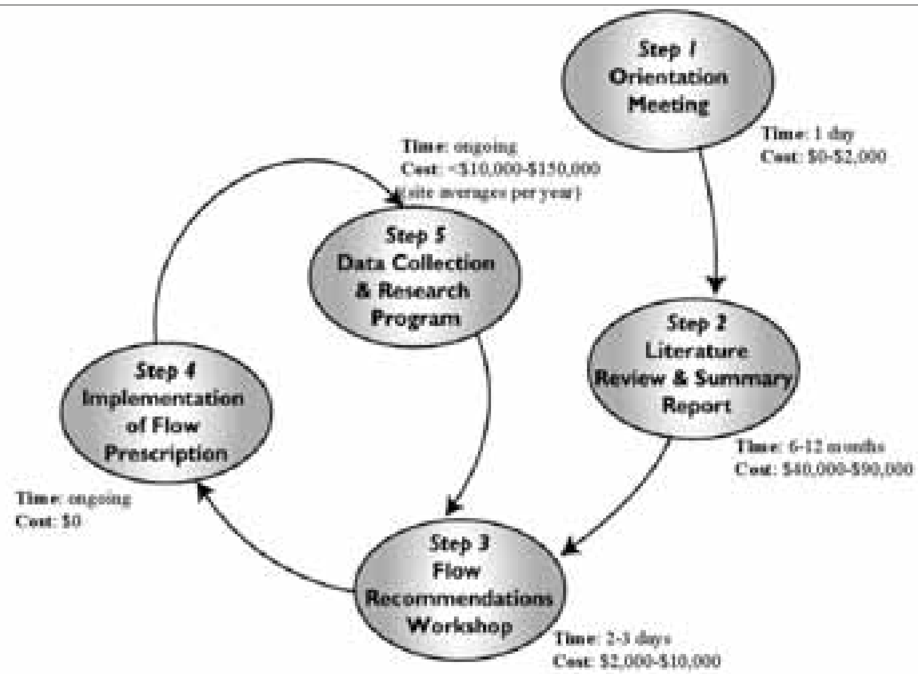

Figure 2. Process for Defining and Implementing Environmental Flows Within an Adaptive Management Context (the "Savannah Process") (modified from Richter *et al.*, 2006).

discussed. Orientation meetings have involved between 40 and 100 people.

2. *Literature Review and Summary Report* – A small team of scientists is tasked with: (a) conducting an extensive review of existing published research and gray literature related to flow-ecology relationships in the river and similar rivers in the region; and (b) synthesizing this information into a "summary report" designed to inform the environmental flow workshop (Step 3). This team has a designated lead, typically consists of 5-10 scientists, and needs to be diverse in its expertise. For example, a team might consist of a hydrologist or fluvial geomorphologist, fish and mussel experts, and riparian and estuarine ecologists. Drafts of both the literature review and summary report are distributed for comment to all who attended the orientation meeting, with comments addressed and the reports redistributed a month prior to the flow workshop.

3. *Environmental Flow Workshop* – This facilitated workshop, which is typically an intensive 2-3 day event, produces two very important products. The first is a unified set of environmental flow recommendations that give consideration to river, floodplain, and – where appropriate – estuarine systems, and encompass requirements for low flows, high flow pulses, and floods for different year types (e.g., climatically dry, average, and wet years). Each of the environmental flow components that make up the recommendations are quantified (flow magnitude, duration, timing, frequency, and rates of change) and explicitly stated in terms of the ecological processes that are hypothesized to support (Figure 3). The second product is a prioritized list of information gaps to help guide research and monitoring efforts. These flow workshops have involved between 35 and 90 people.

20,000-40,000 cfs; 2-3 days, 1/month (Jan-May)
- Provide predator-free habitat for birds
- Disperse tree seeds
- Transport fish larvae
- Flush woody debris from floodplain to channel
- Floodplain access for fish
- Fish passage past NSBLD

Figure 3. A Portion of the Environmental Flow Recommendation for the Savannah River. The magnitude, duration, and frequency of this controlled flood are quantified, as are the ecological processes that will be supported by the flow event.

4. *Environmental Flow Implementation* – This involves modifying reservoir operations or other water management practices to create river flows as called for in the workshop recommendations (Step 3). In terms of implementation, defined environmental flows tend to fall into one of three categories: (a) those that can be implemented immediately without significant conflict, (b) those that require study – typically involving computer modeling – to assess the implications of their implementation, and (c) those with significant social and/or economic implications that require long-term planning and likely substantial investment to implement.

5. *Monitoring and Research* – As noted above, a list of priorities for monitoring and research is one of the important products emerging from the flow workshop (Step 3). Each of the environmental flow components that comprise the recommendations is linked to specific ecological processes. They are, in effect, hypotheses that are tested through coordinated reservoir operations and monitoring. These hypotheses and the scientific knowledge gaps identified and ranked during the workshop provide a foundation for setting formal monitoring and research priorities.

The time and cost for this process varies. To date, environmental flows have been defined (Steps 1-3 completed) at six of the nine SRP sites, taking a total of six to 12 months and costing between $40,000 and $90,000. Environmental flows have been partially implemented (Step 4) at five of these sites, along with different degrees of associated monitoring and research (Step 5). Implementation involves planning, such as storing water earlier in the year, but it is also responsive to specific circumstances such as large rainfall events. Most of the engineer-scientist teams meet quarterly to discuss and coordinate reservoir releases and monitoring for the upcoming season. Estimated costs for monitoring and research at SRP sites range from a low of less than $10,000 to more than $150,000 per year. Sites at the higher end of this range are those where more intensive fieldwork was conducted to support computer model development.

Environmental flows defined using the Savannah Process explicitly ignore all real or perceived constraints to their immediate implementation, including those that are physical, legal, social, political, or financial. The purpose of the process is to define the river flows that are necessary to maintain long-term ecosystem health. Any necessary tradeoffs between this goal and other expectations for water management are made elsewhere. This approach to defining environmental flows has: (1) helped advance understanding of the ecosystem processes that will not be supported by different management options, and (2) highlighted opportunities to align ecosystem restoration or protection with other more traditional human demands for water such as improving flood control or hydropower generation.

In collaborating to move through the Savannah Process, water managers and scientists establish working relationships that are mutually beneficial. At each of the SRP sites where environmental flows have been defined and are being implemented, formal and informal conversations now occur between these groups on a quarterly, monthly, or even weekly basis. The engineers benefit from having real-time access to experts who can provide constructive guidance on how to meet multiple management objectives in the most ecologically beneficial (or at least benign) way. The scientists benefit by engaging the water managers – those who control river flows – as partners in research. As a collective, they are positioned to run experiments to determine how different flow conditions relate to ecosystem health and the goods and services humans derive from healthy ecosystems. This relationship is ongoing and allows for experimentation not only around a single event or for a single year, but for a long series of years. This directly supports adaptive management and serves to advance river science.

Finally, the Savannah Process has begun to see application beyond the SRP and the United States. The process is currently being used to define environmental flows for municipal water supplies involving dams and ground water extraction in places such as the Rivanna River in Virginia and the Verde River in Arizona. The process is also being applied in China and Honduras, the latter of which is faced with a dearth of scientific information and is relying heavily on indigenous knowledge. It is in part this flexibility that has gained the process a growing acceptance. Moreover, it is the pairing of engineers and scientists through the process that will lead to improved management, advances in science, and better protection and restoration of rivers globally.

REFERENCE

Richter, B.D., A.T. Warner, J.L. Meyer, and K. Lutz. 2006. A Collaborative and Adaptive Process for Developing Environmental Flow Recommendations. River Research and Applications 22:297-318.

AUTHOR LINK Andrew T. Warner
The Nature Conservancy
406 Forest Resources Bldg.
University Park, PA 16802
(814) 863-2506 / Fax: (814) 865.3725

E-MAIL awarner@tnc.org

Andrew Warner is a Senior Advisor for Water Management with The Nature Conservancy's Sustainable Waters Program. He also is the Conservancy's National Coordinator on the Sustainable Rivers Project, a national collaboration between TNC and the U.S. Army Corps of Engineers. Andy has 18 years of experience in the environmental and conservation fields on projects and policy relating to water, water quality, and floodplain management. In his current position, Andy works with government agencies, academic institutions, and private organizations to identify and implement innovative water management strategies that meet human demands while maintaining healthy ecosystems. Andy received a Master of Science in Watershed Science from Colorado State University and a Bachelor of Science in Water Resources from Ohio University.

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WATER RESOURCES
IMPACT

MODELS AND SOFTWARE FOR SUPPORTING ECOLOGICALLY SUSTAINABLE WATER MANAGEMENT

John T. Hickey

INTRODUCTION

The Sustainable Rivers Project (SRP) is an ongoing partnership between the U.S. Army Corps of Engineers (Corps) and The Nature Conservancy (Conservancy) to improve the health and life of rivers by changing the operations of Corps dams (see article by Andrew Warner in this issue for more information about the SRP). Experiences at different SRP sites are helping to refine a roadmap for technical support of ecologically sustainable water management pursued by Corps projects (Figure 1). This collaboration between water managers and scientists has also fostered the development of specific tools through the Corps' Hydrologic Engineering Center (HEC) that provide information to help managers better understand the implications of reservoir operation decisions. (The mission of HEC is to support the nation in its water resources management responsibilities through programs in research, training, planning analysis, and technical assistance.) This article details a few of the tools being used to help study river flows at SRP sites and concludes with some perspectives on technical support for ecologically sustainable water management.

The tools described by this article do not represent the full spectrum of technologies being applied to make water management more ecologically sustainable. Rather, they represent the addition to this body of work resulting from the SRP sites and HEC engagement. For additional reading related to tools and approaches related to ecologically sustainable water management, the following papers and websites may prove helpful (Arthington and Pusey, 2003; King ***et al.,*** 2003; Hughes, 2001; www.fort.usgs.gov/ASTA/;www.catchment.crc.org.au/research/index.html).

As awareness leads to improved scientific understanding (and vice versa), more strategies linking water and ecosystem management will be identified, which will in turn become new analytical challenges for software tools

DEVELOPING A TECHNICAL ROADMAP

Technical support for ecologically sustainable water management typically begins with establishing a solid hydrologic understanding of how the river has been altered. This requires the preparation and analysis of hydrologic data sets that compare river flows for regulated (with reservoirs and other alterations of the flow regime) and unregulated conditions (Figure 2). These data can be prepared through a variety of mass-balance, stochastic generation, or simulation approaches. Choice of method depends on the availability and condition of gage data as well as the budget and preferences of the study team investigating the river. Once completed, these data serve as a foundation for additional technical efforts, including processes for defining ecosystem flow recommendations. They also relate to the six linked models noted in Figure 1.

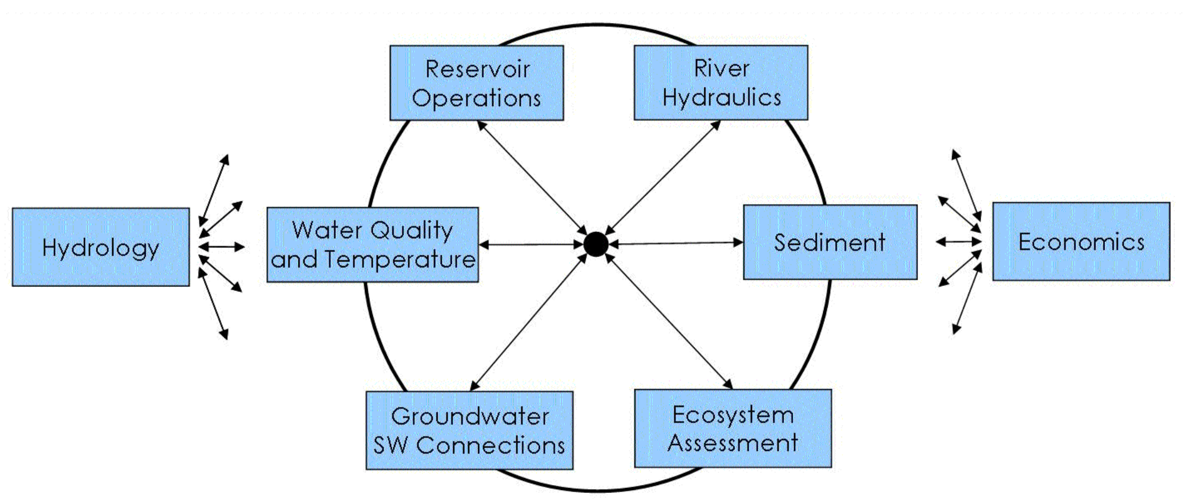

Figure 1. Connections Between Different Types of Models for Supporting Ecologically Sustainable Water Management.

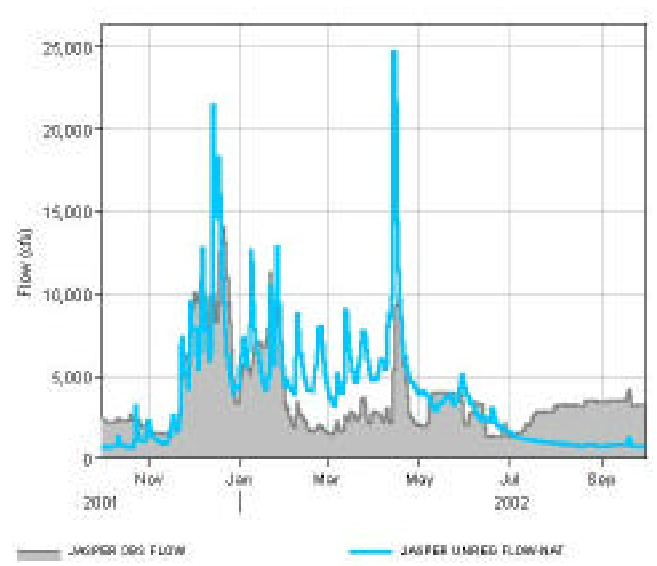

Figure 2. Regulated (Obs) and Unregulated Flows for the Middle Fork Willamette River at Jasper, Oregon. There are three major reservoirs upstream of this location. Note the reduced peaks to limit downstream flooding, increased flows in the spring and summer to meet downstream flow targets, and the seasonal capture (spring) and release of volume (fall) as the pools are brought up from and drawn down to winter levels, respectively. Data prepared by Portland District, USACE.

Defining Ecosystem Flow Recommendations

The first SRP site to complete an ecosystem flows workshop was the Savannah River, where nearly 50 scientists collaborated to formulate ecological recommendations for flows in the Savannah River (see articles by Andrew Warner and Amanda Wrona-Meadows ***et al.,*** in this issue). During this workshop, many hydrographs were created, discarded, and morphed. Facilitators were pressed to track all of the recommendations and lacked an easy way to present results electronically. It was noted that a tool capable of rapidly displaying, adjusting, and documenting hydrographs would make the formulation process easier and if this tool was also capable of plotting historical hydrologic data to guide the scientists upon their request, then the product as well as the process would be improved. These comments and others inspired HEC and the Conservancy to collaboratively develop the Regime Prescription Tool (HEC-RPT).

The latest SRP site to complete an ecosystem flows workshop was the Willamette River (see article by Leslie Bach ***et al.,*** in this issue). It was the first to use HEC-RPT (Figure 3) to help groups of people reach informed agreements about how to manage the flow regime of a river. Recommendations formulated in HEC-RPT can be exported for analysis in other software, including reservoir operations, river hydraulics, and ecosystem assessments.

Operations, Hydraulics, and Ecosystem Assessment

Generally, of the six linked models in the center of Figure 1, reservoir operations, river hydraulics, and ecosystem assessment are at the core of technical support for ecologically sustainable water management.

Reservoir operations models simulate the storage and release of waters in systems of reservoirs. These models are typically either rule-based simulation or goal-based optimization models, or a combination of the two. Simulated water releases in rule-based models are guided by rules specified by the modeler (e.g., a minimum flow rule might say "avoid releases less than 10-cfs"). Rules are created, prioritized, and modified to make simulated releases agree with how the reservoirs are actually operated. When the model is producing reasonable results, rule sets can be changed to test different management approaches (start with current operations and change from there). Optimization models take a different approach – they make decisions that optimize the net benefits of the water, subject to user defined constraints. This is a nice complement to rule-based approaches because it encourages study teams to consider a different perspective about operations (start at an optimized operation and change from there). HEC-ResSim (Reservoir System-Simulation) is a rule-based model being applied at a number of SRP sites (Figure 4).

River hydraulics models use channel topographies to translate flow rates to river depths, velocities, inundated areas, and a host of other output. Models are described by the number of dimensions in which water velocities are computed (1-d means that velocities are computed in line with the river channel at any given cross section, the second dimension adds a velocity component from bank to bank, and the third adds a vertical velocity within the water column) and by whether the model performs steady (flow values are simulated independently) or unsteady state (time series of flow are simulated) calculations. The River Analysis System (HEC-RAS) is a 1-d model that performs steady and unsteady state simulations (Figure 5). It also has recently added algorithms for computing stream temperatures and sediment transport. Hydraulic modeling is a critical step in understanding the physical connections between land and water, which enables a more detailed look at ecosystem dynamics.

Ecosystem assessment techniques and the software that support them run the gamut from simple regression equations that compute biomass based on variables like river flow and reservoir storage to complex models for simulating things like forest or fish population dynamics. Towards the middle of that spectrum is the Ecosystem Functions Model (HEC-EFM), a tool that helps translate changes in a flow regime to an ecosystem response using statistical and spatial analyses (Figure 6). As part of the progression of models, output from reservoir operations and river hydraulics models are fed into HEC-EFM, which then computes how those changes affect different aspects of the ecosystem. Statistical and spatial results are generated to estimate the direction and magnitude of ecosystem changes.

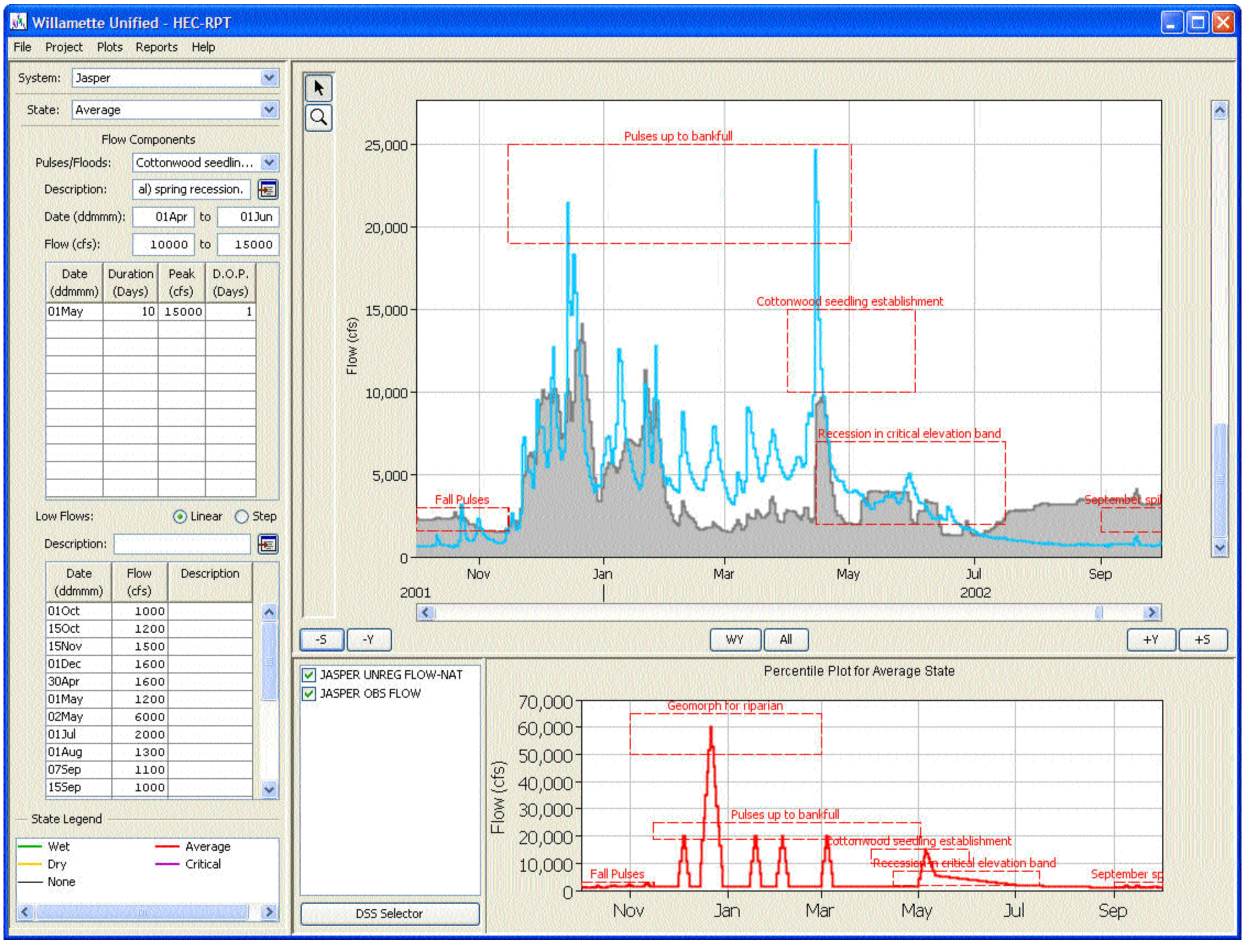

Figure 3. Main Interface of HEC-RPT With Results From the Willamette Flows Workshop. The software allows users to view historical data (note that the time series in the upper plot are the same as those in Figure 2) and electronically trace flow recommendations for the ecosystem and other perspectives on how the river might be managed.

CONCLUSIONS

By fostering dialogue between water managers and biologists about how to make water management more ecologically sustainable, efforts like the SRP are helping to illuminate new opportunities to improve the methods and tools used in technical support of ecologically sustainable water management.

The tools detailed above are primarily engineering software. Development of models in the water management arena has typically been guided by the needs of engineering tasks like floodplain delineation and reservoir simulations for flood routing, hydropower, and water supply. Ecosystem concerns have not been dominant influences. This has created engineering software with much latent potential for environmental applications, as demonstrated (in a small way) by the partnered development of HEC-RPT, which adopted many of its components from existing software.

There is a growing awareness of the influence of water management activities on ecosystems. As awareness leads to improved scientific understanding (and vice versa), more strategies linking water and ecosystem management will be identified, which will in turn become new analytical challenges for software tools. Funding pathways that encourage ecologists and biologists to participate more in the evolution of engineering models are needed to accelerate the growth of these technical capabilities.

ACKNOWLEDGEMENTS

Several HEC efforts in the environmental arena (including integration of stream temperature in HEC-RAS and continued development of HEC-EFM) are supported in part by the Corps' System-Wide Water Resources Program (SWWRP). HEC thanks SWWRP for its continued support. More information about SWWRP and the HEC tools is available at www.erdc.usace.army.mil/ and www. hec.usace.army.mil/, respectively.

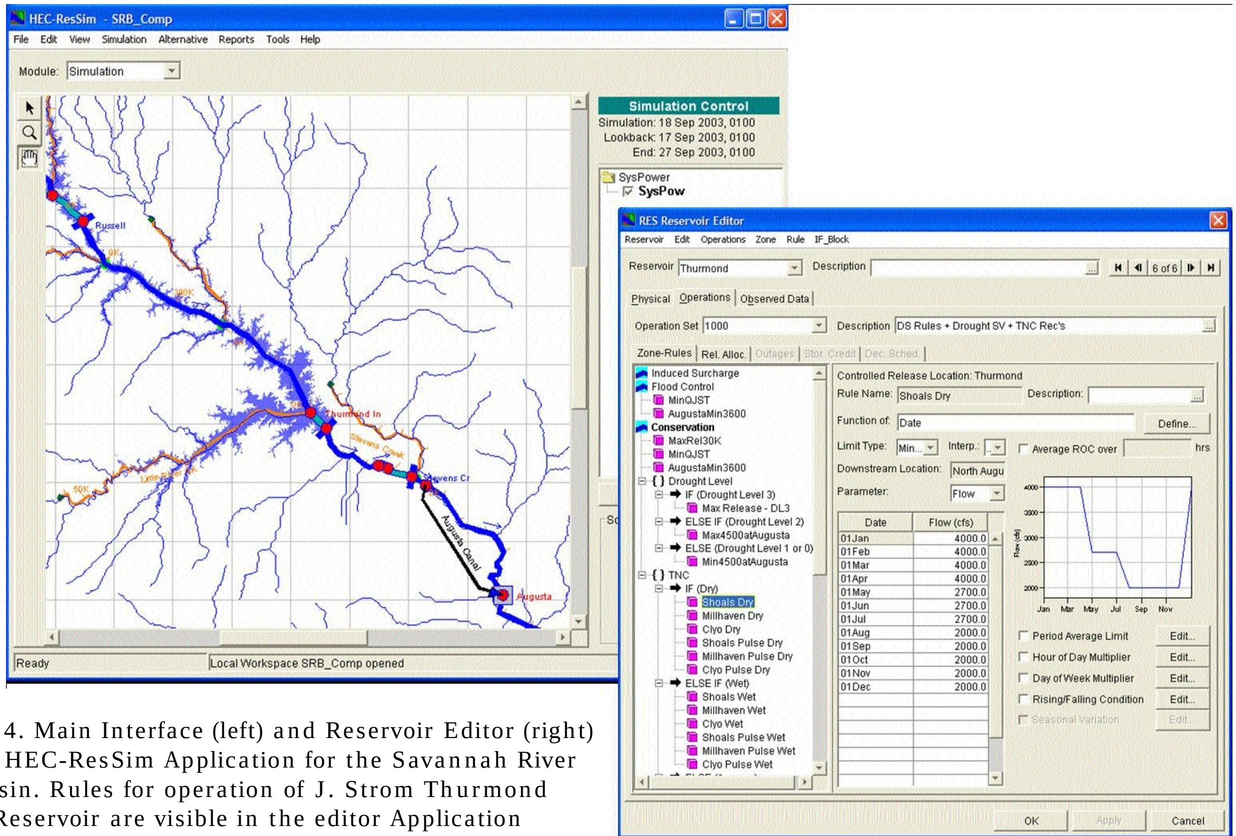

Figure 4. Main Interface (left) and Reservoir Editor (right) of an HEC-ResSim Application for the Savannah River Basin. Rules for operation of J. Strom Thurmond Reservoir are visible in the editor Application created by Jason Ward and Stan Simpson, Savannah District, Corps.

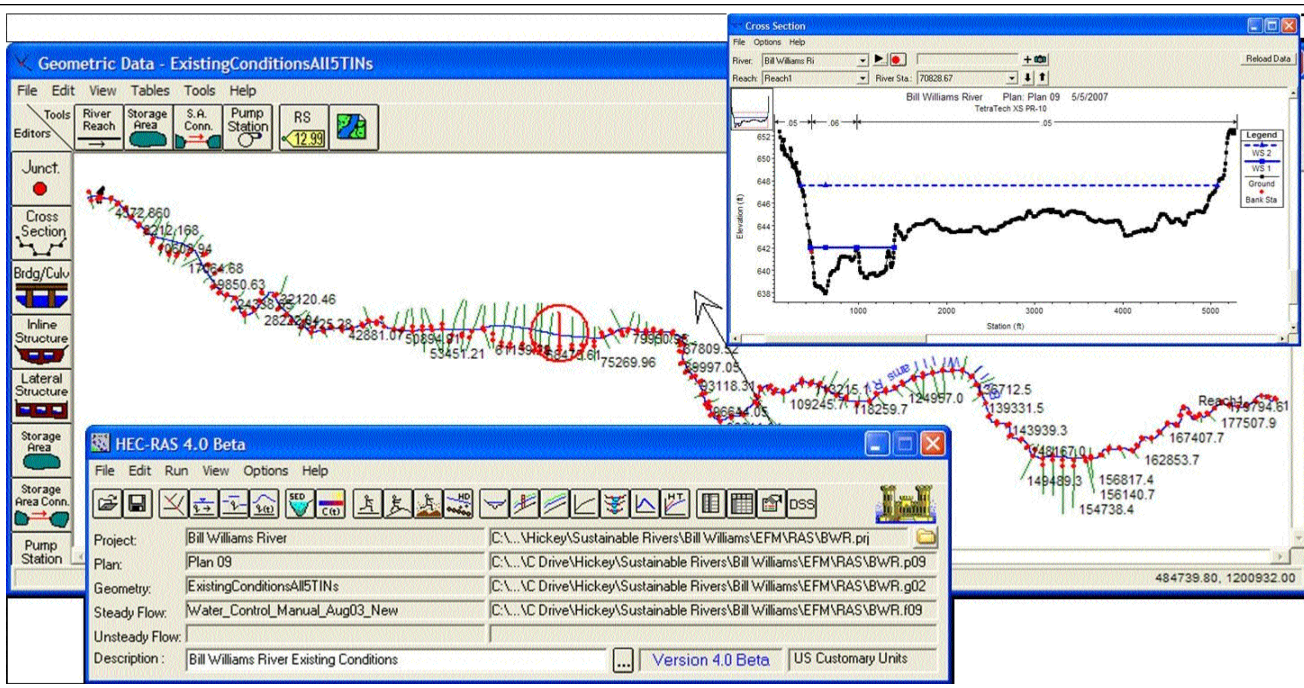

Figure 5. Main Interface (bottom), Geometric Data Editor (middle) and Cross Section View (top) of an HEC-RAS Application for the Bill Williams River, Arizona. Two steady state profiles are shown in the cross section view. The solid horizontal line is the simulated water surface for 7,000-cfs, the current maximum release rate of the upstream reservoir. The dashed line is the water surface for 100,000-cfs, which is close to the historical maximum flow in the pre-dam record. Application created by Van Crisostomo, Los Angeles District, Corps.

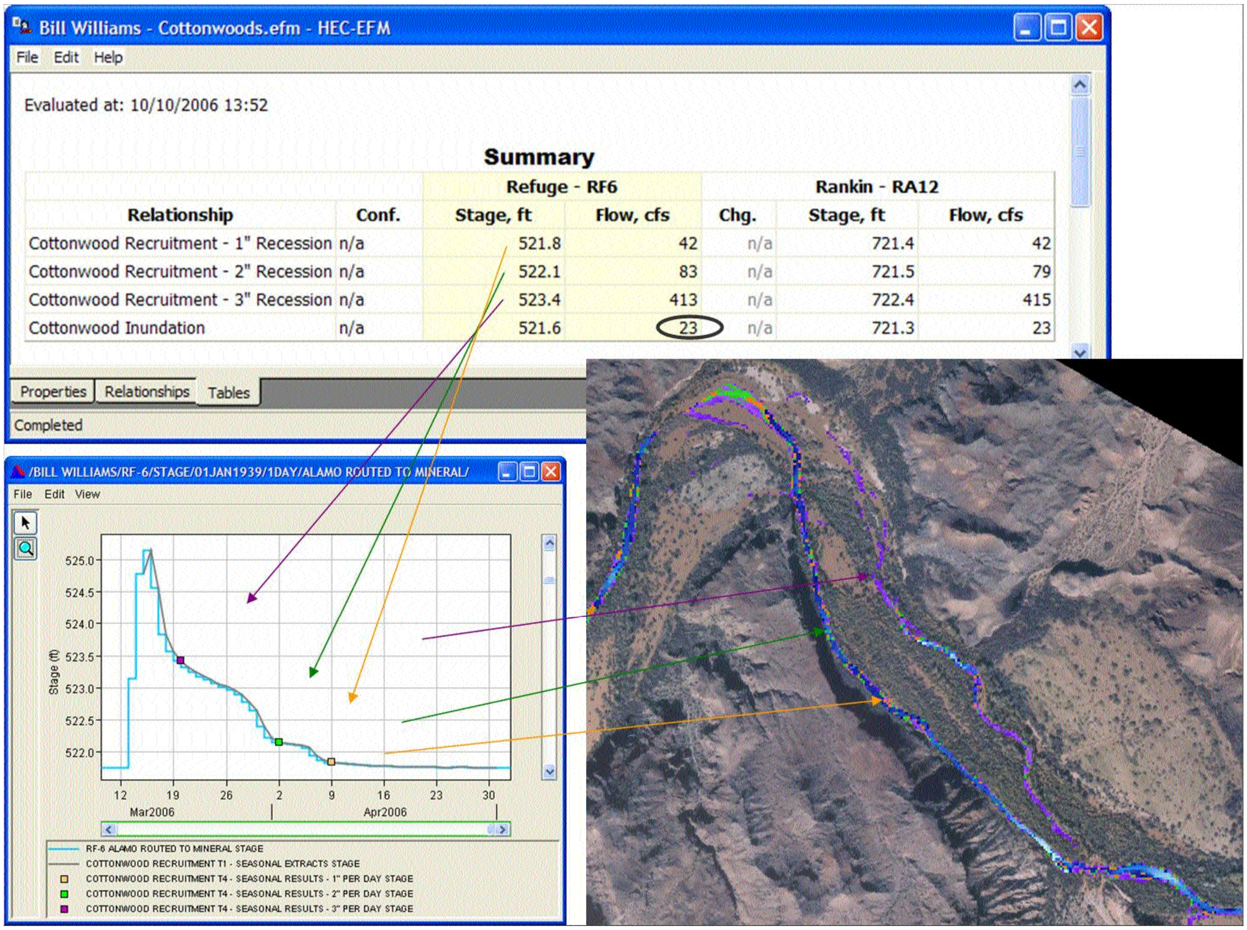

Figure 6. Figure shows an HEC-EFM Analysis of Simulated Cottonwood Establishment Produced by an Experimental Flow Release (bottom left) From Alamo Dam on the Bill Williams River, Arizona. Three recession rates (1 inch, 2 inches, and 3 inches per day) were tested as suitable for cottonwood recruitment. Each rate was used as a statistical parameter in HEC-EFM, which computed the point on the recession limb where the rate was last exceeded. These statistical results were output to the main interface of HEC-EFM (top) and then modeled using HEC-RAS and GeoRAS to generate spatial layers (bottom right) showing where cottonwood seedlings were predicted to establish.

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AUTHOR LINK John T. Hickey
USACE, CEIWR-HEC
609 Second Street
Davis, CA 95616
(530) 756-1104 / Fax: (530) 756-8250

E-MAIL john.t.hickey@usace.army.mil

John T. Hickey is a Senior Hydraulic Engineer at the Hydrologic Engineering Center of the USACE. At HEC, he leads development of the Ecosystem Functions Model (HEC-EFM), which is a tool for analyzing ecological effects of changes in flow regimes, and the Regime Prescription Tool (HEC-RPT), which is a tool designed to help groups of people reach agreements about how to manage river flows. While at HEC and in past positions as a biohydrologist, water manager, limnologist, and fisheries biologist, John has studied river, lake, and reservoir systems across the U.S. He is a registered professional engineer and received a M.S. in hydrologic science and engineering from Colorado State University-Fort Collins, and a B.S. in environmental and forest engineering from the SUNY College of Environmental Science and Forestry-Syracuse. John is also pursuing a PhD in ecosystem and water resource management from the University of California-Davis.

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GREEN RIVER, KENTUCKY, CONSERVATION PROJECT

W. Michael Turner

How can something exist and not exist at the same time, effect change yet remain almost invisible and virtually unknown? Such a situation would not appear to be a formula for success. But, it is, and therein is the story of the Green River Conservation Partnership.

Citizens and agencies of Kentucky and the Federal government had been working in their own areas of interest in the Green River basin for many years. Mammoth Cave National Park (MCNP) was largely a result of citizen involvement. Contamination of Lost River and Hidden River caves prevented visiting such until pollution was ended as a result of U.S. Environmental Protection Agency involvement in the early 1990s.

The Nature Conservancy (TNC) began its involvement in the Green River basin in the late 1990s and served as a catalyst to bring together many parties sharing an interest in the river. The National Park Service, the U.S. Army Corps of Engineers (Corps) and others had worked together before but now there seemed to be a more common and unified purpose – protection and restoration of the Green River. These projects include the Sustainable Rivers Project, the Handy Riparian Habitat Restoration Project, Mussel Propagation and Reintroduction, Conservation Reserve Enhancement Program and the possible removal of Lock and Dam No. 6.

GREEN RIVER BASIN

The Green River basin is located almost entirely in west central Kentucky covering more than 9,300 square miles. Topography varies from gently rolling in the east to the moderately rugged Western Kentucky coalfields and then into a broad, nearly flat alluvial flood plain as the Green River joins the Ohio River. Generally, the lower third of the basin has more flooding due to relatively level terrain. The middle third, especially tributaries, is greatly impacted by acid mine drainage. Threats to the upper third, the area of Green River Bio-reserve, include agricultural runoff and timbering.

SUSTAINABLE RIVERS PROJECT

The Green River is one of the most biologically diverse rivers in the country. Among its 151 species of fishes and 71 species of freshwater mussels are 12 endemic fishes, more than 35 imperiled aquatic species, and 10 threatened or endangered species that depend on the river and its tributaries for their life cycle requirements. Examples include the eastern hellbender, American eel, and gray and Indiana bats. The Green River forms the base level for on-going development of the Mammoth-Flint Ridge cave system, the longest mapped cave system in the world. The endangered endemic Kentucky Cave Shrimp is one of many species dependent upon this subterranean habitat. The Green River holds the last known reproducing population of the endangered ring pink mussel.

Green River Lake became the first Corps project to receive approval for permanent operation for ecological benefits downstream of a Corps reservoir as part of the Sustainable Rivers Project, a joint effort of the Corps TNC. Final approval was granted on May 16, 2006. This approval was the culmination of a collaborative effort that had its beginnings with a fall 1998 meeting between the Corps' Louisville District and TNC.

Beginning in 1999, TNC and Corps staff worked together to develop reservoir management alternatives that were ecologically sustainable while maintaining authorized project purposes. A preferred plan was identified and implemented on an experimental basis in December 2002. The most important changes are: raising winter pool elevation; delayed fall drawdown and spring filling of the lake; greater use of maximum releases during non-crop seasons; increased releases following crest of downstream high water events; and passing of precipitation events, especially summer thunderstorms, through the uppermost gates of the lake's multilevel control tower as much as possible. Benefits realized from these changes are: improved conditions for reproduction of aquatic species, especially endangered mussels; improved water quality of releases primarily during fall drawdown; extended recreation season on the lake; and variability of releases mimics natural hydrograph prior to dam construction. While temperature control is improved, periods of colder water releases remain a concern during the spring. Experimental operations were evaluated for three years prior to becoming permanent. It was this joint effort at Green River Lake that led directly to the establishment of the Sustainable Rivers Project.

> *The Green River Conservation Partnership has no formal organization, no charter, no rules and regulations ... rather, it is the sum of its parts and members working together in their own areas of expertise toward a common goal to protect and improve the river*

There have been physical changes in the stream channel, especially within the first 32 miles. Greater movement of bedload sediments, large woody debris, and braiding of gravel bars has been observed and is associated with higher releases during fall drawdown. The effect is a return to more naturally occurring stream processes within this reach of river, a positive impact with regard to maintaining and restoring downstream channel and stream habitat lost to vegetative encroachment and sedimentation over the previous 33 years of operations. Another important physical change is elimination of unnatural backflows into Mammoth Cave caused by fall drawdown of Green River Lake.

THE HANDY RIPARIAN HABITAT
RESTORATION PROJECT

The Corps and TNC were evaluating the Green River Lake operation when, in 2000, Congress authorized nongovernmental organizations as cost-sharing partners for certain Corps authorities. The Handy Riparian Habitat Restoration Project became the first such cost shared project between the two organizations. The project constitutes 32 stream miles immediately downstream of the lake. The U.S. Fish and Wildlife Service identified this location as the greatest contributor of sediment to the upper Green River.

At their confluence, the Green River and Russell Creek have watersheds of 743 and 289 square miles, respectively. The uncontrolled watershed of the Green River was reduced to 61 square miles with lake impoundment. Russell Creek became the dominant stream as its watershed is not controlled by any reservoir. For 33 years Russell Creek directly impacted the project site, eroding soils and removing bottomland hardwoods while increasing sediment load and degrading aquatic habitat.

Green River Lake eliminated most out-of-bank flooding in the project area. Prior to impoundment, the project area experienced out-of-bank flooding with each five-year storm event. Now flooding occurs only with a 100-year event. Lack of flooding severely restricts natural recruitment of native trees by eliminating the primary method of seed dispersal.

The project was constructed in the fall 2001 and plantings were finished in spring 2002, all while operational studies of the lake and river were ongoing. At a May 2002 project dedication, Louisville District of the Corps and the Kentucky Chapter of TNC signed the first partnering agreement between two local units setting the stage for others that followed. This agreement also benefited the review and approval process for revised operation of the lake.

MUSSEL PROPAGATION AND REINTRODUCTION

During this same period, the National Park Service constructed a facility for freshwater mussel propagation in MCNP. The facility at Tennessee Technological University, in cooperation with the U.S. Geological Survey, raises mussels for reintroduction into suitable habitats in the Green River basin. The Freshwater Mollusk Conservation Center of Kentucky Department for Fish and Wildlife Resources operates the MCNP facility.

These and two other similar regional facilities are making important advances in propagation of mussel species. Reintroduction of species or augmenting of existing populations is expected soon as in-stream habitat

Green River Handy Riparian Habitat Restoration Project (or simply, GR ecosystem restoration site) Near Greensburg, Kentucky (photo by Richie Kessler, TNC, Winter, 2000-2001).

responds and stabilizes under the SRP operational plan for Green River Lake.

CONSERVATION RESERVE ENHANCEMENT PROGRAM

The U.S. Department of Agriculture, the Kentucky Department of Conservation, and the Kentucky Department of Fish and Wildlife Resources, cooperatively operate the TNC-initiated Conservation Reserve Enhancement Program (CREP) within the bio-reserve. The program provides payments to land owners along the river and tributaries to put land into conservation easements requiring certain land management practices. CREP was very beneficial to the revised operation of Green River Lake and its approval as the first SRP project through removal of low lying lands from agricultural production.

LOCK AND DAM NO. 6

The Corps Louisville District has recommended removal of Dam 6 allowing restoration of 17 river miles, almost all within MCNP, to natural conditions. The river, upstream of MCNP, is designated an Outstanding Resource Water. Such designation ends at the upper reach of Pool 6. It is expected that the 17 mile stretch will attain the same physical and biological characteristics as that of the nearly 100 miles of Outstanding Resource Water upstream. At present, removal remains only a controversial proposal.

LOOKING AHEAD

The Corps Louisville District, TNC, and the many partners of the Green River Conservation Partnership are involved with: (1) monitoring reservoir operations and biological and physical responses; (2) considering modifications to existing outlet works of dams; (3) developing comprehensive reservoir regulation system for all four basin lakes; (4) removing Lock and Dam 6, restoring 17 miles to free flowing stream environment; and (5) studying/implementing SRP practices at Barren River and Nolin River lakes if practicable.

CONCLUSION

The Green River Conservation Partnership has no formal organization, no charter, no rules and regulations. Rather, it is the sum of its parts and members working together in their own areas of expertise toward a common goal to protect and improve the river. There has been significant progress in the past decade. Recognition of accomplishments of the many partners is indicated by those who have visited during this period including: U.S. Senator Mitch McConnell; Secretary of Agriculture Anne Venneman; Christine Whitman, Director of U.S. Environmental Protection Agency; General Robert Flowers, Commanding General of the Army Corps of Engineers; Assistant Secretary of the Army John Paul Woodley; and Steve McCormick, President, The Nature Conservancy. The efforts of two partners, the Louisville District, Corps of Engineers, and the Kentucky Chapter, TNC, even led to the development of a national program, the Sustainable Rivers Project, to enhance environmental productivity and sustainability of the nation's freshwater streams. Not bad for something that doesn't really exist!

AUTHOR LINK W. Michael Turner
U.S. Army Corps of Engineers
P.O. Box 59
Attn: PM-P-E
Louisville, KY 40201
(502) 315-6900 / Fax: (502) 315-6864

E-MAIL michael.turner@lrl02.usace.army.mil

W. Michael Turner completed his BA at Eastern Kentucky Univ. in 1974 and continued graduate studies in biology at the Univ. of Louisville. His career began with the Louisville District, USACE, in August 1976 as an outdoor recreation planner. Since October 2000 he has served as supervisory ecologist and chief of Environmental Resources. He has been recognized by the USACE for achievements including the discovery of the first reproducing population of the endangered Indiana bat in Kentucky; creation of 1,400 acres of wetlands for bald eagles and migratory waterfowl near the confluence of the Ohio and Mississippi rivers, and acquisition of almost 2,100 additional acres for mitigation; monitoring freshwater mussel populations for the past 20 years; developing dredging disposal criteria to benefit the endangered interior least tern; and managing the first cost shared ecosystem restoration project between The Nature Conservancy and the USACE.

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BILL WILLIAMS RIVER, ARIZONA: RESTORING NATURAL VARIABILITY IN AN ARID LANDS RIVER

Andrew Hautzinger

A truism of managing natural systems is that Mother knows best. This is being applied to the management of Alamo Dam to return elements of the natural hydrograph to the Bill Williams River (BWR). This article explores the unique gifts Mother Nature gave to the BWR system, the BWR's natural hydrograph, and why so much work is occurring to manage this river's natural resources. This article also highlights a few tools that have been developed to apply the best of the river sciences to questions about balancing human water needs with the needs of the environment. Finally, it touches upon the importance of having a commitment to experimentation and to monitoring.

The BWR drains over 5,000 square miles of sparsely vegetated (and sparely populated) Arizonan desert country. After the Salt River and Verde River, the BWR watershed is Arizona's largest. The BWR is tributary to the lower Colorado River (LCR) and one of only three perennial tributaries to this section of the Colorado. Much of the interest in the ecology of the BWR stems from the almost complete paucity of functional riparian habitat on the Lower Colorado River (LCR) itself.

Historically, the BWR was primarily used by humans for farming, ranching, and mining. Mr. Bill Williams himself was a beaver trapper who was infamous for going "wild" for long stretches of time, reappearing in town, beaver pelts over his shoulder, when most bets were he'd long since died.

...not enough emphasis can be placed on the need to have a significant and durable commitment to experimentation and monitoring ... with all the advances in river science over the past few decades, we are still limited in out ability to accurately characterize natural dynamics

While the hydrology of the BWR today is very different than it was before 1968 when Alamo Dam was constructed (see Figure 1), for a variety of reasons the river's riparian system has maintained a higher level of natural function than is typical of altered river systems in the American West. This habitat diversity maintains a concomitant and exceptional degree of biodiversity within the LCR. BWR represents about half the acreage of the mature large-stand cottonwood-willow forests left in the LCR (see Figure 2). It supports over 350 bird species, and 11 of the LCR's 34 butterfly species are now only found in the BWR basin. Its upper tributaries have significant native fish populations. This habitat diversity helps maintain a concomitant, exceptional and now unique biodiversity on the LCR. The BWR National Wildlife Refuge has documented over 1,000 species including 56 mammals, 29 fish, 304 plants and fungi, 54 amphibians and reptiles, and 261 invertebrates. Many of these species are no longer found elsewhere on the LCR.

While there are encouraging signs of ecological health on the BWR, the presence of Alamo Dam has dramatically changed fundamental physical and biological processes on the BWR. Based on an analysis of hydrographs generated from available data (BWR has been gauged since the 1890s), the BWR is the poster child of the flashy southwestern river, prone to apocalyptically large floods, followed by months of quiet, dry weather. Statistically, the BWR has been described as being the southwest's "flashiest" watershed (TetraTech, 2002). Looking at the reach below Alamo Dam, the system's geomorphology presents a classic hour-glass land form. Stretches of tight canyon are broken by large flood plains filled at depth with porous sedimentary rock (alluvium). During extended dry periods, there typically is no flow in the BWR in the upstream parts of these floodplains. However, at the lower ends of these floodplains, as the river valley begins to contract from broad floodplain to canyon, water typically reappears, bubbling out of the saturated alluvium to form stretches of perennial flow. Over the river system's lower 40 miles, the system possesses some four to five ephemeral reaches, and a similar number of stretches with fairly dependable perennial flow. Thus, for any given level of base flow in the river system (typical base flow-releases out of Alamo Dam are between 20-50 cfs), any number of flow conditions can be manifested over the 40 river miles below the dam.

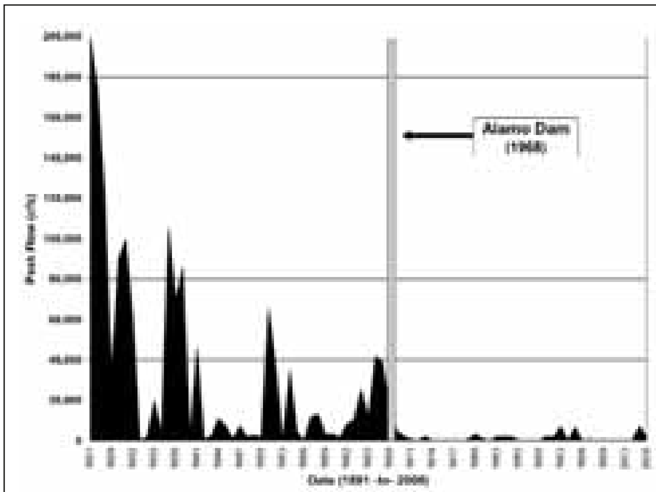

Figure 1. Annual Peak Flows (Bill Williams River, Arizona).

Figure 2. Cottonwood-Willow Gallery (Bill Williams River NWR, Arizona).

Understanding the pattern represented by this river's hydrology is tricky enough, but linking the river's biology to its hydrograph proves even more challenging. Much of the scientific work on the BWR has focused on linking the flow regime (which can be highly controlled with releases from Alamo Dam) to biotic responses and needs. How do low summer flows affect new tree seedlings? How do high flows in the fall impact aquatic organisms? How much of a flood does it take to remove beaver dams? To allow scientists and managers to grapple with these types of questions, much effort has been expended to develop tools to evaluate system response to dam releases. Use of experimental floods (based on the natural hydrograph), has been a fundamental and critical part of this tool development effort.

Tools that have been utilized to model the system have primarily been generated by the U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC). Models include a one-dimensional hydraulic model with GIS integration capabilities based on Light Detection And Ranging (LIDAR) generated topographic information (HEC-RAS); a reservoir-operations simulation model (RES-SIM); and an integrated physical-biological model in which spatially specific biotic responses are predicted based upon quantitative estimates of ecosystem flow requirements (Ecosystem Functions Model or HEC-EFM) (Shafroth and Beauchamp, 2006). These tools have allowed predictions on the biological relevance of flow events. What flow or range of flows are likely to establish woody riparian seedlings ... or develop and maintained desired aquatic habitat?

The increased accuracy and range of functionality that is associated with today's predictive models has improved our ability to manage complicated natural systems. These tools allow the scientist and the manager to generate much more detailed hypotheses that can then be ground tested for model refinement and calibration. The role of experimental flows is critical in this dynamic: there is no substitute for testing flow-related theories or assumptions with actual flow events.

The scientists and managers working on the BWR have recently conducted a series of experimental releases from Alamo Dam, looking at the pre-dam hydrograph for design guidance. Experimental releases occurred in 2005, 2006, and 2007 with varying goals and objectives. The primary goal associated with the 2005 releases was to evacuate the reservoir after a series of large and sustained storm events filled Alamo Lake with over 400,000 acre-feet during a period of 120 days (breaking a grueling six-year drought). Beyond this flood control objective, a secondary objective was articulated – could the releases be timed and shaped such that the dam releases could mimic the function of natural flows and help to establish a new generation of cottonwood-willow? This successful experiment (many thousands of seedlings established in 2005 have survived into the spring of 2007!), highlighted the usefulness of mimicking elements of the natural hydrograph, most especially in regards to the seasonality of the flow event.

In March 2006 and April 2007, two more experimental releases were conducted (with high flows of 2,000 cfs and 1,000 cfs, respectively). Both of these events were smaller than the 2005 releases (which equaled the dam's maximum release of 7,000 cfs). The 2006 and 2007 events were designed to allow physical and biological observations during flows that occupied the lower end of the system's flood regime. All of the experimental flows had biologic objectives. What would these flows do to newly-repaired beaver dams? What shifts could be observed in the aquatic insect community? While results are still being analyzed, early indication are that both of these flow levels made significant changes in beaver dams (a high percentage encountered significant damage, while a few were washed out completely) and aquatic insect communities (a shift towards more lotic native-dominated taxa directly after flows were observed).

In summary, the experiences on the BWR are similar to work going on around the world, where people are using science to help determine if development and use of water leaves room for protection of flow-dependent wildlife. The work of the BWR team (please go to http://billwilliamsriver.org for more details) has demonstrated that it is critical to look at the natural hydrograph to identify broad ties between flows and the biota. This linking of the hydrograph to the biology forms the cornerstone of achieving environmental goals associated with dams and the like. Our work on the BWR has shown that using experimental flows that mimic some portion of the natural hydrograph is a most effective learning tool.

Finally, not enough emphasis can be placed on the need to have a significant and durable commitment to experimentation and monitoring. With all the advances in river science over the past few decades, we are still limited in our ability to accurately characterize natural dynamics. This is doubly true when we attempt to ameliorate environmental damages caused by human induced changes. As most of the world's river systems are altered by human actions of some sort, it is incumbent upon us to look at pre-altered "natural" conditions to glean those natural processes and functions that we can encourage and facilitate (even in reduced form and scale) to further the goal of environmental benefit. The work discussed in this paper strongly suggests that mimicking parts of the natural hydrograph is a great place to start.

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AUTHOR LINK Andrew Hautzinger
U.S. Fish and Wildlife Service
Division of Natural Resources
500 Gold Ave. SW, Suite 9016D
Albuquerque, NM 87102
(505) 248-7946 / Fax: (505) 248-7950

E-MAIL andrew_hautzinger@fws.gov

Andrew Hautzinger Andrew holds a B.S. in Watershed Science from Colorado State University (1991). He has worked for the U.S. Fish and Wildlife Service's Region 2 for the last 10 years, as a Regional Hydrologist. He provides water resource and water right support to four national wildlife refuges located in the state of Arizona, along the lower Colorado River. Prior to his work with the USFWS, Andrew was employed with the U.S. National Park Service Water Resources Branch, where he worked on a national scale providing technical support for the national parks. Prior to that, Andrew worked for two years with the U.S. Bureau of Land Management, in Craig Colorado, where he worked closely with energy companies on legal compliance issues.

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WATER RESOURCES
IMPACT

SAVANNAH RIVER, GEORGIA: SCIENCE TO SUPPORT ADAPTIVE IMPLEMENTATION OF ENVIRONMENTAL FLOWS TO A LARGE COASTAL RIVER, FLOODPLAIN, AND ESTUARY

Amanda Wrona Meadows, Darold Batzer, Merryl Alber, and Rebecca R. Sharitz

INTRODUCTION

Rivers of the Southeastern United States traverse a wide coastal plain where they are characterized by broad floodplains and expansive estuaries. Because of ample rainfall and the flat terrain, these rivers were historically subject to large, frequent floods, particularly in the spring or associated with tropical storms or other major rain events. Because floods can be hazardous to human settlements, extensive networks of dams have been built on many, if not most, major Southeastern rivers, and river flows have been closely regulated to minimize flooding. This has made it difficult for managers to meet competing interests for water such as property protection, hydropower, or recreational needs, along with the needs of downstream habitats and species. The services provided by healthy functioning floodplains are rarely considered in management plans. Floodplains provide flood protection, water reclamation, pollution abatement, aquifer recharge, wildlife habitat, and recreation opportunities. Estuaries and their associated tidal marshes are vital natural areas, providing habitat for fish, shellfish, and wildlife; maintenance of water quality via waste assimilation and nutrient processing; climate control via carbon sequestration; prevention of sediment erosion; and protection from storms. Riverine, floodplain, and estuarine habitats may become degraded by regulation, because many biological functions in these crucially important ecosystems rely on natural variation in flows including flooding.

FLOODPLAIN ECOLOGY

The periodic inundation of floodplains is believed to be the major factor in sustaining the ecological functions of river-floodplain systems (see review in Junk and Wantzen, 2006). The high overall productivity and biodiversity of these systems is due largely to the many-fold increase in aquatic areas occurring upon floodplain inundation. Flood pulses can exert a range of influences such as shaping the morphology of river channels and floodplains, affecting soil oxygen and moisture levels, and impacting biological and chemical transformations among nutrient pools. Flood pulses regulate plant reproduction, with seedling establishment only successful under certain hydrologic conditions (Schneider and Sharitz, 1988). Flood pulses during the plant dormant season (October-March) can increase soil moisture, disperse seeds, and inhibit germination of upland species (those species not considered wetland residents), on lower elevation sites.

When the frequency of floods is reduced in areas of intermediate (or higher) elevation, it may result in drier soil conditions that allow invasion of upland species. Thus, in rivers where pulses have become regulated, tree species that dominate juvenile size classes (saplings, seedlings) may have a different flood tolerance than canopy species that were established prior to flow regulation. In contrast, floods occurring during the growing season limit tree seedling survival during the early phases of recruitment, and summer floods of more than a few days are likely to cause mortality of newly established seedlings. The copious plant growth on floodplains, especially trees, becomes an important source of organic matter input (leaves, wood) throughout the system. Once decomposed, some organic materials move into the channel and then to downstream habitats.

The Savannah River provides an opportunity to give much needed definitions to the concept of adaptive management as well as the opportunity to test large scale aquatic ecosystem response to flow restoration

In addition, healthy floodplains support a community of invertebrates (insects and crustaceans) and fish specifically adapted to live and breed in wetlands. Most fish activity in Southeastern floodplains occurs during the winter and spring flood pulses. Floodplain habitat availability to riverine fishes depends on the physical extent and duration of floodplain inundation, the rate of rise and fall of the flood-pulse, and pulse seasonality. Rapidly rising and falling pulses, which also tend to be short in duration, are unlikely to provide meaningful benefits to fishes. Pulses that occur when water temperatures are low also are less likely to benefit fishes than pulses that coincide with spawning and juvenile growth periods (typically spring and early summer months). Perhaps the primary reason that fish move onto floodplains is to exploit invertebrates as food, and like fish the resident invertebrate community is strongly influenced by the character of flood pulses.

Nonaquatic animals can also be affected by flood pulses. Late spring floods can destroy nests of ground-nesting birds, but prolonged late flooding provides canopy birds with protection from a variety of nest predators. Longer-term effects on bird communities will likely reflect the frequency (both within the year and annual rate) of flood pulses, as well as changes occurring in the plant community.

ESTUARY ECOLOGY

As flood pulses make their way downstream they ultimately influence estuaries and their associated intertidal marshes. Because tidal wetlands are regularly inundated to levels that are primarily influenced by sea level (Figure 1), flood pulses have a different effect in these areas as compared to upstream. Rather than increasing the period or extent of inundation, a flood pulse in a tidally-influenced area will be manifest as a slug of low salinity water. The distribution of many estuarine resources, including marsh plants, plants, animals or bacteria that live on tidal creek sediments or living within the water column can shift in response to changes in salinity. Changes in the pattern of inflow will also affect the delivery of nutrients, organic matter, and sediment, which can in turn affect estuarine productivity rates and trophic structure (Alber 2002). The effects of freshwater pulses are likely to vary depending on the length of the pulse as well as the individual life histories of estuarine organisms, but freshwater regulation can affect migration patterns, spawning habitat, and species diversity of both fish and invertebrates (Drinkwater and Frank 1994).

A short-term period of reduced salinity (i.e. days to weeks), that occurs with a flood pulse, is likely to affect the distribution of motile organisms as they move to stay in water of a preferred salinity. Wetland plants and sedentary organisms (such as oysters or benthic infauna) are generally able to tolerate a range of salinities. Over the longer term (years), however, a regular regime of flood pulses may well cause more permanent shifts in the distributions of all organisms, with effects on population dynamics and community composition.

To the extent that decreased flow tends to "squeeze" the estuary this may result in decreased areas of appropriate habitat. Upstream habitats in particular, such as tidally influenced forests and marshes, are most likely to show an immediate and measurable response to changes in freshwater inflow than habitats closer to the ocean. It is not clear how a change in the intertidal marshes, particularly a shift from tidal fresh to salt marsh, will affect the ecosystem services that marshes provide. Plant diversity is higher in tidal fresh as compared to salt marshes, but trends in overall biodiversity are less clear. Recent studies have shown that, while primary production is equivalent in fresh and saltwater marshes, rates of decomposition are much slower in fresh than salt marshes, leading to increased accumulation of soil and higher concentrations of organic carbon and nitrogen in fresh marshes (Craft 2007).

In addition to upstream management of dams and reservoirs, other types of perturbations will also affect estuarine areas. Channel dredging and sea level rise will both result in increased upstream penetration of seawater and an associated decrease in the low salinity

Figure 1. Overlooking Doboy Sound Salt Marsh, Georgia (photo by Amanda Meadows).

habitat, whereas an increase in storm activity will increase freshwater flow. Understanding the implications of changing flooding regimes and the delivery of freshwater to estuarine habitats will remain an important area of study.

THE SAVANNAH RIVER PROJECT

The Nature Conservancy (TNC) scientists are working with partners to protect downstream aquatic habitats in the Savannah River basin, Georgia, by advancing ecosystem flow restoration and adaptive management. The U.S. Army Corps of Engineers (Corps) maintains three large dam and reservoir projects within the basin. Under the water management regime of the last 50 years, there has been a removal of natural variability in the hydrograph including a reduction in peak flow volumes and frequency (Figure 2).

The Corps in partnership with TNC has released experimental controlled flood pulses per scientific recommendations developed specifically for the Savannah River. In order for the Corps to adopt ecological water management as standard practice, flow recommendations, or flow restoration hypothesis, must be tested in a scientifically credible manner. TNC and partners such as the U.S. Fish and Wildlife Service, Georgia and South Carolina Departments of Natural Resources, The University of Georgia, Savannah State University, The Southeastern Natural Sciences Academy, and Augusta State University have begun to implement monitoring approaches to determine pre-controlled and post-controlled flood release conditions (Figure 3).

Figure 3. Dr. Darold Batzer and His Students Sampling the Savannah River Floodplain During an Experimental Controlled Flood (photo by Andrew David Tucker).

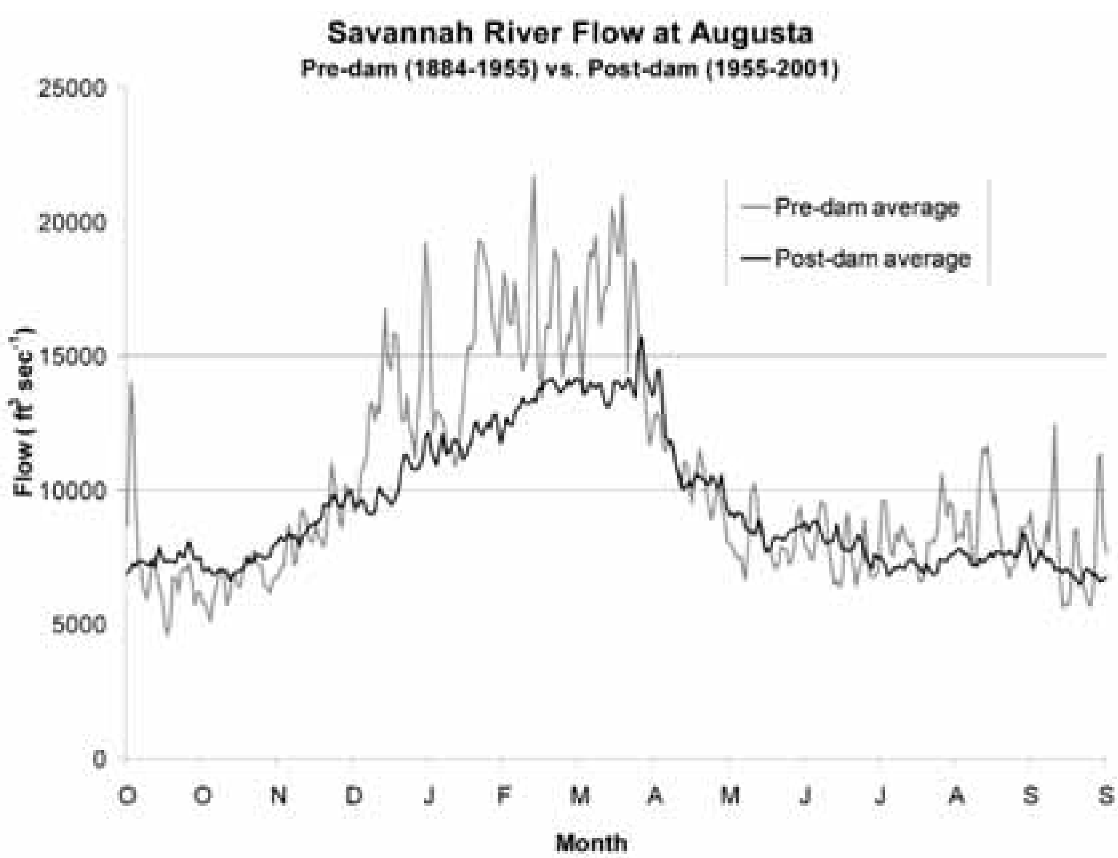

Figure 2. Comparison of Pre-Dam and Post-Dam Monthly Average Flows on the Savannah River, Measued at Augusta, Georgia, From 1884 to 2001.

This effort of supplying science to support ecosystem flow restoration has been successful because of the work of professors, students, agency biologists, Corps hydrologists, and volunteers. Initially flood pulses have been measured with dynamic response indicators such as floodplain fish use, quantity and duration of floodplain flooding, anadromous fish movements, shifts in floodplain invertebrate communities, water quality, and a temporary shift in the average location of the saltwater/freshwater interface in the estuary (Wrona *et al.,* 2007). Bench mark, or long-term indicators such as riverine freshwater mussel populations or floodplain tree recruitment and growth will need to be measured over decades. Although the adaptive management process essential to ecosystem flow restoration in the Savannah depends on rigorous scientific measures, funding sources for this type of science, especially long-term monitoring, are scarce. The cost of both short and long-term monitoring is high and is difficult to "sell" to the public as an important conservation action.

The Savannah River provides an opportunity to give much needed definitions to the concept of adaptive management as well as the opportunity to test large scale aquatic ecosystem response to flow restoration. By continuing to monitor the effects of flow restoration and feeding these results back into the adaptive management framework, we will be able to advance the Savannah River as successful example of ecologically sustainable water management.

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AUTHOR LINK Amanda Wrona Meadows
The Nature Conservancy
P.O. Box 9391
Savannah, GA 31412
(912) 239-9800 / Fax: (912) 437-5368

E-MAIL awrona@tnc.org
dbatzer@bugs.ent.uga.edu
malber@ugs.edu
sharitz@srel.edu

Amanda Wrona Meadows, Dr. Meadows earned a M.S. in Zoology and a Ph.D. in Marine Science from the University of Georgia where she did her research at the Marine Institute at Sapelo Island. Between degrees she worked with the South Carolina Dept. of Natural Resources Marine Resources Research Inst. in Charleston as a Marine Biologist. She has been the director of the Savannah River Project for The Nature Conservancy for over three years and works as a scientist, educator, fundraiser, and in government relations. She is coordinating the continued ecosystem flow restoration and monitoring effort of the Savannah River with partners such as the U.S. Army Corps of Engineers, South Carolina, and Georgia Departments of Natural Resources, U.S. Fish and Wildlife Service, Augusta State University, and the University of Georgia.

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▲ Water Resources Continuing Education Opportunities

AUGUST 2007

5-14 / 33rd International Geological Congress (IGC). Oslo, Norway. Prof. Arne Bjorlykke, President of the 33rd International Geological Congress (arne.bjorlykke@ngu.no) or Scientific Program Committee (secretariat@33igc.org) (www.33igc.org)

13-17 / Shortcourse – Geomorphic and Ecological Fundamentals for River and Stream Restoration. Lake Tahoe, CA. **Contact** restoration.ced.berkeley.edu/shortcourse. Also restoration_shortcourse@yahoo.com

20-21 / Short Course – NGWA Geothermal Heat Pump Conf. (#5112). Columbus, OH. **Contact** NGWA, 601 Dempsey Rd., Westerville, OH 43081 (800-551-7379; 614-898-7786; w: ngwa.org/e/other/continue.cfm)

SEPTEMBER 2007

5-7 / Alabama Water Resources Conference. Orange Beach, AL. **Contact** www.auei.auburn.edu/conference or 334.844.4132

11-13 /2007 Wallingford Software International User Conference. Howbery Park, Wallingford, UK. **Contact** David Ford, Ford-Peacock Consultncy Ltd. (+44 (0) 1295 722213; w: david@ford-peacock.com)

WATER RESOURCES
IMPACT

WILLAMETTE RIVER, OREGON: MOVING TOWARD BASIN-WIDE FLOW AND FLOODPLAIN RESTORATION

Leslie B. Bach, Matthew Rea, Mary Karen Scullion, Karl Kanbergs, and Jeff J. Opperman

INTRODUCTION

Over the last 50 years, river management has evolved from an emphasis on economic outputs to one that includes consideration of broader human values. Agencies and organizations are "retooling" to account for the changing paradigm, and new and expanded partnerships are forming to meet multiple, and sometimes conflicting, goals. In Oregon's Willamette River Basin, managers and interest groups are using innovative scientific and decision-making approaches to seek this balance. This article describes a process for developing strategies to improve flow regimes and floodplain function in the Willamette Basin. The process is founded on unique partnerships, collaborative approaches for synthesizing scientific information and developing environmental flow recommendations, and an adaptive and integrative framework for implementing these changes.

THE WILLAMETTE RIVER BASIN AND THE RESERVOIR SYSTEM

The Willamette River is the largest river system in Oregon and the 13th largest river, by volume, in the conterminous United States. The mainstem river is 180 miles long and there are over 11,000 miles of streams and rivers within the basin. The river is vital and literally central to the region: 19 cities and towns, including the three largest population centers in Oregon – Portland, Salem, and Eugene-Springfield – are situated along, or near, the banks of the Willamette River and its tributaries. Nearly 70 percent of all Oregonians live within 20 miles of the river.

The Willamette Basin is home to a rich diversity of native fauna and flora including 31 fish, 18 amphibians, 15 reptile, 154 bird, and 69 mammal species (Hulse *et al.*, 2002). The river and its tributaries support important runs of anadromous and resident fish including salmon, steelhead, and trout. The basin's floodplains and wetlands provide habitat for the Oregon Chub, the western pond turtle, Fender's blue butterfly, and many sensitive plant species. The Willamette Valley's location on the Pacific flyway makes it an important area for migrating and wintering waterfowl.

The U.S. Army Corps of Engineers (Corps) operates 13 dams in the Willamette Basin - 11 multiple purpose storage reservoirs and 2 regulating reservoirs. All 13 of the dams are located on major tributaries; there are no Corps dams on the mainstem Willamette River. The dams are operated as a system (Figure 1), with flood damage reduction a primary purpose. Hydropower, navigation, irrigation, municipal and industrial water supply, recreation and flow augmentation for fish, wildlife, and water quality are also authorized purposes. In total, the dams control flows on six major tributaries affecting approximately 27 percent of the total geographic area of the basin and 42 percent of the upper basin above Salem. Operation of the dams has changed the volume and timing of water flow in the river, resulting in reduced peak flows, increased low flows, and limited natural flooding events (Figure 2).

Restoration and conservation of riverine resources will require addressing several other challenges including water temperature control and fish passage at the dams, point-source and nonpoint-source discharge to the rivers, hatchery management, and upland and urban impacts

Modifications to river flow and water temperature, and loss of channel and floodplain habitat, have contributed to the decline of native fish populations. Of the 31 native fish species that occur in the basin, seven are listed by the Federal or state government as endangered, threatened, or sensitive. In 1999, following Federal Endangered Species Act listings of Chinook salmon and winter steelhead, the Corps began implementing changes in Willamette system operations to better meet the flow requirements of the listed species. An Interagency Flow Management Workgroup consisting of approximately 20 Federal, state, and local entities, recommended flow targets in the mainstem river to assist migration of Chinook and steelhead salmon. A critical and important first step, these targets only addressed listed fish species and did not consider impacts to flow in the tributaries, key areas for spawning and rearing. Additional efforts are now focused on providing tributary flows to meet habitat requirements for fish and other aquatic species.

The system of 13 Corps dams on six major tributaries offers a relatively high degree of operational flexibility. The Corps is able to use different combinations of reservoir fill and release to meet both mainstem river and tributary flow requirements, balancing the life cycle needs of multiple aquatic species with other operating purposes. The complex system of reservoirs allows the Corps to account for year to year variability in hydrologic conditions across the major subbasins. To utilize this flexibility most effectively, managers need more information on the flow requirements of native species and communities.

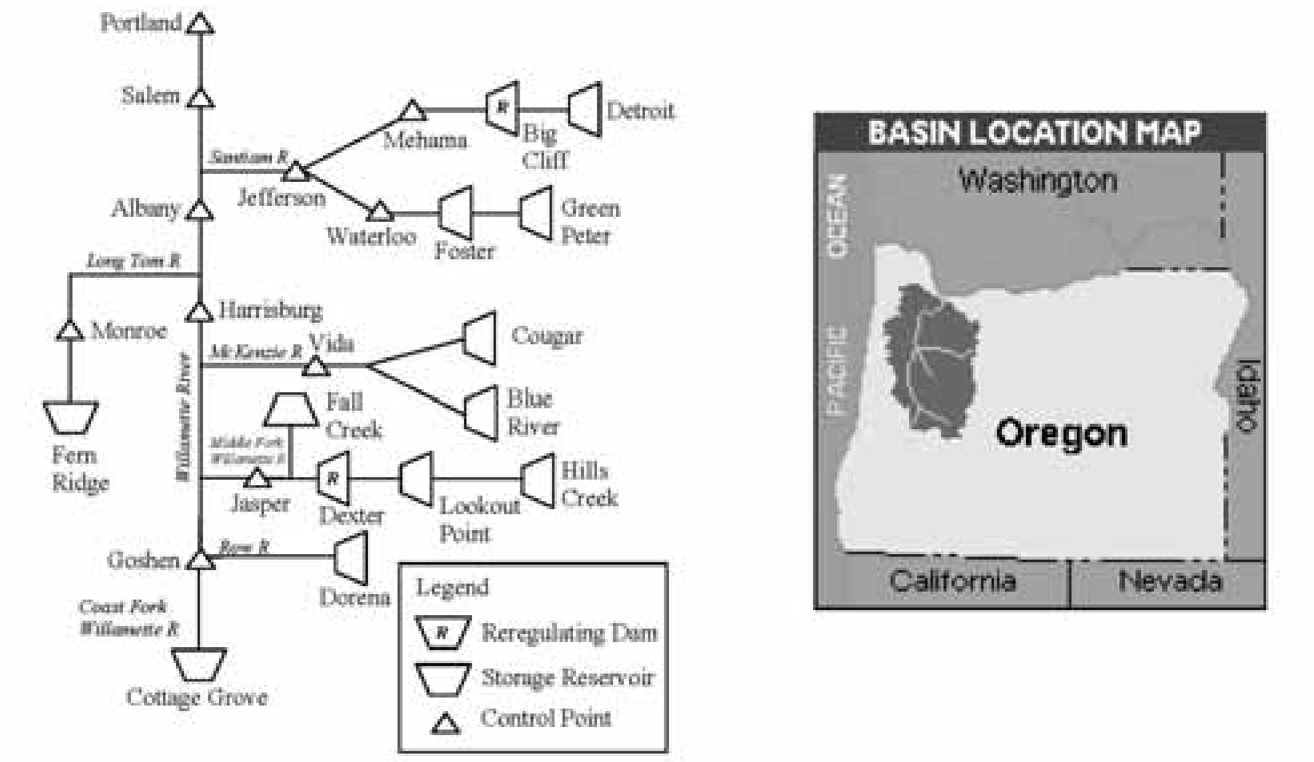

Figure 1. Map of Willamette Bsin and Schematic of Willamette Reservoir System.

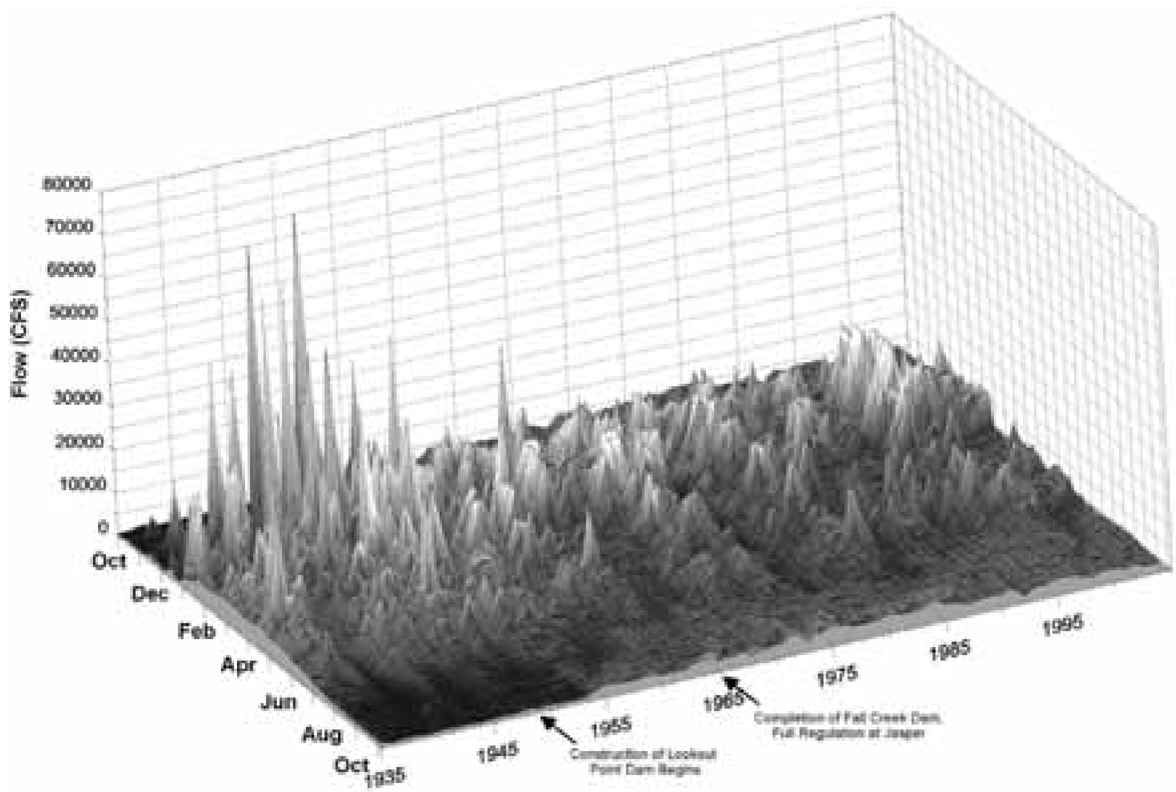

Figure 2. Graph Showing Changes in Observed Flow on the Middle Fork River at Jasper, Oregon, Following Construction of Lookout Point and Falls Creek Dams.

UNDERSTANDING THE SCIENCE: DEVELOPING ENVIRONMENTAL FLOW RECOMMENDATIONS

In 2006, The Nature Conservancy (TNC) and the U.S. Corps of Engineers (Corps) launched a project to determine environmental flow requirements for the Willamette River and its tributaries, and to design and test alternative flow releases from the dams that can meet these requirements without compromising the other purposes of the dams. As part of the Sustainable Rivers Project – a national partnership between TNC and the Corps – the Willamette is one of nine demonstration sites around the United States where scientists are addressing environmental flows and floodplain mangement (see article by Andrew Warner in this issue). The work expands upon the flow targets established by the Interagency Flow Management Workgroup by integrating information on additional species and communities, and by considering flow targets in the tributaries.

Initial efforts are focused on a pilot study in the Middle and Coast Fork subbasins of the Willamette River, which contain 6 of the 13 Corps dams in the basin. In conjunction with the flow study, these tributaries are currently the focus of an ongoing study to identify opportunities to restore natural floodplain function and promote ecosystem restoration, natural flood storage and other benefits.

In January 2007, the TNC and the Corps brought together leading biologists, hydrologists, and engineers from numerous state and Federal agencies, academic institutions, and nongovernmental organizations to develop environmental flow recommendations for the Middle and Coast Forks. The workshop discussions were informed by a literature review and summary report on the flow requirements of key species and ecological processes in the Willamette Basin compiled by the Institute for Water and Watersheds at Oregon State University (Gregory *et al.*, 2007) as well as information on channel dynamics and floodplain morphology. A key tool utilized during the flow workshop was the Regime Prescription Tool (RPT), a graphical interface developed jointly by TNC and the Corps designed to help workshop participants visualize streamflow data and proposed environmental flow recommendations (see article by John Hickey in this issue). The workshop resulted in recommendations for specific environmental flow components, including summer low flows, winter bankfull flows, and fall and spring pulse flows, to meet key ecosystem functions (Figure 3). Workshop participants defined these flow components in terms of magnitude, duration, frequency, and rate of change.

MAKING IT WORK: IMPLEMENTING ENVIRONMENTAL FLOW RECOMMENDATIONS

The flow recommendations generated through the literature review and workshop process can be grouped into three categories for implementation: (1) flow volume and timing adjustments that are within the operational flexibility of the Corps under current project authorizations and water control manuals; (2) larger scale adjustments that may fall within current operational flexibility and authority but will require more detailed evaluation of

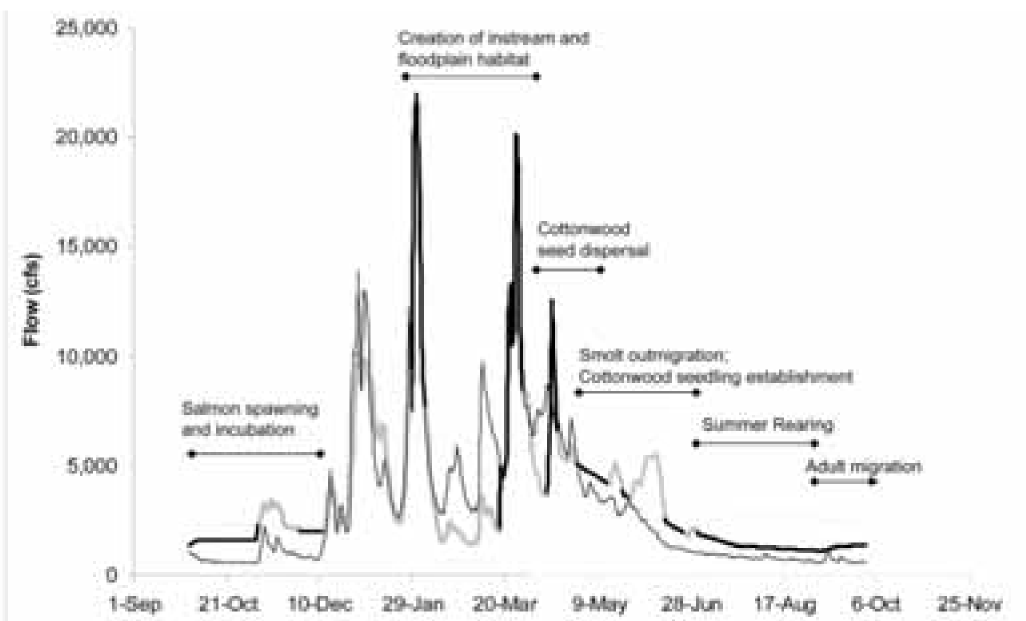

Figure 3. Example of How the Hydrograph of a Single Year, Water Year 2003, Could be Modified to Meet the Recommendations of the Flow Workshop. A hydrograph consistent with the recommendations, represented by the thick line, consists of flows already provided by the managed hydrograph (gray line) and modifications to the managed flows required to meet the recommendations (black line). The thin, dashed gray line shows the managed hydrograph during those periods where the recommended hydrograph departs from the managed hydrograph. The thin, solid black line shows the unregulated hydrograph for that water year.

tradeoffs; and (3) major changes in operation which are clearly outside of the Corps' operational discretion and would require a thorough feasibility evaluation and possible reauthorization action. The recommendations falling into Category (1) are currently being integrated into the 2007 Willamette Conservation Plan (WCP), which guides reservoir operations during the conservation storage and release season. The Corps hopes to be able to implement some of the recommendations, including pulsed flow releases up to bankfull, during annual reservoir drawdown in fall 2007, and again during spring refill in 2008. Monitoring and evaluation will be critical to determining the success of these initial flow recommendations. Computer modeling and field monitoring will be conducted to evaluate the response of the ecosystem to flow changes and will be used to adaptively adjust dam operations as needed.

Category 2 and Category 3 recommendations will require more thorough modeling and evaluation of different alternatives on downstream volume and timing of flows and on reservoir refill and storage conditions before they can be implemented. One example of these kinds of recommendations is small-scale flood-like events over bankfull limits. The Corps may also need to complete decision documents, environmental compliance, and public review under the National Environmental Policy Act prior to implementing these actions.

Community participation is a critical element of the process. With large population centers located along the river, restoring environmental flows and floodplain function will be challenging. In addition, the dams provide a variety of goods and services, including energy production that does not contribute to greenhouse gas emissions, and major recreational opportunities. These issues cannot be fully addressed through the flow management process, and will require further assessment by state and local governments and stakeholders. At the onset of the flow management project, a meeting was held to inform key stakeholders about the project. The meeting was attended by 86 individuals representing 34 entities, including city and county governments, state and federal agencies, and river-related organizations. Continued participation by this stakeholder group will be essential for successful implementation.

Flow and floodplain restoration are only part of the solution. Restoration and conservation of riverine resources will require addressing several other challenges including water temperature control and fish passage at the dams, point-source and nonpoint source contaminant discharge to the rivers, hatchery management, and upland and urban impacts. Despite the uncertainties and challenges, a diverse group of partners is committed to working together to develop flow regimes that can balance multiple goals, and then to implement, learn from, and adapt the flow targets as one step in restoration of the Willamette River.

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AUTHOR LINK Leslie B. Bach
The Nature Conservancy
821 SE 14th Avenue
Portland, OR 97214
(503) 230-1221 / Fax: (503) 808-4515

E-MAIL lbach@tnc.org
matt.t.rea@usace.army.mil
mary.k.scullion@usace.rmy.mil
karlis.kanbergs@usace.army.mil
jopperman@tnc.org

(Note: for any emails sent to co-authors Rea, Scullion, or Kanbergs, you must cc Diana Fredlund at Diana.j.fredlund@usace.army.mil.)

Leslie B. Bach is the Director of Freshwater Programs for The Nature Conservancy in Oregon. Her work focuses on developing and implementing programs and projects to protect and restore water quantity, water quality, and aquatic habitat throughout Oregon. She has over 20 years of experience in various aspects of water resource management, and has previously worked for the Oregon Water Trust, the Oregon Dept. of Environmental Quality, and the U.S. Dept. of Agriculture. Leslie has also worked througout Latin America assisting in analyzing, protecting, and restoring their aquatic/riparian systems.

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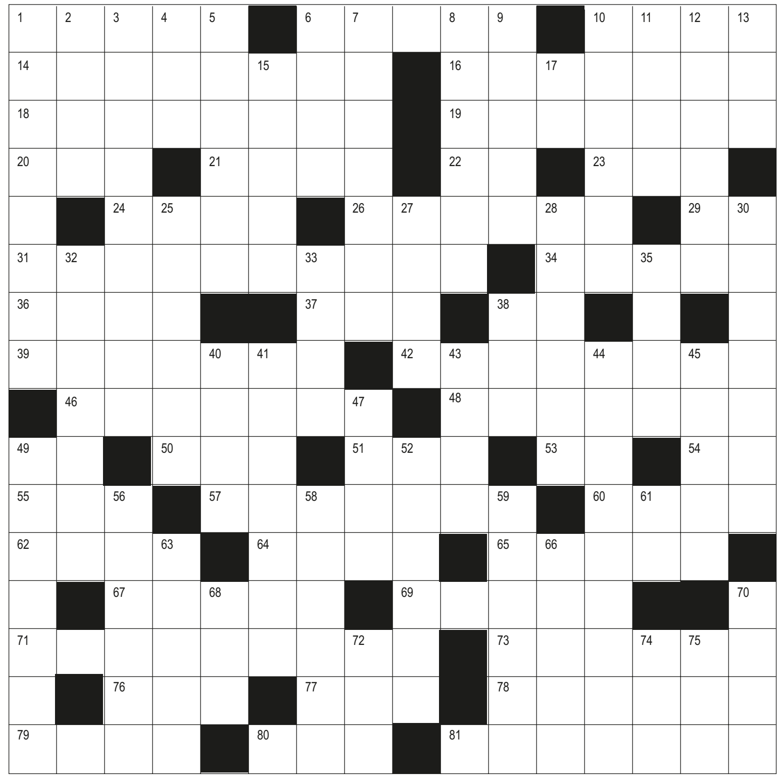
▲ Water Resources Puzzler (answers on pg. 30)



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47 small duck
49 austere
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59 _____ state: nickname of Missouri
61 Laotian monetary unit
63 middle ear bone
66 Martian mare
68 teacher's deg.
70 Nina or Ferdinand
72 Chem. suffix
74 inlet
75 digital audiotape (abbr.

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▲ President's Message ... Gerry E. Galloway, AWRA President, 2007

I am sure that you, along with millions of Americans, witnessed the graduation ceremonies at Virginia Tech and felt the sadness of knowing that many of our water colleagues were not there. Let us continue to keep them in our thoughts and prayers.

Everywhere that I have recently traveled I run into people who want to talk about AWRA and what it and its members have been doing. You all are very busy and representing our organization well. The flag of AWRA flies high because others see the fine work that is going on. Thanks for your contributions.

In May, I was asked by the House of Representatives Committee on Transportation and Infrastructure to testify before its hearing on water and climate change. (My testimony can be found on the AWRA website.) It was a privilege to go before this committee to discuss the challenges that climate change will bring to the water community and to point out to the committee the nation's continuing reluctance to develop the policies and plans that we will need to cope with climate change and its impacts. While it was a personal privilege to appear, the opportunity arose because the committee recognized the role that AWRA plays in communicating water issues to the public and in developing solutions to these problems. At the national meeting of the Association of State Floodplain Managers, I was pleased that FEMA's Mitigation Director, in discussing actions being taken in the nation to deal with the growing flood problem, cited our January water policy dialogue as one of the action agents in moving solutions ahead. Those of you who attended our specialty conference in Vail in June saw the quality of the conversation about emerging contaminants that took place among individuals from AWRA and the professional community at large. While this is truly a challenging area for water resources, I was heartened by the forward-looking approach being taken by many who are at the front lines in water quality science and the useful role played by AWRA in bringing attention to the topic.

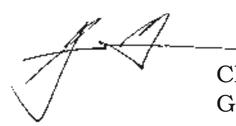
This November's annual meeting promises to provide an outstanding opportunity to continue these discussions and blend them with our knowledge and interest in the many other aspects of national water resources.

Interest in the annual meeting continues to grow in both numbers of potential participants and in the breadth of the subjects that will be discussed in Albuquerque. Although the venue itself will offer us pleasant memories of our meeting, I continued to hear that people are coming to Albuquerque because they want to be where the important discussions are going to take place and to connect with those who will have a role in making critical decisions about water in the years ahead. The interest in Washington, New Mexico, and the rest of the western United States has been extraordinary. Be prepared for a busy four days and plenty of opportunities to meet new friends. My hat continues to be tipped to Mike Campana and his committee for all of their work. I urge you to get your hotel reservations in quickly and to register as soon as possible.

Ken Reid, AWRA's Executive Vice President, and the AWRA staff continue to do everything possible to improve the quality of service we are giving our members. During the spring, I asked Tom Johnson, one of our board members, to lead a committee to examine how new technologies in the IT field might enable us to provide you, the members, faster and better information about subjects of interest to you. Tom was joined on the committee by Dave DeWalle, John Grounds, and Gary Whitton (our own Bill Gates). The committee's report has been circulated to the board and we will discuss it during the late summer to determine what steps we ought to take now and in the future. Tom has many suggestions that merit strong consideration.

In late April and early May I had the opportunity to talk with more than a dozen state section presidents and senior leaders about how we might work better as a team in moving the goals and objectives of AWRA forward. The quality of our field leadership is outstanding and the interest being generated in AWRA activities in the sections continues to grow. I thank these leaders for their efforts.

I continue to ask that, if you have ideas about how to make AWRA a better organization, you would share them with us. Send me an email at gegallo@umd.edu or give me a call (571-334-2103). Thank you again for what you're doing for the Association and our nation's water.



Cheers
Gerry Galloway

Solution to Puzzle on pg. 29

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THE NEW ECONOMY OF WATER

Clay J. Landry and Christina Quinn

FEDERAL LENDING PROGRAMS FALL SHORT OF DRINKING WATER AND WASTEWATER NEEDS

The House of Representatives appropriated $1.5 billion in March to repair and upgrade sewage systems in need of overflow control. The bill, now being reviewed by the U.S. Senate, is one of many attempts to increase funding for drinking water and wastewater programs.

Despite interest by private capital markets, water utilities and municipalities continue to pressure Congress to provide Federal funding for drinking water and wastewater capital improvements. The pressure comes from additional demands to meet stricter clean water standards, improve water supply security, and to upgrade aging infrastructure.

Studies from the Water Infrastructure Network, Congressional Budget Office and the USEPA estimate the investment and operation and maintenance needs through 2019 are anywhere from $70.7 billion to $128.5 billion each year. The amount of financing available through the Clean Water Act and the Safe Drinking Water Act is between $60.5 and $69.2 billion annually, according to the same studies. The question public officials are debating is how to finance the remaining needs.

Arguably water conservation and full-cost consumer rates are the most efficient solutions. Water conservation programs such as the use of water-efficient products can reduce infrastructure needs by decreasing water demand and wastewater flow. More efficient water pricing that reflects the real cost of service would provide a financial incentive for private investment on infrastructure.

Currently, local government officials estimate that, on average, ratepayers pay about 90 percent of the total cost to build their drinking and wastewater systems and federal funds provide the remainder, according to a Congressional Research Service Report released on March 19. Furthermore, water bills are relatively small compared to other common utility and service bills paid by most households. City officials say that raising water fees will not cover the growing needs, especially in communities with declining populations. As a result, the water utilities have been consistently proposing legislation to expand Federal funding programs. However, the significant funding proposals fail to achieve bipartisan support. The parties disagree on the level of funding in comparison to other Federal needs, on the amount of private investment needed, and on add-ons like requiring subcontractors to pay a prevailing wage.

DRINKING WATER AND WASTEWATER FUNDING PROGRAMS

Currently, the state and Federal support for drinking water and wastewater systems come from three financing programs. The first is the wastewater State Revolving Fund (SRF) developed in 1978 from the Clean Water Act. The program provides loans, refinancing, insurance, loan guarantees, purchase debt, and security for leveraging. The financing can be used by public water systems to improve facilities or comply with nonpoint source pollution abatement requirements. The Federal government expanded the SRF to include drinking water systems in 1996. The drinking water SRF is similar to the wastewater fund but offers loans to both public and private water systems for projects to upgrade or replace drinking water source, treatment, storage, transmission, and distribution systems.

The two lending programs allow states to make loans at below the market interest rate, including a zero interest rate using a mixture of Federal and state funds. The annual principal and interest payments begin one year after the project completion and are fully amortized 20 years after the project completion. For drinking water programs, economically disadvantaged communities can have up to 30 years to repay the loan. The drinking water SRF also allows 30 percent of capitalization grants to be used to provide loan subsidies to disadvantaged communities.

The third program is part of the U.S. Department of Agriculture Rural Development Act. The Act supports basic amenities, alleviates health hazards, and promotes the orderly growth of rural areas. The drinking water and wastewater programs offer loans and grants for systems serving less than 10,000 people.

THE DEBATE OVER EXPANDING THE FEDERAL LOAN PROGRAMS

Under the current funding levels, drinking water and wastewater systems fall short of the annual funds needed for drinking water and wastewater systems. The USEPA GAP Analysis estimates anywhere from a $1.9-billion to a $59.4-billion gap between the annual baseline funds available and the annual funding needs from 2000 to 2019.

Congress has reacted to the study by considering bills to increase funding levels. But the amounts have been higher than levels the White House has supported. Opponents of increasing funding argue for privatization of the water systems. Better management practices such as public-private partnerships and consolidation can increase the draw on private funds to fill the demands.

A compromise is to increase private investment through extending public financing to private companies. Currently, the drinking water Federal loans apply to both private and public community water systems. The wastewater SRF only applies to public systems. Expanding the financing to private wastewater utilities could attract more private investment. Also, the government can encourage public-private partnerships and privatization through Private Activity Bonds (PABs). PABs extend a tax exempt status to public and private partners on interest earned. Currently, PABs are limited by volume. Opponents of publicly financing the private sector say that it forgoes Federal tax revenue and interferes with the market by supporting some private investment more than other private investment.

While the debate continues, more interim solutions seem to be full-cost pricing to ensure that sufficient revenues are in place to support the costs to construct, maintain, and operate the infrastructure; water conservation to encourage efficient water use; and resource coordination between water systems in the same watershed.

E-MAIL CONNECTION

Clay J. Landry (landry@waterexchange.com)
Christina Quinn (Quinn@waterexchange.com)

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Federal and State Drinking Water and Wastewater Systems Funding Programs

	Water Pollution Control Revolving Loan Fund	**Drinking Water Revolving Loan Fund**	**USDA Rural Development Loan and Grant Programs**
Year Authorized	**1987**	**1996**	**1972**
Eligible Uses	Loans; refinancing; insurance; loan guarantee; purchase of debt; security for leveraging; 4% grant for administration	Loans; refinancing, insurance; loan guarantee; purchase of debt; security for leveraging	Loan guarantee; grants
Terms	Interest between 0 and market rate; 20-year terms; longer terms allowed in some states	Interest between 0 and market rate; 20-year terms; 30-year terms, and subsidized loans (principal forgiveness) for economically disadvantaged systems	Grants can cover a maximum of 75% of eligible facility development costs; loan guarantees are for up to 90% of any eligible loss incurred by the lender and lenders pay a 1% guarantee fee, which may be passed on to the loan recipient
Eligible Projects	Projects for wastewater treatment plants; qualified nonpoint source and estuary improvement projects	Projects to upgrade/replace drinking water source, treatment, storage, transmission, and distribution	Improvements for water supply and distribution systems and waste collection and treatment systems; acquiring land; acquisition of water sources and water rights; pay costs such as legal and engineering fees necessary to develop the facilities

WATER RESOURCES IMPACT

INCREASE YOUR PRODUCTIVITY FOR BETTER LIFE/WORK BALANCE

Marshall Brown

Often it seems we are so busy putting out daily fires that we do not ever get to accomplish anything of real significance – those things that would make us happiest in the long run. Life becomes something to "get through" instead of an exciting path to greater fulfillment.

The efficiency of technology only increases the pressure we feel to do even more than ever before. All of it leaves us feeling too busy and robbed of a sense of accomplishment. So what can we do to increase personal productivity? Below are some tips to help you to get more done in less time – and do what you really want to be doing.

Often busy-ness is a cover for not really knowing what's the best thing to be doing. To get around this, you have to know what your priorities are in the moment. To determine this you need know what your larger life priorities are.

Stephen R. Covey, best-selling author of "The 7 Habits of Highly Effective People," suggests writing a personal or organizational mission statement, a statement that summarizes your higher purpose and goals in life.

Without a mission, you won't be able to say no to tasks. You can only know what to say no to when you know what to say yes to first.

We can learn all the self-management tricks in the book, but none of them will be worth a dime if we do not follow through and use them. That is where self-discipline comes in. There's no easy, painless way to enforce self-discipline, but if we do not utilize it, we will be left forever unfulfilled.

Brian Tracy, one of the world's top business speakers and author of 35 books on business and personal productivity, offers some very simple advice: simply start doing what you know you need to do. Stop pushing it off for later. Once you start seeing the results active self-discipline yields, the desire for the payoff begins to become greater than your resistance to taking action.

To more easily promote successful self-discipline, Covey and Tracy suggest breaking down tasks into smaller chunks and then simply focusing on taking the first steps. This way all your tasks and goals won't feel so overwhelming, which makes it easier to take action.

David Allen, author of "Ready for Anything," points out how crises typically arise because secondary priorities have been neglected. He suggests working on unfinished tasks to open up your creativity. It is more difficult to focus on the bigger, more urgent tasks when you are painfully aware of ongoing but necessary projects that you never seem to start, such as reorganizing your files, catching up with your accounting, or updating your phone book. So set aside some time – even if it is just an hour or two a week – to work on these longer term, but less urgent projects. Just don't let these tasks become distractions from working on the bigger picture goals.

Work when you're supposed to be working! ... If you want to maximize your productivity at work and balance it into the larger scheme of your life, focus is crucial. Tracy says the reason people's lives get out of balance is not because they have too much work to do, but because they do too little work. And he means they waste too much time when they are supposed to be working. If you have to, turn off the phone and shut down your email. You will find the more work you do get done, the better you feel – which motivates you to keep doing more of the same.

And some quick tips ...

- Write out your goals.
- Break down your goals into actions.
- Break down these actions into bite-sized chunks.
- Schedule these chunks into your planner.
- Follow through with action.
- NEVER give into the temptation to do the small things first just because they're small.
- Intersperse periods of intense work with periods of recovery, even if brief.

(Marshall Brown, a certified career and executive coach has always had a passion for helping people find ways to live more fulfilling lives. As a coach, Marshall helps individuals to find their passions and encourages them to move ahead in reaching their goals.)

E-MAIL CONNECTION

marshall@mbrownassociates.com or visit
www.mbrownassociates.com (202.518.5811)

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WATER RESOURCES IMPACT

WHAT'S UP WITH WATER?

Eric J. Fitch

LAND, WATER, AND THE UNDISCOVERED COUNTRY

As an academician, May is always my season of contentment. My students either graduate or go forth to other fruitful endeavors such as internships, jobs, or like activities. At the same time, for the last decade, I've helped to organize and participated in YES (Young Engineers and Scientists) Days. This is an event where participants from local industries, agencies, and colleges spend a couple of days putting on talks and exhibitions to help interest our local 7th graders in studying science and engineering. In these young faces I see the undiscovered country, the Future.

Two recent sets of publications have captured my interest and have caused me to worry for both my college students and those 7th graders regarding the world and the problems that we baby boomers are leaving them. I was recently listening to NPR when the host interviewed Cullen Murphy, author of "Are We Rome?" It is a fascinating study comparing the Roman Empire in its wanidays and the "American Empire." Obviously there are clear parallels, but there are some surprising areas of similarity and dissimilarity (e.g. many people assume that Rome fell at its most "decadent" period and fear for America because we seem decadent to them). Actually, Rome was arguably at its most religious, even pious in modern terms. There was probably genuine surprise that Rome fell to the "pagan" barbarians wondering why God did not save them. This year I have also been following the releases of sections of the current report of the Intergovernmental Panel on Climate Change (IPCC); the international body of scientists and other authorities who are pulling together the best information on climate change. My reactions coming away from reading these materials placed me in a less sunny frame of mind. I harken back to an earlier time in our history and a set of cautionary tales shared by a USDA/SCS scientist W.C. Lowdermilk.

Lowdermilk was the assistant chief soil scientist of the Soil Conservation Service (now the Natural Resource Conservation Service) from 1933-1947 who traveled throughout the Middle East, the Mediterranean basin, and China in 1938 and 1939. He visited the sites of great ancient civilizations and studied the historical soil and water conditions. He wrote up his observations and published them in a Soil Conservation Service Bulletin (AIB No. 99) in 1953. Since then, the bulletin entitled "Conquest of the Land through 7,000 Years" has become the most requested publication in the history of the USDA. Part travelogue, part conservation science report, and part jeremiad, this 24-page pamphlet both eloquently and colloquially relates a correlation between the fall of past civilizations to abuses of their land and fresh water resources. He also shared his observations with regard to successful conservation practices and finished with cautionary tales regarding conditions here in the United States (U.S.). At the conclusion of the booklet, he shared a reflection that he had while visiting Palestine (aka Israel). He wondered if Moses should have given an Eleventh Commandment to the Hebrews and all humankind: "Thou shalt inherit the Holy Earth as a faithful steward, conserving its resources and productivity from generation to generation. Thou shalt safeguard thy fields from soil erosion, thy living waters from drying up, thy forests from desolation, and protect thy hills from overgrazing by thy herds, that thy descendants may have abundance forever. If any shall fail in this stewardship of the land thy fruitful fields shall become sterile stony ground and wasting gullies, and thy descendants shall decrease and live in poverty or perish from off the face of the earth."

Today in the U.S. those of us in the field of water management have some great advantages over Lowdermilk, though we see many of the same things. From my father's generation, through my generation, and down to the generation of my niece and nephews, the ones coming into its majority today, we have made quantum leaps in our knowledge and understanding of the natural world. On top of the advances in understanding of the physical and biological nature of this world and its dynamics like those represented by the IPCC reports, there has been a steady march forward in terms of analysis of the human part in the grand equation. For example, many of us matriculated debating neo-Malthusian analyses which have shown us the consequences of overpopulation and excessive resource consumption (e.g. "The Limits to Growth" and "Beyond the Limits" by Donella Meadows *et al* with the cornucopian arguments of Kahn, Wildavsky and Simon). Social scientists from anthropology and geography to political science and sociology have finely dissected the interrelationships of humans and nature (e.g. "The Long Summer" and "The Little Ice Age" by Brian Fagan). Progressive thinkers have helped us to integrate this knowledge into a workable dynamic for adaptively managing human civilization to mesh with the natural world (e.g. "Design With Nature" by Ian McHarg). In addition, we have hope and optimism in these social tools and forces. To paraphrase a popular TV series of my youth, "...we can rebuild it. We have the technology. We have the capability to build a better world ...better, stronger, faster." But that better world is not one dependent upon our domination of the world, but in adapting to change and preserving as much as we can of the master blueprint.

Where Lowdermilk had the advantage was in a different kind of faith; not faith in a higher power (which he seemed to have in abundance) but a faith that seemed to be much more in abundance in the 1930s-1950s in this country. Throughout most of my lifetime, we have had leaders in government tell us that government cannot do anything right, and it is getting harder now to disagree. If you read Jean Edward Smith's eponymously titled new biography of FDR, you can see into another time; a time when people had faith in government to do great things and great things were done regardless of party. FDR, Truman, and Eisenhower all came out of this mold. JFK gave us hope and vision; LBJ tried to fulfill JKF's vision. Since those days we have been on a ride of diminishing expectations; with our leaders being sabotaged by combinations of personal flaws, disloyal opposition and rampaging cynicism. Unfortunately, this growing lack of faith in government took place while we were just starting to confront key environmental problems nationally and globally. Today, we face a rapidly changing world with Malthusian dilemmas becoming bigger and bigger wolves at the door. I argue that population growth and diminishing safe water, soil, food, and other critical resources along with debts of money and good will must force us to have faith in government. If we are to have at least the same quality environment to hand over to the next generation as we have today, active integrated management of water and soil resources from a national perspective is the minimum we need. Lack of faith in our abilities and incompetence are no longer luxuries we can afford.

The IPCC report tells us that we are already past or rapidly approaching some key "tipping points," and that significant changes are already happening. Studies indicate we are losing massive numbers of species and habitats nationally and globally. If projections prove accurate, sea level rise will threaten coastal habitability for many states, and completely obliterate some other nations before these 7th graders are ready for retirement. Critical attention to resource management and habitat preservation on a national and global level is an immediate necessity and that can only be done by countries, governments, and people who believe in themselves. As for the U.S., we need to go beyond national water and land use plans that are simply "plans," and go for implementation that has teeth. We need to have faith that through government, in conjunction with business and nonprofits and communities, we can address the question of greenhouse gas emissions and adaptively manage the changes that are going to take place to optimize protection of humans, our built environment, and the natural wealth of our environment.

E-Mail Connection

fitche@marietta.edu

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WATER RESOURCES
IMPACT

TERMS OF ART AND OTHER (MIS-) COMMUNICATIONS

Michelle Henrie and Kyle S. Harwood

In a previous *Water Resources IMPACT* column we explored the various types of lawyers and practice areas that are involved in water resources issues and projects. Just as different professions (economics, engineering, planning, etc.) have their own language and terminology, the different practice areas of law have specialized terms and ways of communicating in a written and verbal format. In order for a nonlegal water resources professional to be an 'informed consumer' of legal services, it is important to appreciate the legal language, and in particular, the importance to lawyers of a 'term of art.' In this column we will explore a basic framework for legal 'terms of art;' Latin words and phrases, specific or defined terms, and common legal phrases.

Clearly a great deal of confusion can result when professional communications use language that has different meanings for different readers. One of the ways that attorneys distinguish themselves from other professions is with the use of Latin words and phrases, or other legal terminology. We would encourage nonlegal water resource professionals to ask their attorneys for an explanation of any legal terms for two basic reasons. The first is that an attorney is likely assuming that everyone knows what she or he is referring to unless asked, and a misunderstanding about the nature and extent of an affidavit, motion, or expert report could be very significant for everyone involved. The second, from our own experience, is that the process of explaining the legal term can be as useful for the attorney as for the audience. We have had, on occasion, a surprising insight trying to explain a legal term to a colleague, sometimes to our dismay. As an 'informed consumer' of legal services you should be concerned if your attorney co-worker is unwilling or unable to explain the legal terminology that they are using.

Latin words and phrases are perhaps the most obscure communication that one will hear from an attorney. If an attorney shakes her head and says that "the darned judge acted *sua sponte*" and then proceeds to talk about a plan of action and who needs to do what, others may be left wondering what happened to the other work plans and assignments. In this instance, the term *sua sponte* means that the judge acted on her own accord and not in response to a motion or court filing. Judges can and do act in ways that they think are in the best interests of a case, and it can be particularly frustrating to attorneys who wanted the opportunity to brief and argue the same issue. Our favorite legal Latin phrase, which comes up in many conversations with clients, is *res est misera ubi jus est vagum et incertum*, or 'it is a wretched state of things when law is vague.'

Common legal phrases are similar to the Latin phrases above, except that some attorneys or nonlegal professionals may confuse a legal term with its nonlegal definition. In transactional legal work, the terms 'offer' and 'acceptance' have very particular meanings and they are truly 'terms of art,' interpreted by the judiciary and intentionally used by attorneys in the practice of law. An 'usufructuary' property right to water makes clear a lawyer's need to distinguish the relationship of the public and a water right owner to a water right in contrast to many other types of property interests that one may have in land or personal property. We mention the usufructuary right in water law since the right to use and enjoy the benefits of water which is held by the public is a unique aspect of water resources. 'Offer,' 'acceptance,' 'usufruct,' and 'sua sponte' are all explained best in the venerable Black's Law Dictionary that most attorneys will have somewhere on their bookcase. Most attorneys will also have stories about how Black's tortured them or saved them in law school. Unfortunately, the Black's publishing company has not made itself available online for free. We recommend the Merriam Webster's Dictionary of Law at the Findlaw site (dictionary.lp.findlaw.com) or Nolo's Everybody's Legal Dictionary (nolo.com).

Lastly, specific terms may be defined by contract, court case, or other written document and are most like the forms of terminology used by the nonlegal water resource professions. If one needs to determine the meaning of 'induced drawdown' or 'fixed overhead and replacement costs' then hopefully a local or professional resource can be consulted.

Written and verbal skills are the core competencies of a lawyer. The language used, an in particular 'terms of art,' are especially important to a lawyer's work. The conflict and confusion that can come from alternate definitions is particularly high in the water resources field because of the variety and number of other professions that work on such projects. We hope that this short article encourages nonlegal professionals to become more informed consumers and will make transparent that which legal terminology can obscure.

E-MAIL CONNECTION

ksharwood@ci.santa-fe.nm.us
mhenrie@bhfs.com

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SOLICITATION FOR WORKSHOP PROPOSALS (DUE JULY 31)

WORKSHOPS WILL BE HELD ON SUNDAY, NOVEMBER 11, PRIOR TO AWRA'S ANNUAL WATER RESOURCES CONFERENCE November 12-15, 2007

The American Water Resources Association's Annual Conference will be held in Albuquerque, New Mexico, November 12-15, at the Embassy Suites Hotel. We expect this conference to be one of AWRA's largest, as a record 414 abstracts have been received.

On the Sunday (November 11) before the conference begins, AWRA will stage as many as four (4) workshops at the Embassy Suites. These can be as short as 2 hours or as long as 8 hours. We are now soliciting workshop proposals. If a proposal is accepted, AWRA will collect the fees for the workshop conveners via the registration process. AWRA can offer CEUs.

If you would like to have AWRA consider a workshop proposal, please send a Word document (no more than one page) to Michael Campana (aquadoc@oregonstate.edu) and Karl Williard (williard@siu.edu) by July 31, 2007. It should contain the following information:

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(2) Name, affiliation, contact info (email, phone) for the convener(s)
(3) Length
(4) Special needs (PowerPoint projector, DVD player, each attendee needs to bring a laptop, wireless Internet access, etc.)
(5) Previous offerings (number of times)?
(6) Target audience
(7) A brief (1-2 paragraphs) description of the objectives, what will be covered, etc.

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- JT11 Volunteer/Interested Citizen
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- JT13 Other

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- CF Consulting Firm
- EI Educational Institution (faculty/staff)
- ES Educational Institution (student)
- LR Local/Regional Gov't. Agency
- SI State/Interstate Gov't. Agency
- IN Industry
- LF Law Firm
- FG Federal Government
- RE Retired
- NP Non-Profit Organization
- TG Tribal Government
- OT Other ____________

EDUCATION CODES

- HS High School
- AA Associates
- BA Bachelor of Arts
- BS Bachelor of Science
- MA Master of Arts
- MS Master of Science
- JD Juris Doctor
- PhD Doctorate
- OT Other ____________

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- AG Agronomy
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- CH Chemistry
- EY Ecology
- EC Economics
- ED Education
- EG Engineering
- FO Forestry
- GR Geography
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- GI Geographic Information Systems
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- OE Oceanography
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