Letter Report Assessing the WATERS Network Science Plan

Committee on the Review of the Water and Environmental Research Systems (WATERS) Network

Water Science and Technology Board

Division on Earth and Life Studies

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July 7, 2009

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Assistant Director for Geosciences
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Assistant Director for Engineering
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Dear, Dr. Killeen, Dr. Lightfoot, and Dr. Peterson:

In 2006, the National Science Foundation (NSF) requested that the National Research Council's (NRC's) Water Science and Technology Board review and assess the adequacy of the conceptual design and planning process for NSF's proposed Water and Environmental Research Systems (WATERS) Network. In response, the NRC formed a committee (see Attachment B for committee membership) that first issued an interim report evaluating the Draft Science, Education, and Design Strategy for the WATERS Network (NRC, 2008). Subsequently, in response to requests from NSF, the statement of task for the committee was modified towards reviewing a vision-level Science Plan, and the NRC and committee agreed to provide quick advice on part two of the statement of task (see Attachment C). This letter report summarizes the committee's assessment of whether the Science Plan "sets forth a vision of what could be accomplished with an observing network to transform water science and engineering research and education" and "whether the Science Plan makes a compelling case for establishing the WATERS Network with Major Research and Facilities Construction (MREFC) funding." We address these two questions individually below and offer an overall assessment as well. The committee's final report, which is anticipated to be completed in fall 2009, will address the third part of the statement of task, along with a more detailed review of the Science Plan (task #2).

Vision for Science and Engineering Research

The WATERS Network Science Plan identifies many of the important questions and research issues that need to be addressed if we as a nation are to meet the water management

challenges facing society today and in the future.[1] The world and our nation face pressing and, in some places, urgent water problems stemming from a changing and uncertain climate, coupled with varying and uncertain demands for water over time and space. In addition, human behavior impacts the use and management of water and the condition of the resource itself, and these impacts need to be better understood if this resource is to be sustainably managed. The Science Plan envisions an integrated approach involving the natural, engineering, and social sciences with potential to help address these issues through a network of hydrologic observatories in the United States.

The Plan outlines the opportunity to collect, analyze, and integrate hydrological, environmental science and engineering, and social science data at a level that has not been possible before. Opportunities for cutting-edge research are envisioned through the collection of data from sensors distributed at sites along gradients or at nested sites that will enable the improvement of the understanding of the complete water balance within a research site. The proposed network also could support research on how better to design and build engineering systems for water management and the collection of social science data from individual sites and on a national scale to better understand human-water resource interactions and impacts. The Network's support of cyberinfrastructure to store, manage, and provide access to data is key to the success of the project, as it will be used by researchers throughout the nation, via analysis and modeling, to examine questions related to a diverse set of water environments and to better understand complex processes.

The Science Plan was intended as a broad vision document, and our assessment of it in this light is that the document succeeds in communicating a high-level vision for transforming water science and engineering research through establishing an observatory network. The educational impacts of the WATERS Network could also be transformative.

The Committee believes it is important to continue to improve the Science Plan as the program moves ahead through more detailed planning in the conceptual design stage, which is the next stage of the process on the way toward construction, if approved. The committee envisions potential contributions of the WATERS Network to our understanding of water and human health, water-energy linkages, water economics, and international water issues, and these contributions should be described more fully in the future as the Science Plan evolves. With respect to international issues, the Science Plan describes a number of objectives that link with the goals of international programs. As one example, WATERS could make major contributions on behalf of the United States to the Global Water System Project (GWSP), which is addressing human interactions with the hydrological cycle in terms of natural and built environments. The WATERS research findings also could become an important US contribution to international development programs, particularly for those countries where water issues are most critical.

The Science Plan was conceived as a high-level vision statement and not as a design document. The committee wants to stress, however, that careful attention to developing a clear and complete plan for cyberinfrastructure will be critical in the future. The challenges of building

[1] The overarching science question for the WATERS Network is: "How can we protect ecosystems and better manage and predict water availability and quality for future generations, given changes to the water cycle caused by human activities and climate trends?" Three second-level research questions posed in the Science Plan are: 1) how is fresh water availability changing and how can we understand and predict these changes; 2) how can we engineer water infrastructure to be reliable, resilient, and sustainable; and 3) how will human behavior, policy design, and institutional decisions affect and be affected by changes in water? (NSF, 2009)

the cyberinfrastructure network are indeed formidable. The WATERS vision of having observing system cyberinfrastructure across the natural, social, and built environments and the need to share infrastructure with existing agencies and organizations goes beyond anything that has been accomplished in the past. Consequently, the planning will be correspondingly challenging and many open issues remain.

Case for Establishing the WATERS Network with MREFC Funding

MREFC is a possible mechanism to provide the infrastructure for the WATERS Network. One of the major strengths of the WATERS Network is that hydrologic sciences, engineering disciplines, and the social sciences are cooperatively developing the Network plan with the full support of the three NSF directorates. This would be the first MREFC project that involves more than one directorate, and, thus, WATERS would become a model for conducting interdisciplinary research within NSF and the MREFC program. The integration of the social sciences with the natural and engineering sciences has been a long-standing challenge, and the integrated WATERS Network would provide a unique opportunity to integrate the social sciences into water science. The committee does not have knowledge of whether this type of multi-disciplinary, large infrastructure project could move forward within other existing (non-MREFC) mechanisms at NSF.

The NSF guidelines[2] state several conditions that a project must meet to qualify for MREFC funding. Among the conditions are the following: "To qualify for MREFC investment, networked infrastructure must exhibit systems characteristics greater than inferred simply by the connectivity of its parts." The understanding also is that the facility would "require large investments for construction/acquisition, over a limited period of time, such that the project cannot be supported within one or more NSF Directorate(s)/Office(s) without severe distortion to the funding of its portfolio of activities." The committee understands that NSF intends these guidelines to mean that a *facility* must satisfy the condition that addressing the proposed science questions would require construction of the network in its entirety over a short period and that pieces of the network (e.g., one or a few of the observatories) could not effectively meet the science objectives. That is, we assume that a proposed network would have to satisfy both the "systems characteristic" and the "large investments over a relatively short period" conditions to qualify for MREFC funding. The LTER network and the more recent Critical Zone Observatories, funded under directorate research programs, are examples where individual observatory sites conduct transformative science without meeting the MREFC criteria, even though additional comparative insights are gained by having multiple observatories.

As currently described in the Science Plan, the proposed network of observatories appears to be a collection of many pieces. Some of the components are new, while others would consist of existing sensors or observatories operated by mission agencies that could be shared or repurposed to meet objectives of the WATERS Network. According to the committee's understanding, construction of all of the pieces over a relatively short (5-year) period is envisioned, consistent with typical MREFC facility requirements. The Science Plan does not clearly articulate a rationale for why WATERS *as a facility* is required to address the key science questions. That is, the Science Plan does not present a convincing case explaining why the simultaneous construction of the entire infrastructure is essential to answer the science questions,

[2] http://www.nsf.gov/bfa/docs/mrefcguidelines1206.pdf

as opposed to phased construction of a few observatories at a time. The document does not explain clearly why any of the three major questions cannot be approached regionally and, in fact, why some current efforts are not addressing the science questions, at least in part. For example, the first major WATERS question is "how is fresh water availability changing and how can we understand and predict such changes?" The US Climate Change Science Program is carrying out work described as follows: "FY 2008 activities will focus on a few regional case studies in which both models and measurements will be used to develop closure in the terrestrial water cycle budget for those regions. This multi-agency CCSP project will utilize existing regional sites to improve observational capabilities (surface, subsurface, and remote sensing). A range of climate zones will be considered to provide a suitable research framework that concurrently addresses climate/water cycle science and water resource management issues."[3] The WATERS Science Plan does not describe, even conceptually, why efforts such as these are insufficient to address the first major question[1] and, thus, why the network as a facility (in the sense of NSF's MREFC program) is needed.

As the WATERS team goes forward, there are two possible options that the committee sees. First, the WATERS team could bolster its case that a national network of observatories is required to address the science questions that are posed. Are there national-scale testable hypotheses that only a network of observatories such as the one envisioned by WATERS could address? These testable hypotheses would be intermediate between the three high-level science questions[1] and the specific science cases (exemplified by snow hydrology, hypoxia, and the engineered system in the Science Plan). Because one of the clear strengths of the WATERS Network is the integration of hydrology, engineering, and aspects of the social sciences, the national-scale testable hypotheses should integrate across these disciplines.

Second, an alternative funding procedure under the MREFC or some other mechanism within NSF might be considered, if feasible, for establishing a phased network of observatories such as envisioned in the WATERS Science Plan. It may not be best for advancing water science to demand that spatially distributed and temporally extensive measurements at a set of observatories pass a "facility" test. Rather than emplace a network of sensors that is based on a fixed initial design (or an initial set of hypotheses), it may be far more efficient to build out a field design as one learns how the hydrologic-human systems operate at a site. If the entire network is not simultaneously required to address the science questions, it is probably more sensible to build the network incrementally and let the questions and experiments evolve in an adaptive framework. This approach, which is not constrained by MREFC timelines for design and construction phases, could take better advantage of advances in technology over time, such as for sensors and components of the cyberinfrastructure. Also, capital costs are lower initially and are spread out over a longer period of time.

Summary

In summary, the committee is very favorably impressed by the progress that has been made by the WATERS team over the past year. We think that they have identified an overarching theme and a set of high-level research questions that can be used as a foundation for formulation of second-level science questions. The three examples of hypothetical nodes in the proposed network demonstrate clearly that fundamental, transformative research is likely to stem

[3] http://www.usgcrp.gov/usgcrp/Library/ocp2008/ocp2008-focus.htm

from the project. We find the collaboration among three directorates at the NSF to be a refreshingly positive step. There are improvements that can be made to the Science Plan in the future that would make it even stronger and the committee believes that the document should evolve as the project proceeds.

The Science Plan presents a compelling case for the need for new work in natural science, social science, and engineering, but the committee found the question of whether the project should be established within the MREFC framework to be less clearly answered by the Science Plan. That is, assuming that the current MREFC guidelines require that the WATERS Network be a *facility*, the Science Plan does not present a cogently argued rationale in support of the claim. The data products and cyberinfrastructure elements envisioned would benefit from the full network of observatories, but the case for the need of a facility in terms of accomplishing new science is not fully developed. Thus, the WATERS team should focus on clearly articulating the case for why the network of observatories as a whole is needed to address both the high level science questions and the second level science questions that will be developed as the project proceeds.

Sincerely,

George Hornberger

George Hornberger, Chair
Committee on the Review of
the Water and Environmental
Research Systems (WATERS)
Network

Attachment A: References
Attachment B: Committee membership
Attachment C: Statement of task
Attachment D: Acknowledgement of reviewers

cc:
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ATTACHMENT A

REFERENCES

NSF (National Science Foundation). 2009. Living in the Water Environment: the WATERS Network Science Plan. Arlington, VA: National Science Foundation.

NRC (National Research Council). 2008. Prelininary Review of the Draft Science, Education, and Design Strategy for the Water and Environmental Research Systems (WATERS) Network. Washington, D.C.: National Academies Press.

ATTACHMENT B

COMMITTEE ON THE REVIEW OF THE WATER AND ENVIRONMENTAL RESEARCH SYSTEMS (WATERS) NETWORK

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ATTACHMENT C

STATEMENT OF TASK

In response to NSF's request, the WSTB has assembled a committee to:

1. Review the draft report on conceptual design for the WATERS Network and associated planning documents, including project office committee reports and reports prepared by CUAHSI to be supplied as "background" information. This review will include an assessment of the adequacy of the design plan relative to the stated mission and goals of the WATERS Network, the grand challenges it is being established to address, and the specific science questions and environmental drivers on which the design is based.

2. Review the WATERS Science Plan, and the associated documents to be provided (e.g., WATERS Network Project Office committee reports on education, modeling, etc.), to assess whether the Science Plan makes a compelling case for establishing the WATERS Network with Major Research Equipment and Facilities Construction (MREFC) funding. The Science Plan should articulate grand challenges that will attract widespread support; provide a foundation for formulation of second level science questions; and set forth a vision of what could be accomplished with an observing network to transform water science and engineering research and education.

3. Advise the WATERS Network Project Office and NSF on how the WATERS Network can be integrated efficiently and effectively with the observational programs related to water resources of other federal agencies, state and local governments, and the private sector, considering the different missions of these agencies (including NSF, whose "mission" is to support fundamental research and education).

ATTACHMENT D

ACKNOWLEDGMENT OF REVIEWERS

This letter report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We wish to thank the following individuals for their review of this report: Patrick L. Brezonik, University of Minnesota; William K. Michener, University of New Mexico; Edella C. Schlager, University of Arizona; David L. Sedlak, University of California, Berkeley; Charles J. Vörösmarty, University of New Hampshire.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by Mary P. Anderson, University of Wisconsin-Madison. Appointed by the National Research Council, she was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.