MSU-WATER: A NEW WAY OF ADDRESSING WATER QUALITY AND QUANTITY CHALLENGES

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INTRODUCTION

The Clean Water Act of 1972 (CWA) has had a profound impact on the nature of household and industrial wastewater discharge and treatment in the U.S. A myriad of federal and state programs created by the CWA has dramatically reduced liquid discharges from industry, waste treatment facilities, and other point sources, helping to improve surface water quality (Wayland, Witter, and Purdy, 1999). Under the Construction Grants program (Title II) of the CWA, more than $67 billion in federal funds were invested in the construction of publicly owned wastewater treatment works (POTWs) from 1972 to 1987 (EPA, 1997). During this period, more than 60% of the cost of POTW construction could be financed by government grants that did not require repayment (EPA 1991). By covering construction and infrastructure development costs, these grants allowed recipient communities to maintain manageable tax burdens and therefore invest in facilities with little political dissent (Wayland, Witter, and Purdy 1999).

Onsite systems in the United States produce one trillion gallons of wastewater each year (EPA 1986). Forty-one states have reported groundwater contamination resulting from faulty septic systems (Gleick, 1993: 255), and contamination of rural drinking water wells by untreated wastewater is responsible for most cases of waterborne illnesses (NSFC 1996). Nutrient enrichment from failing septic systems in shoreline areas causes eutrophication and nuisance weedy growth in surface water bodies. A survey of coastal and Great Lakes communities in 1998 found more than 1,500 reports of beach closings and advisories that were associated with storm water runoff (EPA 1999: 68727). Studies in California have concluded that there is a 57 percent higher rate of illness in swimmers who swim adjacent to storm drains than swimmers who swim more than 400 yards away from storm drains (EPA 1999: 68727).

A 1993, survey of local health departments nationwide revealed that there were at least 87,000 failing septic systems and over 92,000 systems in need of repair (NSFC 1996). In a recent (October 12, 2000) article in Lasing State Journal it was reported that "Michigan will need to spend $5.8 billion over the next two decades if it wants to avoid further problems caused by crumbling sewage systems, according to a report prepared for a coalition of environmental groups" (Lansing State Journal 2000). Peter Gleick (1993) may have said it best:

> "As we look at the twenty-first century, several challenges face us. Foremost among them is how to satisfy the food, drinking water, sanitation, and health needs of the ten or twelve or fifteen billion people, when we have failed to do so in the world of five billion."

Phase II of the Clean Water Act

Rural areas, with less dense populations and lower wastewater volumes, have not been a priority for federal or state funding of new wastewater facilities, but these areas combined represent a major pollution stream to our surface water bodies (Wayland, Witter, and Purdy 1999). On October 29, 1999, EPA Administrator Carol Browner signed the Phase II NPDES Storm Water Regulations that were published in the Federal Register on December 8, 1999 (EPA 1999).

In Michigan there are an estimated 22 counties and 252 institutions that will be required to comply with Phase II requirements (EPA 1999). The development of MSU-WATER (Watershed Action Through Education and Research) was in response to the water science and management needs by the citizens of the State of Michigan. It will provide MSU with a watershed management plan that will meet and exceed requirements by the Michigan Department of Environmental Quality and EPA.

MSU-WATER – GENERAL DESCRIPTION

Michigan State University is the pioneer Land Grant University. For almost 150 years it has maintained a reputation for being a leader in agriculture, environment, and natural resource sciences. The goal of MSU-WATER is to link the university's water science research, outreach, and teaching programs to help manage and protect Michigan's, the nation's, and the world's surface and groundwater resources that sustain all life. To do this we have chosen to start with Michigan State University and demonstrate that we can manage the water resources on our own campus.

The overall objectives of the MSU-WATER include:

- To create a watershed management plan for the East Lansing campus;
- To collaborate with upstream and downstream partners in an attempt to meet and surpass relevant water quality standard requirements;
- To work towards elimination of point- and the reduction of non-point source pollution along the Red Cedar River and its tributaries;
- To increase awareness of water quality issues and encourage the adoption of individual actions that protect water among all stakeholders within the watershed;
- To explore the development of an undergraduate and graduate level interdisciplinary educational program in water sciences and management;
- To integrate the new graduate program and new research projects and outreach programs into MSU's international programs; and
- To conduct semi-annual water conferences at MSU which are problem-driven and solution-focused with colleagues from around the world.

Central to MSU-Water's success is an active service-learning program delivering technical expertise to communities, counties, and institutions. Faculty and graduate students are already engaged in a number of service-learning programs with communities and stakeholder groups in the area. The Red Cedar Watershed Coordinating Committee is a partnership of two county Environmental Health Departments, Drain Commissioners (elected country officials charged with managing surface water flow), Michigan Department of Environmental Quality, Michigan Department of Agriculture, eleven communities, and MSU faculty. This team has been awarded an EPA 319 grant to conduct a baseline assessment of the Red Cedar Watershed. All of the communities in the watershed have signed letters committing resources to the program. Community Action Panels are being formed with various stakeholders groups (e.g., farmers, developers, regulators, etc.) who are helping with the identification of key issues, the development of a questionnaire, and education materials. Programs are also being conducted with township officials to draft watershed management zoning regulations.

Another example is work that is currently underway with the Greater Lansing Regional Committee on Phase II Nonpoint Source Pollution Prevention. Seven townships and two major communities have joined forces with Michigan State University and Tetra Tech, Inc., to develop a regional watershed management plan. MSU plays the role of linking this effort with the Red Cedar Watershed Coordinating Committee. MSU is seen as a partner in the program and an advisor on technical alternatives. These two projects represent the first time all 10 groups have worked together on a joint planning program.

Since August four doctoral students and one masters student have identified thesis topics associated with these two projects. In addition, a number of undergraduate students are involved in data collection and analysis. There are currently two courses (graduate

and undergraduate) that are providing active learning opportunities within the Red Cedar Watershed. The undergraduate course has its students working with middle school students in area to understand the cause and effect relationship with water quality problems. New experimental courses are being discussed that will incorporate undergraduate and graduate students into the construction of wetlands, stream bank restoration, community assessments, and implementation of watershed management plans.

MSU-WATER is committed to the Land Grant University tradition of working with people in the field to identify and define problems, and then using its research capabilities to find solutions to the problems.

MSU Approach to Meeting the CWA Requirements

MSU-WATER is a proactive pollution prevention program that will not only meet the requirements of the CWA, but will also establish a premier teaching, outreach and research site on the East Lansing campus. Major components of the initiative will include the following:

- Conducting a baseline assessment of the watershed components and process, including all water uses, water users, and their long-term needs;
- Establishing a comprehensive database of this information;
- Identifying and ranking water quality problems;
- Developing a set of planning constraints and decision criteria;
- Establishing clear and specific goals for reaching desired outcomes;
- Identifying the most appropriate methods for comparing management alternatives;
- Identifying the economic and legal feasibility of best management practices;
- Developing management alternatives;
- Integrating feasible options into MSU's grounds maintenance, outreach, teaching and research functions;
- Implementing a clear and comprehensive plan for managing the East Lansing campus that meets the planning and management needs of MSU and that establishes the campus watershed as a living laboratory for outreach, teaching, and research; and
- Adopting an evaluation process for all phases of the process.

Teams of faculty from 6 colleges and 16 departments, in addition to university maintenance units and local and state governmental agencies have been formed to carry out these tasks. Noted scientists and leaders have been selected to establish teams that will meet these tasks and develop long-term research, outreach and teaching initiatives.

MSU-WATER – GENERAL PROGRAM

Baseline Study: River, Groundwater, and Sediment Quality

Team Leaders: Dr. David T. Long, Professor of Geological Science and Dr. Thomas Voice, Professor of Civil and Environmental Engineering

The baseline study of river, groundwater and sediment quality on MSU's campus will consist of the collection of spatially and temporally distributed water and sediment samples and measurements. The goals of the study will be to determine the current biogeochemical and hydrogeological state of the water and the influence of MSU on the water. The five tasks to accomplish these goals are:

- collection of historical data;
- collection of current groundwater data;
- collection of current river data;
- sediment sampling; and
- assessment of the data.

Historical data will be collected or identified from thesis, dissertation, and research of investigators at MSU; the U.S. Geological Survey; the EPA; and state, county, and city agencies. The data to be collected will include the chemistry of the river, groundwater, and precipitation; river stages; groundwater heads; land uses; and climate information (e.g., precipitation and temperature). This data will be added to the watershed database and integrated into a campus geographic information system (GIS).

Sediment Sampling

Current characterization of chemical contaminants in sediments is also planned. The plan is to evaluate sediments in a progressive manner, first identifying specific contaminants present at levels of potential concern, followed by more intensive sampling as determined appropriate to locate sources of contamination and determine MSU's contribution to the problem.

Analyses

The general methods outlined here will also be used for analyzing the river, outfall, and well water compositions. Each well will be purged with a

peristaltic pump at a rate of approximately 200 ml/min. A flow cell will be used to continuously monitor temperature, pH, dissolved oxygen, Eh, and specific conductance until stable (usually 20-30 minutes). Sulfide and preliminary nitrate and nitrite concentrations will be measured in the field using sulfide vacu-vials (Chemetrics). Concentrations of dissolved Fe (II) will be determined in the field using phenanthroline colorimetric analysis. Alkalinity will be determined in the field by potentiometric titration. Groundwater samples will also be collected and analyzed for total major cations (e.g., Ca, Mg, Na, K), and anions (including F), total trace metals (e.g., Cd, Fe, Mn, Al), total radionuclides (U), dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), methane (CH_4), sulfate (SO_4), and ammonium ion (NH_4).

Cations (major and trace) in the extracts from the sediment leaches and water samples will be analyzed using inductively coupled plasma mass spectrometry (ICP-MS). MSU has an ultra-clean lab with an ISP-MS facility for these measurements. In addition, the ICP-MS unit (Micromass Platform) has hexapole technology that allows the easy analysis of metals such as As, not typically analyzed by more traditional ICO-MS methodologies.

Human Health

Team Leaders: John Hesse, Visiting Professor of Fisheries and Wildlife and Robert Godbold, Director of the Ingham County Department of Environmental Health

This component includes baseline assessments of bacteriological contamination of the Red Cedar River and fish tissue. The Red Cedar River offers students and members of the community such recreational opportunities as canoeing, fishing, and wading, and educational experiences in the form of in-stream studies. These activities should be able to be carried out without concerns of exposure to unsafe water or fish.

Bacteriological Sampling

Michigan has established Recreational Water Quality Standards for partial and full body contact. As it flows through campus, the river water should meet the higher standard of full body contact of 130 *E. coli* per 100 milliliters (ml). These standards were established by rule under the authority of Part 31 of Act No. 451, P.A. of 1994. Weekly samples are being taken.

Fish Tissue Analysis

Although MSU has an ordinance prohibiting fishing on campus because of its designation as a wildlife preserve, the state regulatory agencies consider all of the Red Cedar River as waters of the state open to fishing. A very limited amount of fishing does indeed occur on campus and some anglers may consume the fish. If there are point sources of chemical contaminants on the MSU campus, human exposure could also occur if fish from campus migrate off campus (upstream or downstream) and are caught and eaten by other anglers and their families.

Certain fish in Michigan waters contain chemical contaminants in their tissues at levels of public health concern. Chemical analyses on fish from the Red Cedar River have been limited to one sampling of northern pike and carp (representative of predatory and bottom feeding species) at locations upstream of campus near Webberville. This testing, conducted in 1991, showed relatively low levels of most contaminants. However, polychlorinated biphenyl (PCB) levels were high enough that the Michigan Department of Community Health currently recommends that women of childbearing age and children not consume carp larger than 18 inches in length more often than one meal per month and smaller carp no more than one meal per week. Due to mercury levels, women and children should not eat northern pike over 26 inches more often than one meal per week. There are no restrictions for non-sensitive individuals on these two species. Mercury and other contaminant levels were all within acceptable ranges for the general population.

In collaboration with Department of Fisheries and Wildlife, ten individual fish of four species (all of legal size) will be collected from the Red Cedar River on the MSU campus during year one of the project. Standard edible-portion fillets will be analyzed for mercury and 23 chlorinated organic chemicals routinely monitored by the State of Michigan in fish tissue. Northern pike and smallmouth bass will be collected as the most commonly occurring predatory game fish species on campus. Carp were selected to represent a bottom feeding species. Rock bass were selected to represent panfish. For each species sampled, it is desirable to include a range of sizes, above the legal limit, that might typically represent sizes of fish caught and kept by anglers for consumption. Because older, larger fish tend to have the highest contaminant levels, an attempt will be made to collect carp over 18 inches in length and rock bass over eight inches since there are no legal size limits on these two species.

Fish, Wildlife, Aquatic Invertebrates and Physical Habitat

Team Leader: Dr. Dan Hayes, Associate Professor of Fisheries and Wildlife

The biota using the Red Cedar and its floodplain is valuable in several respects. First, the more visible species such as waterfowl and salmon contribute to the aesthetics of the river, and to the natural beauty of our campus. These species attract people of all ages to come and enjoy the campus and hopefully spark a sense of inquiry into the ecology of the river. Secondly, organisms such as fish and aquatic macroinvertebrates are sensitive to the water quality. As such, they are useful indicators of the health of the river system and the surrounding watershed. Finally, some organisms may play an important role in changes in water quality that occur as the Red Cedar flows through campus. In particular, ducks and geese can add nutrients and bacteria to the river via their feces.

Research conducted by MSU faculty and graduate students in the 1950s and 1960s provide evidence of aquatic conditions during that time period. However, due to the dearth of recent information on the aquatic biota in the Red Cedar River, we propose to conduct a survey of these organisms and associated habitat. This survey will not be restricted solely to campus, but will include river reaches upstream and downstream of campus to allow for a proper interpretation of the results in the context of the continuum of changes in biota that occur along the length of the river. Although it may be desirable to include other taxa in a survey of the biotic resources of the Red Cedar, the following elements will be investigated:

- Assessment of macroinvertebrate assemblage
- Determination of abundance and diversity of fish
- Estimate of seasonal use of the river by waterfowl
- Characterization of physical habitat features (slope, width, sediment, flow)

Although many anthropogenic activities pose a threat to the ecology of the Red Cedar River, several areas are of particular concern, especially in the context of campus watershed management. Some of the critical potential stressors include: excessive sediment delivery to the river, excessive nutrient inputs, loss of connectivity among river habitats due to culverts or other in-stream structures, and high contaminant loadings. With these, and other potential stressors in mind, the overall goal of this research is to provide an assessment of the current status of the Red Cedar River on campus.

Wetlands

Team Leaders: Dr. Thomas Burton, Professor of Zoology and Fisheries and Wildlife, and Dr. Alvin Smucker, Professor of Crop and Soil Science

Watersheds that contain large areas in wetlands are less subject to flood damage and exhibit better water quality than watersheds with little area in wetlands. Thus, one goal of MSU-WATER is to document existing wetlands and begin the planning process to restore and create wetlands at strategic areas of the campus.

The 1988 map of Campus Natural Areas prepared by Campus Park and Planning gives some idea of the diversity of wetlands on campus. These include: (1) Red Cedar and Sanford Natural Areas in the floodplain of the Red Cedar River; (2) the Bear Lake Natural Area; and (3) ponds and depressional wetlands in many of the woodlots even though these are not mapped as wetland areas.

The characterization of existing wetlands includes a biological assessment, chemical assessment, soils inventory and hydrogeological assessment of existing wetlands and areas that are likely sites for creation or restoration of wetlands on campus. Natural areas that connect or could connect to each wetland will be identified. Land use around each wetland area will be included in this inventory. The potential for each of these natural and created or restored wetlands to be used in education and as demonstration projects for use in water quality, conservation biology, etc. will be assessed. The fragmentation of natural areas on campus and the location of the wetlands in relation to these fragments offer the possibility of using these wetlands and fragments to determine needs for connectivity, buffer areas, and a variety of other concepts that are integral to conservation biology. The inventory of the wetlands will be part of the total baseline assessment of campus.

Representative wetlands of each type on campus will be sampled using non-destructive sampling techniques for vertebrates (observational data for mammals and reptiles and observational surveys plus call surveys for amphibians and birds) and plants. Voucher specimens will be collected for plants as appropriate, taking care not to remove any threatened or endangered species. Aquatic invertebrates will be sampled with dip nets, coring devices, and emergence traps. A complete search of theses and dissertations and a review of the literature will be conducted to document research conducted historically on the biota, chemistry and soils of these wetlands.

Assessment of Wetland Functions

Wetlands function like nature's kidneys: they provide flood and storm water control by absorbing large quantities of water like a sponge and they protect the quality of both surface and groundwater by filtering out sediments and recycling nutrients, pesticides, and other pollutants. The wetland functions will be researched to understand how to integrate the wetland function in the campus landscape to lower the human-created impact on the watershed. Research will be needed to further understand the impact of a population on a wetland including the impact of construction, the application of pesticides, and the effect of best management practices (BMPs). The lessons learned from this research will be extended to other communities throughout the state and demonstration sites will be developed on campus.

Demonstration activities and sites will include wetlands used to control surface run-off from impervious surfaces (i.e. streets, roofs, parking lots) and from combined sewer overflows. Displays in demonstration wetlands will be designed to:

- illustrate how wetlands and best management practices should be constructed and maintained;
- examine principles to be followed when constructing a wetland;
- demonstrate planting and seeding strategies for establishment of wetland plant communities with notes on which plants are most likely to establish and grow under various conditions;
- show impacts of road and parking lot construction on wetlands;
- demonstrate how to establish and market wetland mitigation banks;
- illustrate how wetlands can be used for remediation projects, to lower golf course impacts, to enhance wildlife usage, etc.

Environmental Soil Conditions

Team Leaders: Dr. Alvin Smucker, Professor of Crop and Soil Science; Dr. Gregory Lyman, Outreach Specialist of Crop and Soil Science; Dr. Delbert Mokma, Professor of Crop and Soil Science; and Dr. Clayton Rugh, Assistant Professor of Crop and Soil Science

Belowground seepage of contaminated water is one of the primary and often hidden contributors to pollutants in the Red Cedar River. Soil topography, naturally deposited soil types, and coarse textured back-fill during construction of buildings adjacent to the river are potential contributors to horizontal flow of belowground plumes containing contaminants. Sources of contaminants include leaky sewage (e.g., E.-coli, various P and N sources) and storm sewer drains (e.g., petroleum products, Cl, Zn, Cd, etc.), construction contaminants (e.g., solvents), slowly moving plumes (e.g., heavy metals, halogens, pesticides and bacteria) moving horizontally at depths from 20 to 500 cm belowground and adjacent to the banks of the Red Cedar River. Natural and anthropogenically modified soil profiles within 50 meters of the Red Cedar will be sampled for soil taxonomic, physical, chemical, and biological characteristics. Specific sites, where contaminant plumes are identified will be sampled at more intensive intervals and at greater distances from the river.

Phase one of the soil evaluations will include taking core samples at 25-50 m intervals along and within 5 meters of both sides of the banks of the Red Cedar River. These collection sites should be located by triangulation from a fixed benchmark and entered into the campus wide database. Data collected from these samples will include:

- depths and uniformity descriptions of each soil horizon;
- texture, bulk density and porosity of soil within each identified horizon;
- samples of each horizon for complete biogeochemical analyses;
- baseline samples of each horizon will be air-dried and stored for future analyses.

Metadata will include surrounding vegetation, surface topography, locations of water mains, and gas lines as well as storm and sewer drainage systems, which enter into the Red Cedar River. Once these data are collected, commercially available 2D and 3D soil drainage models will be used to predict belowground flow of specific chemical and biological contaminants into the Red Cedar River. Students enrolled in graduate level courses will generate graphs and tables for comparing riverside soil heterogeneity that will further characterize contaminant plumage flows into river and stream currents. These data will also be highly useful and serve as guidelines for determining minimum data sets required by metropolitan and commercial agencies for accessing belowground contaminate sources of streams and rivers. Additionally, these soil borings will be most useful in determining the best sites for locating the engineered wetlands described in preceding wetlands section.

Forestry

Team Leader: Dr. Carl W. Ramm, Associate Professor of Forestry

Watersheds and watershed protection have long been part and parcel of the forestry profession. There are a number of woodlots and forested areas on campus, and some line the banks of the Red Cedar. Forests help prevent soil erosion, allow for improved water infiltration, and provide shade, which can be an important cooling factor in waterways supporting fish populations.

One of the long-term goals of the Department of Forestry has been the development of a GIS for each of the off-campus and on-campus research units. Since 1998, the NAVSTAR global positioning system (GPS) has been used to accelerate the mapping process. The Department operates a Trimble GPS base station in cooperation with the other natural resources departments in the College of Agriculture and Natural Resources (CANR). Property and stand boundaries on forest research units are geo-referenced using GPS field receivers. These reference points are then exported from Trimble's PathFinder Office software to ArcView, a powerful and relatively easy to use GIS package. Individual geographic information systems have been developed for the Upper Peninsula Tree Improvement Center and the Jim Wells Forest in the Upper Peninsula, and for the W. K. Kellogg Forest and the Lukens property in the Lower Peninsula (at the W.K. Kellogg Forest, a GPS field receiver was used to geo-reference Augusta Creek, springs feeding into the creek, and structures erected by Trout Unlimited for stream improvement).

The objective will be to complete the GIS under development for the MSU campus. All forested areas (including woodlots) will be surveyed, geo-referenced, and added to the current GIS. Departmental files will be reviewed and historical stand characteristics will be added to the GIS database. This data includes past inventories for many of the forested areas on campus. In critical forested areas permanent sample points will be randomly established. Each point will be geo-referenced and its understory and overstory data will be sampled and added to the GIS database.

Data Management and GIS

Team Leader: Dr. Jon Bartholic, Professor and Director of the Institute for Water Research and Department of Resource Development

A critical component of MSU-WATER will be the establishment of a data management system that not only serves as a central storage area for acquired data, but also encourages communications and information sharing among the various project components. A web-based system will be developed to allow for easy access to project goals and objectives, linkages between project components, and timelines. All available information will be geo-positioned to facilitate access and analysis according to the components of the project. A common GPS unit will be utilized by all of the project investigators (where appropriate) to ensure that accurate locational data are collected. Time intervals, quality control, metadata, and specific measurements will be stored in a relational database. Thus, access to any field or groups of fields will be possible as will general analysis with results able to be queried, accessed, and displayed.

Developing an effective watershed management plan for the MSU campus community will also require an assessment of the land use, including the physical, biological, and human resources. The development of a common integrated spatial information system to aid decision-makers, planners, or university officials in making science-based decisions on a watershed basis is needed but currently does not exist. A geographic information system (GIS) will provide a means for integrating and linking various data collected from the campus watershed project. The effort will be linked to the existing, campus-wide GIS/CAD data and analysis facility.

Web-Based Database System Design And Implementation

During year one of the project, information regarding what is needed will be gathered, including the following:

- Determine main application areas for the database and type of data that will be included.
- Identify potential user groups. Key individuals within each group will be selected to carry out subsequent steps of information collection and specification.
- Determine preferred interface for each group.
- Compile existing documents concerning the MSU watershed.
- Examine user priorities for using the information. Interviews with key individuals to assess the worth of information and the setting of priorities will be conducted.
- Address data conversion concerns and geo-referencing issues.

The information collected will be summarized in a document form for review and feedback from the team leaders.

The second phase of this component will be choosing the Database Management System (DBMS). Current DBMS products will be assessed based on cost and performance factors, availability of service, training requirements, and operation and maintenance cost. After the assessment is completed, the necessary software and hardware will be purchased and the system set up. Once the system is in place, the database will be designed, implemented and fine-tuned. Feedback will be encouraged throughout the implementation process.

Social Assessment

Team Leaders: Dr. Michael Kaplowitz, Assistant Professor of Resource Development; Dr. Geoff Habron, Assistant Professor of Fisheries and Wildlife; and Dr. Craig Harris, Professor of Sociology

This work will rely on focus groups, surveys, and ongoing community advisory panels to assess the values, beliefs and knowledge of various stakeholder groups, including undergraduate and graduate students, administrative personnel, faculty, staff and operations personnel, and citizens of neighboring communities.

The information gathered will assist the project collaborators in setting research priorities, designing effective, targeted education and outreach programs and determining the most appropriate best management practices to implement as part of the overall watershed management plan. The data that are collected will be linked to the information collected in the other project components in order to test various cause and effect relationships and research hypotheses addressing the concerns of the stakeholders.
Methods to be utilized include the following:

- A series of focus groups will be conducted to learn from various members of the MSU community about their use, understanding, perceptions, and appreciation of the campus water resources. These groups will be designed to solicit input from a range of stakeholders, and will be comprised to elicit information about watershed perceptions and practices from individuals at various levels from the wide range of subject fields and activities at MSU.
- A survey of stakeholders will help to establish baseline knowledge of water quality issues and awareness of best management practices (BMPs). The survey will help establish planning priorities and determine stakeholders' willingness to accept and maintain BMPs and policies for improving and protecting water quality. It is envisioned that a survey of a stratified cluster sample of stakeholders in the watershed will be used to ensure that the various stakeholder groups are represented.
- A series of community advisory panels (CAPs) will be assembled to assist in developing educational packages and outreach programs for the campus community. Members of the CAPs will be recruited from the various groups of stakeholders. The CAPs will provide forums for public input and feedback; help set education priorities; and aid in the development of educational and outreach materials.
- A survey of those involved with MSU's human waste management, grounds and maintenance activities, and agricultural waste operations will be conducted. The surveys will collect information on current and future waste disposal activities as well as determine the need for testing of any potential impact of activities on water quality. This information will be used to determine if nutrients are being properly managed to avoid adverse impacts on water quality.

Watershed Management Plan Development

Team Leaders: Dr. Scott G. Witter, Acting Chairperson of Resource Development, Ruth Kline-Robach, Water Specialist at the Institute of Water Research; Megan McMahon, Environmental Quality Analyst, Surface Water Quality Division of Michigan's Department of Environmental Quality (MDEQ); and Erich Ditschman, Senior Project Leader, Tetra Tech, MPS

In conjunction with the assessment activities, this team will develop a campus-wide watershed management plan. By assimilating the information obtained through the project components discussed in this article, a framework for the campus watershed management plan will be developed using a systems approach. The plan will identify and rank water quality problems, specify clear goals and objectives for the watershed planning initiative, select watershed management alternatives, and establish an overall timeline for watershed planning activities.

The watershed management plan will include the following Phase II requirements:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control

- Post-Construction Runoff Control
- Pollution Prevention/Good Housekeeping

Michigan will follow a two-track permitting process. One track will closely resemble a traditional NPDES permit approach and include a Notice of Intent (NOI). A second track will follow the State's 1997 "Voluntary Storm Water Permit." This watershed management plan will be included as a part of the Red Cedar Watershed Coordinating Committee's Red Cedar Watershed Assessment. This activity is funded by a $195,000 EPA/MDEQ grant.

Once the watershed plan has been approved by MDEQ, a proposal will be written for Clean Michigan Initiative funds to implement various BMPs within the watershed and research projects to test the efficacy of various BMPs will be established. A series of proposals will be developed to expand the research, outreach, and teaching components of this project. This project will also seek support from the private and public sector to test water management technologies.

The development of this plan represents a major departure in operations for Michigan State University. Historically outside consultants have been hired to write plans. The results have been good reports, with minimal buy-in from faculty and students. Because of this there has been no change in how MSU conducts its teaching, research, and outreach programs. MSU-WATER is led by faculty, staff and students representing six colleges and 16 departments, all of whom are interested in long-term research, outreach, and teaching programs.

Coordination with Existing Programs

Team Leaders: Dr. Scott G. Witter, Acting Chairperson of the Department of Resource Development; Dr. David T. Long, Professor of Geological Science; and Dr. Jon Bartholic, Professor and Director of the Institute of Water Research and Department of Resource Development

A number of related projects and activities are currently underway across campus that provides opportunities for important project linkages. These are discussed briefly below.

Wellhead Protection – Michigan State University has developed a wellhead protection program (WHPP) to help ensure the safety of the campus drinking water supply. This project has accomplished the following to date:

- A team has been assembled with representatives from various university departments and organizations
- A delineation of the wellhead area was completed
- A contaminant source inventory that identifies where bulk contaminants are stored within the wellhead area and possible routes through which these contaminants could reach the groundwater has been completed
- A program statement to help ensure that wells are properly abandoned has been drafted and is currently in the review stage
- A public education and outreach program to encourage support from the university community in protecting the groundwater has begun
- Strategies to help ensure that groundwater remains uncontaminated, such as recommending land-use practices, best management practices and periodic inspections of the wellhead area are being formulated
- A contingency plan that provides instructions on what to do in case of a water supply emergency has been developed
- Procedures will be developed to ensure that new wells are sited with good wellhead protection practices being followed

Significant opportunity exists to consolidate some of the WHPP activities and the proposed watershed management efforts. Specifically, portions of the public education and outreach activities can be combined; management practices and contingency planning should be considered together; and GIS and monitoring data shared between the two groups to minimize duplication of efforts.

MSU 2020 Vision -- A series of Planning Principles and Planning Parameters for all campus master plan components is being created as part of this initiative. Component I of the MSU Master Plan is focused on parking, transportation and open space. The next component of the Master Planning process will focus on buildings, facilities and program needs. Future phases will include energy consumption, environmental issues, utility system analysis and detailed planning for each of the campus districts.

MSU-WATER collaborators will maintain close contact with the 2020 Vision initiative, in order to ensure that project activities, including the construction of wetlands and development of various watershed management alternatives fit within the guidelines outlined in the University's Master Plan.

University Committee for a Sustainable Campus -- The Academic Council created the University Committee for a Sustainable Campus (UCSC) in the fall of 1998. The committee's functions include guiding the assessment of the University's energy, water and solid wastes and serving as a clearinghouse of campus environmental research, teaching, learning and service activities. The committee advises the university community on recommended policies and actions to conserve resources and create a sustainable future. Representation on the committee is drawn from each of the colleges, operations, and relevant student programs. The UCSC reports through the Council of Environmental Deans to the Vice President for Research and Graduate Studies.

The UCSC was recently awarded a $249,522 grant from the U.S. EPA to develop a campus sustainability program. Funds will be used to establish a full-time office for three years to develop linkages between all partners in the MSU community and beyond. Seeking grants, developing a university-wide course on sustainability, encouraging additional research on campus into sustainability issues, highlighting achievements, and measuring and reducing the campus environmental footprint are all part of committee's plans.

USDA Water Sciences Fellowship – The fellowships provide interdisciplinary scholarships designed to initiate innovative research emphasizing systems science/computer simulation as it relates to varied aspects of the water sciences. Research components of the MSU/CANR Water Science Program include, but are not limited to the following: Systems Modeling and Simulation, Surface Water Flow and Chemical Movement, Agriculture Water and/or Waste Management, Risk Assessment, Legal and Economic Analysis, Watershed Management, Groundwater Flow and Chemical Movement, and Contaminant Remediation.

<u>Education Component</u>

Team Leaders: Dr. David Long, Professor of Geological Science; and Dr. Jon Bartholic, Professor and Director of the Institute of Water Research and Department of Resource Development

Michigan State University is recognized as a leader in environmental studies, with the strength of these studies related to the breadth of research interests and collaboration among faculty that crosses departments and colleges. The initiation of MSU-WATER affords an opportunity to take advantage of these strengths to further the educational experience in environmental studies at MSU as well as stimulate new research collaborations. The education component of the project may be unique to college campuses. It will consist of four tasks.

One of the first tasks will be to identify those courses on campus that use aspects of the Red Cedar watershed, particularly those that make environmental or societal measurements within the watershed. This will be accomplished by faculty surveys via email, flyers, and word of mouth.

A workshop will be held among interested faculty to allow for presentations about Red Cedar-related courses. With this information faculty can examine 1) how they could incorporate information collected from the Red Cedar watershed from the other courses into theirs and 2) determine if different or additional measurements could be added to their courses that could not only improve the educational experience for students but also be used to complement measurements being collected in other courses. These measurements would provide a framework for the long-term monitoring of the Red Cedar watershed.

The third task will be to explore, perhaps in a workshop setting, the possibility of establishing a watershed studies academic program. The purpose of such a program would be to give students the multi-disciplinary experience necessary to understand and tackle environmental problems, and the disciplinary experience to solve problems.

The final activity will be to explore the possibility of setting up a summer program in watershed studies. This program should be multidisciplinary, and would focus on making spatial and temporal measurements of chemical, physical, biological, and societal aspects of the Red Cedar watershed. This "field type" course could serve as (1) a key course for the watershed studies program (third task), (2) an option course for majors in the various environmental science programs on campus, and/or (3) a course offered to colleges and university students outside of MSU.

In addition to the tasks discussed above, every second year a watershed management conference will be held on campus. The purpose will be to focus on the major water quality problems and to define the best solutions currently available. Proceedings will be published following each conference. For the first conference (anticipated in 2002), efforts will be made to link the planning activities with those of the Environmental Speaker Series, an annual event organized by several departments across campus.

Outreach and Outreach Research

Team Leaders: Ruth Kline-Robach, Water Specialist at the Institute of Water Research, Dr. Geoff Habron, Assistant Professor of Fisheries and Wildlife; and Dr. Jon Bartholic, Professor and Director of the Institute of Water Research and Department of Resource Development

Tremendous opportunities exist for developing campus-wide, multi-faceted outreach programs as part of MSU-WATER. Prior to embarking on an outreach program, the project collaborators will determine target audiences, goals and objectives for outreach efforts to these audiences, and possible outreach mechanisms.

The general goal of the outreach component will be to increase awareness, knowledge, and concern about water quality, with the hope of changing behaviors. Examples of outreach products that could be developed include interpretative signs along the river that are linked with the River Trail as it is extended through campus and to the proposed constructed wetlands; organized tours exploring the biota of the river; and a web page that describes the findings of research being conducted in conjunction with the watershed management activities.

Education and outreach activities targeting elementary, junior high, and high school students will also be explored. Outreach programs focusing on K-12 education will be considered and external funding sought for designing and implementing these activities.

In service training on a variety of watershed management issues for MSU Extension field staff will also be considered. On-campus tours and web-based training applications may be utilized for these training sessions.

A major target audience will be township officials and other individuals who are likely to be developing and implementing watershed management plans similar to that being developed at MSU. The goal of outreach efforts directed toward this audience would be to transfer the technological knowledge and skills that the group at MSU possesses and will further refine as this project is implemented. Possible outreach mechanisms include workshops specifically addressing the needs of this clientele, or on-site tours of watershed management activities taking place on campus.

Evaluation

Team Leaders: Dr. Scott G. Witter, Acting Chairperson of the Department of Resource Development; Dr. Mike Kaplowitz, Assistant Professor of Resource Development; Dr. Jon Bartholic, Professor and Director of the Institute of Water Research and Department of Resource Development; and Ruth Kline-Robach, Water Specialist in the Institute of Water Research

A project evaluation will be implemented in years three and four, and will be an integral component of the overall watershed management project. Evaluation activities will seek to determine the success of BMPs that are implemented, the adoption of practices by target audiences, and the transference of research findings to other communities that are addressing water quality concerns.

An evaluation will also be conducted to determine the effectiveness of various outreach delivery methods. The evaluation will consider how different outreach delivery methods affect the target audience at several levels. The goals will be to determine:

1) how people's level of awareness of important water quality issues increases;
2) how people's knowledge and attitudes shift in response to the outreach efforts; and
3) how the target audiences' behavior responds to these efforts.

Specific methods for conducting such evaluations will depend on the particulars of the goals and objectives, target audience, and delivery method, but may include research methods such as questionnaires, behavioral observations, interview panels or focus groups.

CONCLUSION

It is critical for MSU to have a scientifically defensible measure of the success of MSU-WATER. The comprehensive assessment of the current status of ground and surface water quality, the river system and its biota, and other natural resources on campus will provide the baseline information that is a necessary component of a comprehensive watershed management plan. We will then be able to detect changes in response to watershed management practices that are implemented over time, and provide sound advice regarding the efficacy and suitability of a variety of management methods.

The development and implementation of the campus watershed management plan will do more than allow the University to meet the Phase II requirements of the Clean Water Act. We also have the unique opportunity to uphold our Land Grant tradition of excellence, and establish MSU as a premier watershed management teaching, outreach and research site.

MSU-WATER represents a comprehensive approach to watershed management. It is unique in that MSU's 5400-acre campus is the initial focal point for development of baseline studies and development of a watershed management plan. MSU faculty from a number of departments and staff members from several support units, in partnership with local, county and state agencies and local consultants are developing the plan. The project has the commitment of faculty, staff students, in addition to the support of the President, Provost, and Vice President for Finance and Operations and Treasurer.

The project will emphasize the design of sound research projects that will help to address community water quality management issues and the development of innovative education and outreach programs that will serve as models for other universities and communities. After the baseline assessments are completed and the campus watershed management plan is written, funding will be solicited from external agencies and organizations to implement innovative BMPs, including the construction of demonstration wetlands, to protect water quality. The research results will be shared with communities across the state and nation that are struggling with water quality concerns.

Lessons learned from this project are already being shared with nine communities in the greater City of Lansing area. MSU is working with these communities to help develop a watershed management plan for the region that will meet EPA Phase II requirements and help enhance the quality of water available for use by the local citizens.

MSU's campus is roughly divided between urban development and agriculture. It is an ideal setting for developing new cutting edge, science-based demonstration sites for extension and outreach programming, and becoming a focal point for learner based education. As one project member commented, "In a three hour period with my graduate students, I have taken samples, analyzed them in my lab, and presented them in class."

We welcome all ideas and suggestions from our colleagues that may enhance our program. We are also happy to provide information about MSU-WATER as it continues to evolve.

AUTHORS

Scott G. Witter is the Acting Chairperson of the Department of Resource Development and Coordinator of MSU-WATER. He has 20 years of experience in working on watershed management projects both domestically and internationally.

Ruth Kline-Robach is a Water Specialist at the Institute of Water Research and serves as the Water Quality Coordinator for the MSU Extension Water Quality Area of Expertise Team. She also serves as Co-Coordinator of MSU-WATER.

Jon Bartholic is Director of the Institute of Water Research at Michigan State University, past president of the National Institutes for Water Resources, and in 1995 received the Universities Council on Water Resources highest award, "Friends of UCOWR." His special interests are in working together to make science-based decisions on a watershed basis.

Fred Poston is the Vice President for Finance and Operations and Treasurer at Michigan State University. As Vice President for Finance and Operations and Treasurer, Dr. Poston oversees the budget and operations for the university's 43,000-plus students and 12,000 faculty and staff.

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